Communicating Design using 3D Collaborative Virtual Environments and Online Chat

A thesis submitted to The University of Adelaide for the degree of Master of Architecture

by
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THIS THESIS HAS BEEN ACCEPTED FOR THE AWARD OF THE DEGREE
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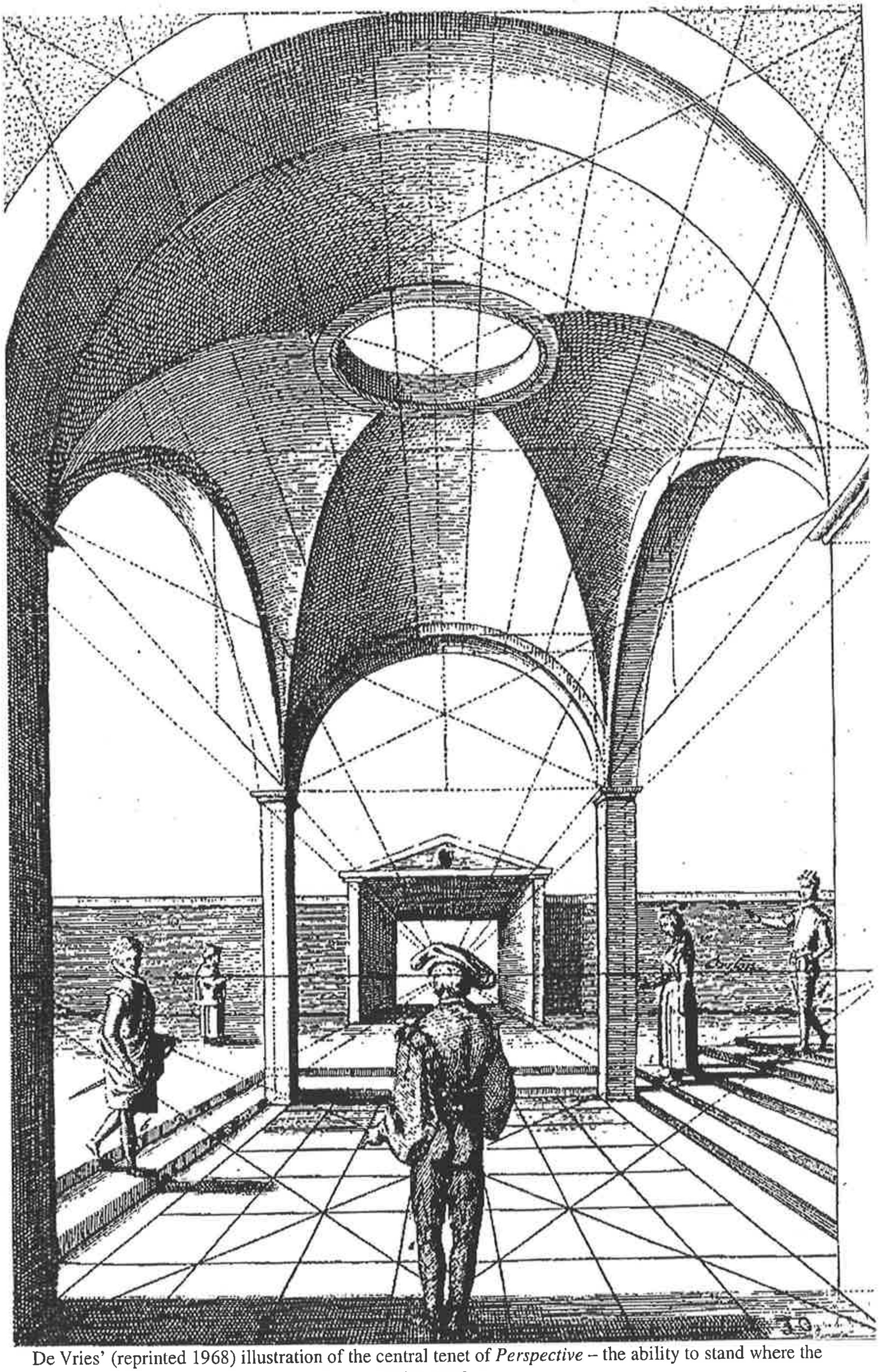

De Vries' (reprinted 1968) illustration of the central tenet of *Perspective* – the ability to stand where the artist stood.

Figures

Abstract

For millennia designers have been using sketches to communicate arrangements of objects in space. Since the Italian Renaissance, in the West, this was formalised as the perspective. Most recently, architects' hand-drafted sketches are increasingly being replaced by 3D computer modelling. The 3D computer-generated perspective extends the humble sketch by adding a photographic realism. Both rely upon the notion that a perspective is perceived intuitively by the lay-person and practitioner alike. While most of the literature reviewed in this thesis extols the virtues of perspective as a medium for communicating spatiality, little mention is made of identifying the role perspective plays in informing *how* perspective communicates spatiality. Its underpinning scientific ontological certainties are generally taken as given. However, whether perspective is how designers actually *see* their design visions is unclear. Moreover, whether designers' familiarity with perspective vision affects how they *choose* to communicate spatiality is equally unclear. As such, this thesis addresses the role of perspective in communicating design. It uses the latest iteration of perspective technology, the real-time 3D virtual environment (3DVE) as a vehicle. A series of pedagogical case studies in the use of 3DVEs is explored. The case studies are founded on exercises with design students as participants. The participants concretise their thoughts in text using online chat whilst exploring various 3DVEs remotely located from each other. The net result of this investigation is that perspective is only one of many methods the participants in this study used for communicating spatiality.

The thesis is structured about six chapters. Chapter 01 introduces the research goals, research question, methodology and thesis structure. Chapter 02 provides a literature review which mounts the case for the ubiquity of an intuitive perspective in design practice and theory since the fifteenth-century Italian Renaissance to contemporary 3D computer modelling. Chapter 03 outlines and justifies the use of a constructivist methodology for teasing out the issues raised in this inquiry. Chapter 04 provides an explorative and detailed analysis of three case studies that all revolve around the role of perspective in communicating spatiality between remotely located design-student participants using online chat to exchange information. Chapter 05 discusses the results of the case studies, providing some preliminary insights. Chapter 06 concludes the thesis. It principally draws upon the literature review and the discussion chapter to provide a conclusive view on the efficacies of perspective in communicating spatiality by the participants of this study.

Statement of Originality

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the university Library, being available for loan and photocopying.

Signed: Theodor G Wyeld Date:

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Above all else, my heart and soul goes to the undying dedication, perseverance, and support of my wife and family, for whom I hope the success of this joint venture will resonate our love in the years to come.

Having completed a Masters of Regional and Urban Planning, and having had time to contemplate the content of its thesis whilst in practice before I started this 'Masters' thesis, I came to the conclusion there was more to my investigations that remained unanswered. My Masters thesis was about challenging the way conservation reports use the analogy of the view from across the street as typical for determining the effect that massing of new construction had on the overview of historical facades in front of them. It included a case study of the Rundle Street East Fruit and Vegetable Market facades – in a historically, culturally and socially significant precinct of the city of Adelaide, South Australia. I used panoramas to demonstrate that we see much more than the limited 25 degree field-of-view (FoV) indicative of a photograph cited in the McDougal and Vines (1985) conservation report. In my 'Masters', I set out to extend this concept. More particularly, I wanted to investigate how a real-time navigable 3DVE might further assist in creating a more holistic experience of the spaces under review for professionals and layperson alike.

1.0 Introduction

This chapter discusses what the thesis is about, why I chose to pursue this study, and the gap I identified in the literature. It outlines the setting within which the study is situated, the background to the study, the research question to be addressed, and the thesis' broad objectives. It then summarises the methodology adopted, key outcomes, and the organisation of the thesis.

1.1 The Role of Perspective in 3D Virtual Environments

The use of computer-generated three-dimensional (3D) visualisations to promote design and planning issues arising from urban development proposals is becoming increasingly commonplace in architecture, engineering, and planning alike. It is also a key feature of developer's proposals. This heralds a shift from their manually constructed equivalents. Computer-generated 3D visualisations include still images, and 3D animations. While still images offer a static impression, 3D animations provide a dynamic experience of a development proposal. Most recently, some work is also progressing in the use of real-time 3D virtual environments (3DVE). 3DVEs are used to take the viewer on a journey through the space of a design proposal in real-time, for which they are in control of the journey's path. In design pedagogy, the increasing emphasis on 3D visualisation as part of the decision making process in architecture, engineering, and planning is reflected in the inclusion of 3D modelling, animation production, and most recently, 3DVEs in the curriculum. As such, its inclusion in practice and pedagogy has attracted much interest from practitioners and academics alike. To-date, much literature has been published on this area, and whole conferences dedicated to addressing the various issues it raises. However, few publications address what is the core technology that underpins these media types – the projective geometry of linear perspective. Moreover, just how the images generated by 3D visualisations are recognised as real spaces is not well understood. Even less so, is the effect this may have on how the spaces depicted *can* be understood.

The core perspective technology of 3D visualisations has its origins in the perspective formulations of the fifteenth-century Italian Renaissance. Perspective in this era arose as a consequence of a number of mitigating factors, least of which the conditions were such that a mathematically constructed method for organising the optic field could be formulated. Accompanying this formulation of a mathematically constructed optic field of view was a contemporary ideology of the time that emphasised the empirical observation of facts over a prior reliance on religiosity and its inherent faiths to explain natural phenomena. This shift to the objectivisms of a scientific empiricism underpinned and was demonstrated in the perspective view. Today, the same objectivity of the scientific method supports and is reflected in the commonly accepted veracity of the computer-generated perspective view.

The widely accepted scientific objectivity and veracity of the perspective view is an important attribute of contemporary uses of computer-generated perspective. As such, it continues to operate within an ideology that predates it by more than six centuries. Despite this obvious connection with the past, few historians pay much attention to the contemporary use of computer-generated perspective. Similarly, few authors on the use of 3D computer-generated visualisation in design practice and pedagogy pay much attention to the historical origins of the core perspectival technology which underpins it. As the perspective of a real-time 3DVE is the latest and most accessible form of perspective construction (in terms of the perspective controls: field-of-view and centre of projection), it lends itself to a study of the effects and affect of perspective on the perception of its virtual spaces contained.

1.2 Why Investigate the Role of Perspective in 3D Virtual Environments?

While 3D computer-generated imagery has infiltrated nearly every form of design communication in the architect's practice, little is know about how its core perspectival technology is perceived or the effect it has on what or how design can be communicated. The increasing emphasis on 3D design visualisation in the design curriculum heralds a shift away from hand-drawn spatial representations to their computer-generated equivalents. Most recently, the real-time navigation and exploration of shared 3D virtual environments (3DVE) provides a medium for what could be referred to as 'immersive designing'. But what is it that the designers are immersed in, and how does this effect the way they communicate their design ideas, if at all?

The growth in interest in the latest perspective technology – 3DVEs – tends to focus on hardware and software issues, and notions of immersion and presence. The role of perspective in these environments is largely assumed to be neutral and intuitive. What we know is that the emergence of perspective as a communicative medium for spatialising design ideas has had a profound influence on architectural practice since the Renaissance. Indeed, it could be said that the notion of architecture as a distinct practice – distinct from construction, art, and engineering – arose as a consequence of the language of design founded on the perspective and its associated drafting conventions. Today's computer-generated perspective is no less effective in inculcating a sense of control over one's environment by being able to record and manipulate its spatialised representation than the Renaissance perspective did. The real-time 3DVE further extends this notion by allowing one to take control of the very perspective controls. How this affects design communication between collaborating designers is unclear, hence worthy of investigation. With the increasingly common inclusion of computer-aided design, animation, and real-time 3DVEs in contemporary design curriculums (the latter being the focus of this thesis) it is timely to investigate the underlying perspectival technology and its effects on design communication.

1.3 Contribution to the field

The increasing use of computer-generated 3D visualisation in practice and pedagogy is circumstantially framed by the ideology that underpins this technology. As the advent of fifteenth-century perspective heralded a significant shift in thinking and practice which continues to this day, it is important to understand what bearing this has on its contemporary use. 3D computer-generated visualisations are often used as surrogate environments for their physical counterparts (real or imagined). This is supported by its apparent veracity. Just how these environments are perceived, physiologically, and intellectually/culturally, is not well understood. This thesis goes some way towards addressing this issue. It makes its most significant contribution to the field in adopting a constructivist methodology to conduct its investigation. In particular, it provides insights into the social context of how real-time 3D virtual environments are perceived and understood by a group of design students in a pedagogical setting.

1.4 Setting

The case studies described in this thesis are contextualised by their pedagogical setting. The case studies are derived from part of a course on Virtual Technologies within a Digital Media Masters program. The case studies referred to occurred in 2002 and 2003. There were thirteen students and three teachers involved across the two years I na series of pedagogical exercises using 3DVEs and online chat.

1.5 Research Question

As a part-time member of the teaching staff in an architecture faculty at the time of this study, by necessity I tailored my investigative study to the context of how design students navigate and interact with the perspective of 3DVEs. Hence, the primary research question that this thesis sets out to address is:

How do design students navigate and interact with the perspective of a real-time 3DVE?

To investigate the key research question, pedagogical case study exercises were conducted with design students. The literature review that precedes the case studies is used to identify:

- how perspective relates to a 3DVE;
- what the implications based on its historical origins are; and,
- what all this has got to do with architectural representation in 3DVEs.

The key gap found in this literature review was that overall there is little investigation of the core perspectival technology used in 3DVEs and how it is perceived.

The case studies were structured in a manner that addressed the spatial concepts communicated by design students navigating and interacting with 3DVEs in a pedagogical setting. The use of pedagogical exercises encouraged design students to do what design students do – work with objects creating spatial relationships (of course, they do much more than this, but this was the part I was most interested in). The exercises used did this by comparing: the communicating of physical construction with its virtual corollary; plans with navigation of their virtual extrusion; and, shared object manipulation in a 3DCVE with how it can be communicated.

1.6 Methodology in Brief

The methodology employed to investigate the research question used a particularly novel approach. Games were used as a motivation for engaging participants in the exercises. The study included masters students of digital media as participants in a series of educational game-like exercises. The qualitative research conducted sought interpretations of the social situations which arose in these exercises. The exercises were designed to build on each other. The exercises used to form the case studies were part of a teaching program. As the settings were social by nature, a constructivist method was used which let me 'listen' to the participants' reasonings . The participating students learned new ways of framing and cooperating within collaborative virtual design spaces. The game-like exercises took place in both physical and virtual environments. The virtual games environments, including the chat application, were developed specifically for this research.

1.7 Key Outcomes

The literature promotes the notion that perspective is an all-pervasive organising schema for recording and communicating spatial relationships in design. In the form of interactive 3DVEs, it is referred to as providing a more intuitive medium for exploring three-dimensional spaces than more traditional methods. This thesis investigates the efficacies of perspective as a spatial communicative medium by encouraging participants to describe their interactions with the perspective of 3DVEs using online chat. What was found was that while perspective is a strong feature of their communications, many other spatial communicative modes emerged which, in some cases, were more efficient than using perspective cues alone. Key among these was the extensive use of two-dimensional planning terms to communicate three-dimensional forms and design moves.

1.8 Organisation

This thesis includes this introductory chapter, a literature review chapter, followed by a chapter outlining a methodology for conducting a series of case studies, which are described in a case-studies chapter, and subsequently discussed in a discussion chapter. It concludes with a summary and final analysis of what was achieved in this study with some notes on possible future directions.

The literature review chapter is organised into two sections. It introduces the use of 3D computer visualisation in practice and pedagogy and it addresses the issue of the use of 3D visualisation in practice and pedagogy. This last section focuses specifically on the latest iteration of 3D computer-generated perspective – the real-time 3D virtual environment. It emphasises the application of 3DVEs in pedagogy. Most recently this technology is being used to explore and expand upon design collaboration. As such, this section also addresses the social dimension of the use of collaborative real-time 3DVEs in pedagogy. The key outcome from the literature review chapter is that perspective and its incumbent ideology has had, and continues to have, a profound influence on how space can be represented, perceived, and articulated.

Following the literature review chapter, the methodology chapter frames the case-study research using Guba and Lincoln's (1989) constructivism. It discusses my emphasis on social understandings of the media within pedagogical settings. The key emphasis in the methodology chapter is on understanding the social context of the study and how this influences the way spatial concepts could be communicated in the case-study exercises used to collect the raw data for this research.

The chapter that follows the methodology chapter analyses the case study data. It does this by critiquing the chat logs collected from the case-study exercise communications. The key outcome from this process is that the chat logs tend to frame the communications in unexpected ways that lead to a variety of spatial communications rather than those associated with perspective framing alone.

In the next chapter I discuss how the case-studies were used to investigate how students of design navigate and interact with the perspective of various 3DVEs. The outcomes of these discussions are concluded in the final chapter.

The final chapter summarises the implications from the discussion chapter and the gap identified in the literature review chapter. It makes its conclusions in a reflective rather than prescriptive manner in the spirit of the constructivist study undertaken.

2.0 Introduction

This chapter contains a brief review of the literature relating to perspective, concepts of space, and the use of virtual environments in architecture pedagogy. It is organized in a series of discrete sub-sections addressing specific, yet interconnected, issues arising from the main research question. The principle purpose of this literature review is to tease out the theoretical issues surrounding the role of perspective in a 3D virtual environment (3DVE).

The perspective we are most familiar with today arose in the fifteenth-century Italian Renaissance. Throughout recorded history artists have often been the first to adopt new technologies and challenged their assumed normal practices. This is no more evident than in the artisan engineers who took up the geometrised perspectival construction methods of the early Renaissance and refined it until it not only simulates the world around us but creates its own reality. Contained in their images are the detailed recordings of cultural practices and technological advances in the medium itself.

Perspective has had a profound affect on how we represent the world around us and how the world can be viewed. As McLuhan (1997, p369) reminds us, words may bring the universe into existence, but visual media has shaped the "content of people's imagery, ...their behaviour and their views." Today, technological media are staples or natural resources much like cotton or oil with equally profound social organising implications. Any "society whose economy is dependant upon one or two major staples...is going to have some obvious social patterns of organisation as a result" (McLuhan, 1997, p161). According to Gombrich (1972) and McLuhan (1997) the current, almost ubiquitous, use of perspectival technologies to articulate modern Western society – in particular, television – now threatens to erode all other cultures. Coyne (1995), on the other hand, claims, how these technologies present themselves – their interfaces – are less significant and influential than their content or programs. Yet, according to Hiem (1995), it is the artist who has revealed, and continues to reveal, the meaning of our interplay with new technologies; and, for Morse (1998, p181, p196), it is the "artists who foreground 'interaction' and 'life' as metaphors... [making] the links and fissures between the material and the virtual perceptible". "The artist is the only person able to encounter technology with impunity" (McLuhan, 1997, p159).

From these statements, it would seem only the artist can stand outside the prevailing paradigm long enough to provide the necessary critical insights to its effects and affects. In the representation of space through various media, artists themselves create their own representation paradigm only to be dismantled by successive generations of artists and movements – a continuous process by which society is able to re-articulate its contemporary spatial ontology.

There are two sections to this literature review. In the first section I discuss the role of perspective in architectural practice and pedagogy. The second is a short review of conference papers relating directly to the use of 3D virtual environments (3DVEs) in architecture pedagogy. This was included to gauge the awareness in this community of researchers of the role of perspective in 3DVEs. This chapter concludes with a summary overview.

2.1 Perspective in Architecture Practice and Pedagogy

2.1.1 Perspective in Practice

A rising reliance on computer modelling in the last decade as a decision-making tool in architectural visualisation of urban infrastructure sees architects, planners, and developers base their decisions on the agreed instrumentality of perspectival space as, Panofsky's (1991) metaphor for, a 'window on reality'. 3D computer-Aided Design (CAD) systems now automates perspective construction first systematised in the Italian Renaissance.

Prior to the widespread use of 3D CAD, as a 2D drafting tool, CAD systems largely replaced the pre-existing drafting paradigm in the design documentation industry. That the use of 2D CAD largely replicated traditional drafting, a distributed, fragmented process, rather than extend its potential, as Levy (1997, p9) points out, it "reaffirmed traditional values rather than [created] a new paradigm"[1]. In a similar manner, the introduction of 3D solid modelling in the computer-aided design of architecture has tended to perpetuate a pre-existing perspectival paradigm where form continues to be the focus of attention[2]. This adds currency to the culture of pragmatism evident in computing generally (Coyne, 1995). The current wave of accessible computing is pragmatically oriented, displaying an open optimism about technology. It falls within a long tradition of rationalism since the rise of the scientific method.

This pragmatism is manifest in the role 3D CAD plays in governments' urban and regional planning strategies. Local, State, Federal and International issues related to the use and development of land and resources are increasingly being modelled on computers to increase the apparent ease to which the data contained is understood. This data is increasingly taking the form of 3D modelled urban developments. Such models can be used to produce still images, animation, or real-time navigable 3D virtual environments.

While the ability for these 3D computer visualisations to "act as a surrogate for the actual experience of the proposed development" is questioned by Levy (1995, p24), the greater

[1] For Perez-Gomez and Pelletier (1997, pp377-78) the "seductive manipulations of viewpoints and delusions of three-dimensionality, ...[in CAD is] still little more than an efficient 'mechanism of composition'.... [It has] contributed next to nothing toward destructuring the hegemony of panoptic space and proposing a more meaningful and participatory urban space."

[2] Contrary to Perez-Gomez and Pelletier's claims, recently we are seeing some CAD projects extended by parametric programming creating new forms not possible using manual drafting methods alone, such as: Frank Gehry's (1997) non-orthogonal, abstract, free-form *Guggenheim Museum*, Bilbao; Nicholas Grimshaw and Partners' (1993) parametrically-determined, sweeping-arched, *Terminal at Waterloo*, London; Prof. Mark Burry

accessibility and acceptance of mathematically accurate 3D CAD and computer simulation has, nevertheless, led to its increased appearance in many types of planning, architectural, and development dispute resolutions. Such simulations follow mathematically derived rules providing phenomenally "accurate descriptions of proposals and [simulations of] the impacts they might cause" (Decker, 1992, p143). This assumes, however, that the mathematical representation matches our perception. Disputes are often a contest between urban planner's aesthetic notions of creating spaces for human experience and developer's economic rationalisations. It may, instead, be that these representations are used to *form* rather than *in*-form our perceptions.

Visual simulations are increasingly used to clarify projected development outcomes. Images used include hand drawn sketches, photographs, photomontage, and 3D computer modelled renderings among others. The methods used to argue on both sides legally, centre on the documents tendered. These documents describe spaces as a combination of abstract notions of how space is organised. Traditionally this representation of space can take many forms:

- orthogonal projections, such as plans and elevations;
- perspective projections;
- physical, scaled models; and
- sectional analyses.

How these are presented impacts the way we perceive the development in its urban context. Our field of vision (FoV) represents a hemisphere of 180 degrees (Carpenter, 1991) (see figure 1).

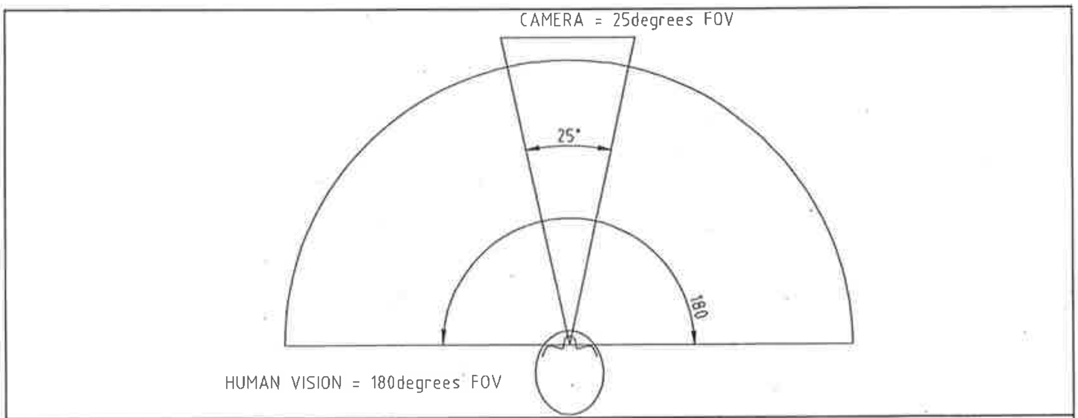

Figure 1. Human field of vision compared to that of a 50mm camera.

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and associates' (1978-2004) CAD-wise reverse engineering of built and unbuilt parts of Antonio Gaudi's *Sagrada Familia*, Barcelona, and so on.

This includes our peripheral vision, but we tend to focus on objects within a smaller 50-degree range (see figure 2a). This means that a simulation based upon a telephoto-lens photograph (see figure 2c) may be too narrow, excluding part of the project's environmental context (Sheppard, 1989). Conversely, a wide-angle lens may make the development appear smaller than it really is (see figure 2d).

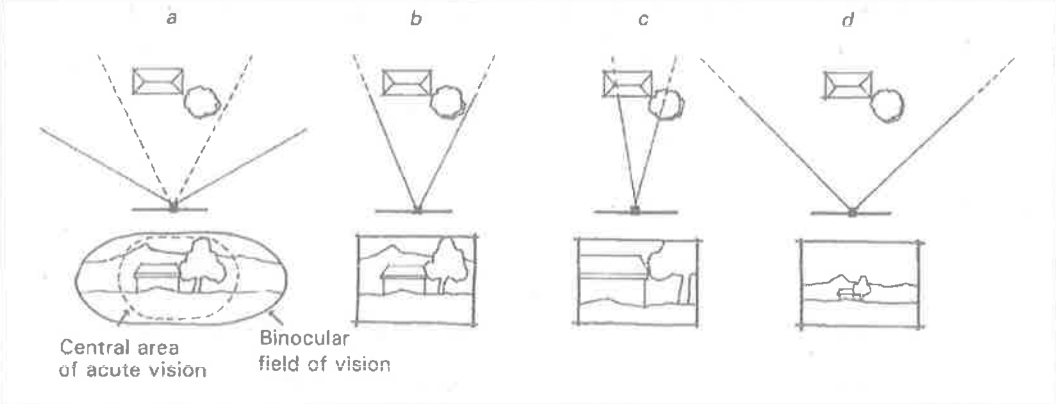

Figure 2. Comparisons of the field-of-view of the eye and camera lenses (Sheppard, 1989, p67). Human eye *(a);* standard camera lens (35 mm camera with 50 mm lens) *(b);* telephoto lens (35 mm camera with 115 mm lens) *(c);* wide-angle lens (35 mm camera with 25 mm lens) *(d).*

The physical scaled model approximates best our experience of space, as it is a scaled substitute for the real space – proposed or existing. A physical scaled model is not, however, always the most accessible, appropriate or convincing method of representing space. A perspective projection, on the other hand, can begin to evoke a sense of 'being there'. But even a perspective projection (with rectilinear lines traced to a finite number of vanishing points) is not a 'true' representation of how we 'see' our visual space.

Architects, planners, and developers using various computer visual simulation techniques to clarify projected development outcomes may impact the way we perceive the development in its urban context. Decker (1992) identified five types of *computer* generated visual simulation:

- Image manipulation at the pixel level;
- Geometric or vector models containing geometric definitions in Cartesian space used to create graphic representations of a proposal in perspective or other;
- Digital montage, a vector model positioned in front of a photograph, oriented and scaled to match perspective and scale-dependent clues in the photograph;
- Animation, or computer walk-through; and
- Mathematically driven or scientific visualisation, usually animated, and numerically controlled.

The problem with most of these is that it cannot be assumed that the layperson has been previously exposed to this mode of viewing. Such mathematically accurate computer modelling, and the use of animated sequences to incorporate the perception of motion through space as an 'as real' visual immersion tool relies on some prior exposure to this type of view that is otherwise an illusion. This comes from a prior-acculturation to viewing perspectival spaces from a very early age through print media, TV, animation, and film. In urban visualisation, computer animations or still visualisations are used to act as surrogates for the proposed development. These computer visualisations use projected geometry to accurately portray three-dimensional 'scenes'. The computer monitor, projector or printed image is in this sense, a modern extension of Panofsky's 'window onto reality' (Elkins, 1994).

A key feature of this 'window onto reality' for urban visualisation is the ability to adopt a particular 'point of view'. In most cases it is the viewpoint that the developer wants to promote – the one that shows the development in its best light. Architects also use this 'point of view' as a common goal in their design narratives. It is used to identify a particular position, either physical or imaginary, in a perspective image. This position can be adopted by others. In planning, conservation plans use the notion of a point of view extensively to make recommendations on how developments in historically sensitive precincts should proceed. The perpendicular view of a facade "from across the street rather than oblique views, [is often] chosen for simplicity and clarity" (EEMCP, 1987) (see figure 3).

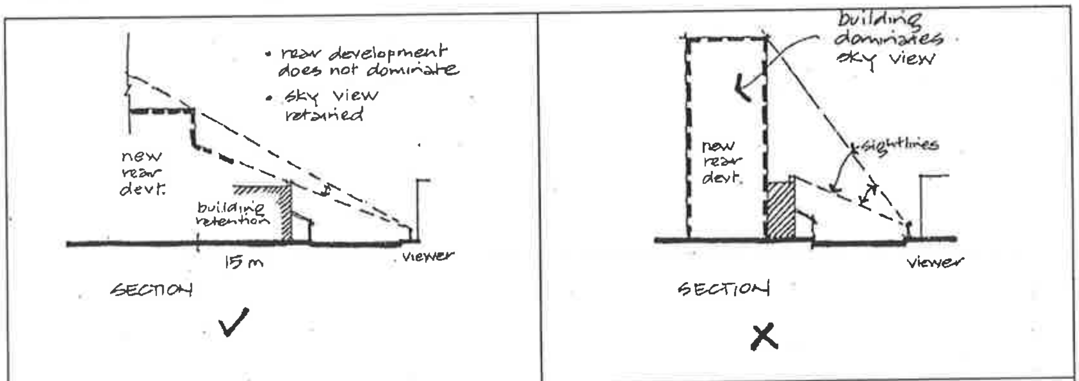

Figure 3. Sectional views used in conservation plans (EEMCP, 1987).

Sectional views are used in conservation plans to show the preferred perpendicular viewing relationship to building facades for determining dominance of rear development in Historically and Culturally significant precincts where historic fabric must be retained.

Projected geometries, in particular representations of perspectival geometries, are considered useful in helping architects, planners, developers, and laypeople alike, to analyse visual space based on the apparent unity perspective applies to each object in a scene related by distance alone. No object can appear larger than any other without occupying its 'correct' place in relation to all other objects. This reliance on perspectival constructions to unify space is used to help contextualise streetscapes. In historically and culturally significant urban precincts perspective is used to assist in the unified identification of what is desirable about a streetscape as a whole.

Rather than a holistic view (a view that includes what is contained in one's peripheral vision), however, a manually drafted, photographic or computer-generated perspective shows only what lies inside its frustum. Moreover, by identifying the centre of projection for an image using vanishing lines, the Frustum effectively focuses our attention on the object at the centre to the demise of its potentially greater context. Objects are perceived as objects *in relation* to each other rather than a greater context. This is what Ivins (1975) identifies as the most important principle of perspective – the relationship between objects and how they are represented. For Latour (1986), the power of this relationship between objects and their representation in perspective is how architects, planners, and developers are able to control space through its geometrisation.

For example, in conservation reports the camera is often cited as indicative of the human viewing experience. But, as discussed, the camera often only captures a small part of our viewing range. Alternatives include the use of 180 degree panoramic projections (Sheppard, 1989), the Virtual Reality CAVE, Head Mounted Displays, and so on. They better incorporate the notion that our spatial *experience* relies also on peripheral vision up to a 180 degree field-of-view, however, while the mechanisms for providing total immersion in a convincing Virtual Reality environment using stereoscopic vision are already available, they also rely on the same orthogonal perspectival algorithms used in most 3D visualisation; their pictorial accuracy is predicated on the same instrumentality of the mathematically manually constructed perspective first formulated in the early Italian Renaissance.

Similarly, panoramic images, generated both by photographic methods and renderings of computer models and their combination are simply large perspective images which rely on a curved viewing plane. Available since the nineteenth-century, such panoramas use a curvilinear perspective technique to generate the 'correct' relationship between viewer and image depicted (see Figure 4).

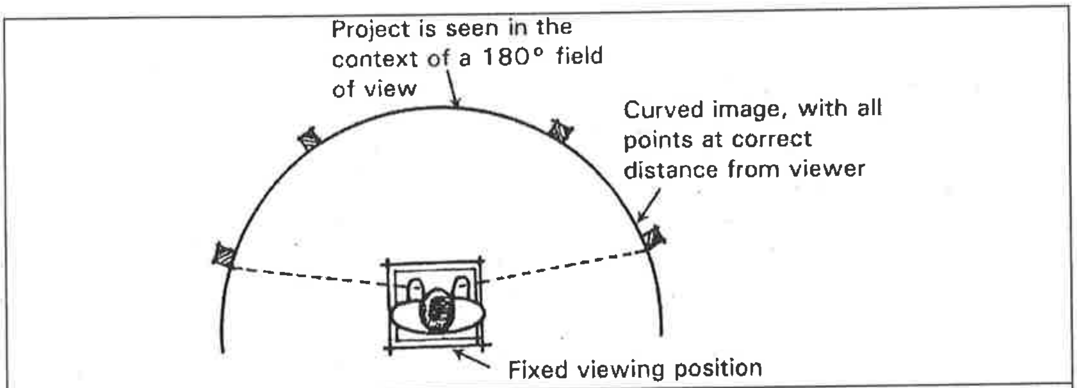

Figure 4. Diorama display for visually correct immersion using multiple vanishing point perspective (Elkins, 1994, p24).

The problem with the use of photography, 3D computer-modelled renderings or manually drafted perspectives for urban development decision-making is that their guidelines typically assume the viewer is placed at the correct location for adopting the centre of projection (Sheppard, 1989; Levy, 1995; Richens, 1999; Decker, 1992; EEMCP, 1987). Apart from the use of a panorama (and even this has its top and bottom cropped), these guidelines assume that what we look at is, 'in-essence', a flattened segment of a sphere in our focal range; that the remainder can be ignored; what falls within the region is what is important[3]. However, our peripheral vision is crucial to our *experience* of space. Attempts to ameliorate this apparent anomaly in the representation of 3D space on a 2D surface include curvilinear perspective, the diorama, and photo montage, among others.

Hockney's (2001) explorations with photomontage and other forms of visual representation, to incorporate the peripheric elements, curvilinear perspective and the diorama go some way towards the recovery of this full 180 degree 'experience of space'. However, while a two-dimensional surface is relied on to signify the space under study, the limitations of its ability to convey the 'experience' of how we 'live space' (move through it, engage with it, describe it, in our everyday lives) remains. Hence, as long as architects, planners, and developers continue to search for new ways to simulate the 'experience' of their designs, perspective will play an important role.

2.1.2 Perspective in Pedagogy

Architects learn their practice of using perspective as a part of a long history of architectural education since the late eighteenth century. The role of perspective representation is an

[3] Today the all pervasive nature of projective geometry and its associated 'window' is not confined to the realm of development visual simulation perspective alone. It is manifest also in the effectiveness of technologies such

integral part of this education. It has been a part of the architect's practice for at least two centuries prior to this. Since the late eighteenth-century, perspective, and later mathematically precise projective geometry, has been taught in design schools (such as the *Ecole Polytechnique*, *Beaux Arts*, *Bauhaus* etc) as the pre-eminent method for mimicking 'nature', or more precisely 'reality' (Blackman, 1998). The use of grids and axes, precise decimal measurements and so on, became the 'obsession' behind all modern design endeavours to follow. Apart from a brief, but enduring, exploration of the infinitudes of axonometry, a practical knowledge in perspective construction became a design aim in itself (Perez-Gomez and Pelletier, 1997).

Perspective construction is not the sole domain of the architect, however. By the mid nineteenth century school-age children were being taught how to draw simple solids in perspective. This can be seen as an important step in the acculturation to perspective as a modern way of 'seeing'. Although, there were many examples of perspective images in illustrated books before this. According to the architecture historians Alberto Perez-Gomez & Louise Pelletier (1997, p304) our (Western) contemporary notions of a Descartian 'objective space' emerged from the descriptive geometry taught in the early design schools. Moreover, "perspective theory was the *invisible hinge* systematising… [the geometrical] projections" being taught and initiated the epistemological model for the acquisition of a scientific truth that made possible the Industrial Revolution, photography and cinematography, panoramas and dioramas, CAD and VR.

It could be said that perspective found its quintessential expression in the mid-nineteenth-century photograph; that the advent of the photograph led to the epistemological dominance of perspective as a way of 'seeing' and representing the world in a scientific manner. This was then later challenged by the extremes of impressionism and pointillism, and in the twentieth-century, by cubism, futurism, and eventually abstract expressionism (Damisch, 1994; Gombrich, 2000; Perez-Gomez and Pelletier, 1997). Marcel Duchamp's early twentieth-century explorations in non-mimetic indexical representation is an example of an alternative reversible geometrical projection through his deliberate use of shadows and anamorphosis. His work highlighted the ambiguity between perspectival illusion and reality (*Tu m'* (1918) comes to mind). It called for a new form of *participation* from the spectator. No longer a passive observer of the all-revealing perspectival realism of the photograph, his work reinvigorated allegories of the medieval ritual. Yet, most recently, the computer, and its

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as radar, infrared imaging, laser sensors, and three-dimensional computer graphics which all depend on the same efficient 3D rendering algorithms, has re-established perspective as the dominant contemporary visual media (Foley et al, 2002; Manovich, 1993; Romanyshyn, 1992).

The emergence of computer-mediated 3D virtual worlds is the latest extension to the growing range of perspectival media forms. These 3D virtual-world cyber-spaces assume for their visual efficacy a theory of perception that is derived of Descartes' (1596 - 1650) simple three-way axial space. The mathematical accuracy of these 3D virtual worlds can be seen as a reification of the eighteenth-century epistemological perspectivism – a visual culture of revealing geometric depth in images of nature leading to the establishment of natural laws, and scientific observation as *the* pre-eminent method for making sense of the world around us (Perez-Gomez and Pelletier, 1997; Kemp, 1990; Kubovy, 1989; Romanyshyn, 1992).

Today's 3D computer graphics can also generate *unnatural*, abstract objects. Typically, in the 3D visualisation of the sciences, arts, and nature studies, we see regular geometric solids floating in a spatial void including metaphoric molecular structures, more grounded architectural renderings, topographical 'landscapes' formed by meshes or voxels in GIS, and complex matrices of columns and rows of variable data in data visualisation, to name only a few (Tufte, 1997; Dodge and Kitchin, 2001). All of these rely on the user's prior-acculturation to this type of viewing to be able to interpret the three-dimensional perspectival spaces depicted. This use of perspective as a method for viewing a three-dimensional space has dominated Western visual culture since the Renaissance (Panofsky, 1991). However, few proponents of architectural visualisation, who adopt a core 3D component as their main graphic user interface, question the premise by which they assume that their 3D interfaces are universally understood.

2.1.3 Section Summary

In this section I described how architects use a variety of methods for representing their design ideas (sketches, elevations, plans, sections, details, and perspectives), and where perspective is still a prominent method for communicating three-dimensional relationships on a two-dimensional surface. However, our natural vision includes a 180-degree hemisphere and this is difficult to simulate in traditional formats, including the panorama. Despite this and other anomalies, the photograph, computer-simulated 3D scenes, or their combination are often still promoted as surrogates of what we see and/or relate to in our urban environments (such as in

logistics of perception (Manovich, 1993).

conservation reports, and planning and development proposals). The embedded notion of a 'correct' viewpoint in these visualisations supports a particular ideology. Central to the ideology, the perspective image tends to dominate because of its combination of a perceived accuracy and scientific underpinning ontology. Perspective representation has been a large part of the architect's formal education since the eighteenth-century. It introduced the notion of a perspectivist epistemological ontology based on the verisimilitudes of perspective as scientific fact to the everyday practice of the architect.

This section argues that there appears to be a largely unchallenged acceptance of the veracity of perspectival imagery in the everyday activities of the architect, planner, or developer. I suggest that there is an implied ideological position adopted where perspective is used for dispute resolution, simulation, and visualisation. This might be better understood if the historical origins of perspective were better known. In turn, this may lead to the investigating of alternative visualisation schemas. This is addressed in subsequent work published by this author.

2.2 Perspective in 3DVEs

2.2.1 The Role of Perspective in 3D Virtual Environments

At the beginning of this chapter I started out by discussing the 3D visualisation of urban space and how architects, planners, and developers increasingly rely on these visualisations in their decision making. But perspective is not just a method for representing three-dimensional space on a two-dimensional surface, it arose at a time when making sense of the world was being actively pursued in a rigorous and scientific manner. Philosophical, religious, and spiritual reasonings for existence and the universe were being replaced by methodical scientific experimentation and factual explanations. Perspective was instrumental in establishing not only a method for scientific recording of observable events but the notion of a 'correct' scientifically verifiable 'point of view'. This profoundly affected the thinking of subsequent philosophers, scientists, and artisans alike. The combined scientific veracity of perspective and artists techniques for representing the world in an increasingly 'realistic' manner provides the cues for their 3D computer graphic algorithmic corollaries. Just how influential perspective has been on our notions of how abstract space is construed in the latest manifestation of an abstract space – cyberspace. Cyberspace, and more importantly the 3D virtual world – how it exists, how we interact with it, and how it is that it has evolved out of other cyberspaces (the telephone, cinema, the internet, and so on) alludes to the notion of the 3D virtual environment[4] (3DVE) and its role in architecture practice and pedagogy. As such, this final section links back to the first bringing together the role of perspective with 3DVEs in architecture pedagogy and research which prepares the way for its use in practice by architects, planners, and developers.

The underlying message that emerges from the literature review up to this point is that perspective has had a profound affect on our ability to describe, conceptualise, and think about the world around us. The arguments addressed so far suggest perspective has affected our very sense of being in the universe. As such, its ideology should figure strongly in any discussions of perception of 3DVEs in architecture visualisation and pedagogy. The remainder of tis section is dedicated to identifying this in the collection of conference papers reviewed.

[4] The term 3DVE is more comprehensive than 3DVW. Although, 3DVWs are described in the previous section as including a myriad of forms, in the context of architectural practice and pedagogy the term 3DVE is more appropriate – it allows for the discussion of the sorts of object manipulations in virtual environments that designers might be more familiar with in their physical forms.

In a review of the literature on the historical origins of perspective it is worth noting that few of the historians cited pay much attention to the implications for the contemporary extension of the perspective paradigm by 3D virtual environments (3DVEs) (see subsequent work published by this author for that review). A brief review of the leading architectural CAD conference literature (eCAADe, CAADFutures, ACADIA, CAADRIA, and so on) was conducted here to address this apparent gap. The review focuses on the pedagogical application of 3DVEs. It reveals that, despite my prediction that perspective ideology should figure prominently in this discussion the contemporary extension of the perspective paradigm by 3DVEs *is* addressed in the literature, yet few authors pay much attention to the historical origins of perspective and its implications for 3DVEs. Nor does either genre address directly the role theories of visual perception plays in understanding how such perspectival technologies are interpreted in the first instance. Hence, the purpose of this review must be to bridge the historical origins of perspective – its theoretical underpinnings within the broader art and architecture theory, and notions of visual perception as it relates to the notion of perspective as physiological fact or convention (see subsequent work published by this author) – with the implications for this in contemporary 3DVEs. Not a comprehensive review – it only includes those papers which refer to the pedagogical use of 3DVEs, as this is the basis of the case studies that form the second major part of this thesis.

Of the papers reviewed only those of Yang (2001) and Hoon et al, (2003) explicitly refer to the historiographical work of Perez-Gomez and Pelletier (1997), Gombrich (2000), Damisch (1994), and Hockney (2001). However, neither paper delves into the theoretical issues espoused by these authors in any detail. Yang simply makes the point that while traditional, manually drafted, perspectives followed the lead of the Masters in the Quattrocento until recently, now digital modelling makes it that much easier to achieve the same results. Similarly, Hoon et al use Hockney as an entry point to bridge history with the present but without any critical discussion or theoretical positioning.

If we now turn our attention to theories of visual perception we find a similar lack of reference to recognised primary authors in the field (such as Wertheimer, Kohler, Koffka, Helmholtz, Marr, and Gibson, among others). Although Tweed (2001) does provide an interesting proposal for incorporating Gibson's (1979) theories of ecological optics into practical architectural education, it does not involve 3DVEs, hence has not been included here; and, Donath et al (1999, p457) refer to proprioceptive cues "caused by movement in real space and interaction with the designed [3D] environment", but only as a cursory issue never really addressing the effects this might have on the *comprehension* of 3D spaces. We need to look outside the usual architectural groupings to find any serious attempts to address 3DVE visualisation and its relationship to accepted theories of visual perception. For example, Slater et al (1996) discuss Gibson (1979) in their investigation of notions of 'presence' in a 3DVE. However, Gibson is quickly abandoned in favour of a more cognitive approach. Indeed, the cognitive approach was typical of most of the material reviewed.

Despite the lack of an underpinning theory of visual perception, or perhaps because of it, the most often used term when referring to comprehension of 3DVEs is that it is 'intuitive'. The problem with describing comprehension of a 3DVE as intuitive is that it assumes that it can be taken for granted as truthful, factual, or real; that no reasoning is involved; and, that it is second nature. Nevertheless, whether this is the case or not is difficult to determine. It is my contention that the reason comprehension of a 3DVE *appears* to be second nature is because we have become so acculturated to its norms through cinema, TV, photography, and so on; that we do not consciously question our comprehension of it. This is what the case studies later in this thesis address.

Contextualised within the notion of intuitive navigation of 3DVEs, the review also reveals little discussion of the inherent problem of moving from 3D sketching to 3D virtual modelling. This suggests it is an unproblematic transition. Rather than referring to primary theories of visual perception, Kevin Lynch's (1960) *The Image of the City* is a popular work cited for his notions of spatial perception. For example, Charitos and Bourdakis (2000, p167) refer to Lynch in their claims that mental pictures of the world are "used to interpret information and to guide action and legibility" in 3DVEs. Later, I will come back to the influence Lynch's work had on discussions of spatial perception in the literature.

Despite the inference that Lynch's 'pictures' would be in perspective the word 'perspective' is never used to describe the representation of 3DVEs, other than as a rhetoric term to describe the user's point-of-view. Many (such as Huang, 2003; Alvarado et al, 2000; Strehlke and Engeli, 2001) try to develop their own theories of spatial perception without ever mentioning the visual perception theorists or the correlation between perception of a perspectively represented world and the real world (as if they were the same; that perspective comprehension is visually automatic). Alvarado et al (2000) carried out a comparison of spatial perception between different forms of architectural representation. They exposed students to a virtual model of a building using either a Head-Mounted Display (HMD), PC monitor, or to the actual building (see figure 5).

Figure 5. Alvarado et al's (2000, p153) physical-virtual comparative study.

They claim their results show no difference between the various media and its physical form. The biggest difference was in understanding the spatial organisation of the building and its surrounds: lowest for the HMD virtual and highest for the actual visit. "Apparently, the immateriality of digital environments weakens the spatial organisation more than properties of elements" (Alvarado et al, 2000, p153). Strehlke and Engeli's (2001) version of visual perception in immersive environments implies learning to swim. They refer to motion as essential for understanding depth in a digital space. This parallels Gibson's (1979) ecological view, although he was not cited directly. Both cite immersion as a key factor in the 'intuitiveness' of their 3DVEs.

Immersion in a 3DVE was a key factor in most of the studies of perception reviewed. Common terms used to describe immersion included: 'convincing', 'inside', 'immediate', 'transparent', 'being there', 'through the window', 'immersive', and so on. These same terms could be applied to the viewing of a traditional perspective. This suggests that, although no direct reference is made to a traditional perspectival viewing, if the illusion is 'real enough' then immersion should be intuitive.

Returning to intuitive, it is worth noting that this has been a popular term to describe the visual perception of perspective since the time of Descartes. Nevertheless, and despite not referring to perspective as the underlying technology of a 3DVE, many of the case-study exercises uncovered in this review were created to test the direct applicability for design students to improve their spatial comprehension using more intuitive immersive 3DVEs rather than hand-drawn perspective. For example, in Roberts' (1999, p442) *Virtual Site Planning*, he outlines a common claim whereby a 3D realtime interactive VE system is developed to help design students better understand three dimensional design issues (see figure 6).

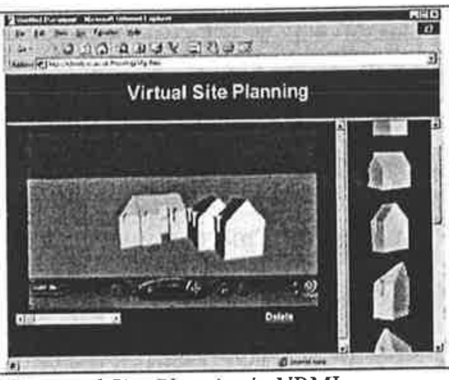

Figure 6. Roberts' (1999, p446) *Virtual Site Planning* in VRML.

These systems are developed to address perceived "difficulties encountered by students in using [traditional 3D] CAD which…[is otherwise] seen as *insufficiently intuitive* to allow effective use" (Roberts, 1999, p442, *my italics*). For Achten et al, (1999, p170, *my italics*) such systems are "a tool for *intuitive*, interactive and realistic evaluation of (non-)existing three-dimensional environments." In practice, Klercker (1998) claims that the 3D visualisation these systems provide similarly helps overcome the illiteracy of the public to standard architectural drawings, including the perspective; that they can experience a 'whole' environment – not just a flattened image in a drawing; and, that this brings the project 'alive.' According to Stappers et al (2001, p126), "often [those] less trained in reading construction drawings,… benefit from experiencing the design in a 1:1 immersive [3D] simulation." Achten et al (1999, p174) are more emphatic: they claim that, "in all cases, representing… abstract sets of data in a three dimensional immersive environment is… helpful for understanding them better." Petric and Maver (2001, p177, *my italics*) argue 3DVEs provide for "a very immediate and real impression of being '*in*' …[*a*] *building*…. [And for the designer,] the *immediacy* and verisimilitude of the experience… [contributes] to the design decision-making process." Moreover, in a later report, they claim "immersive virtual reality systems allow the user… *to 'step through' the window* [a reference to Panofsky's window?] and… enter the virtual world" (Petric and Lindsay, 2003, p838, *my italics*). Knight and Brown (2003) claim their interface to a 3D virtual world was effectively *transparent*. They claim 'presence' in an immersive 3D VE is like '*being there*.' On the other hand, Vasquez de Velasco et al (2001, p330, *my italics*) claim that design students are losing the "ability to produce [the] quick *convincing* perspective sketches that are so crucial in desk critiques, in schematics, and in the design process" due to the proliferation of these 3DVEs. Despite, and including, Vasquez de Velasco et al's claims, none of these authors question the perceptual mechanisms of their 'intuitive' 3DVEs. They assume, uncritically, that the core perspectival media is essentially transparent and universally accessible, hence deserves no special attention. Indeed, there is no attempt to equate the perspectival nature of the 3DVEs discussed with their manually drafted origins. Even Vasquez de Velasco et al make assumptions about the unproblematic transference of the manual method by its computer-generated corollary.

This is because, as Roberts (1999, p443) advocates, the 'fully immersive' systems (such as the HMD and CAVE) are supposedly a natural, "more effective educational delivery mechanism than… the unnatural interface of mouse and keyboard." He suggests we have become so reliant on 3D visualisation as a tool that we no longer need to question its universal accessibility. I claim this has only come about via an acculturation to perspectival media. Strojan and Mullins (2000) go further, arguing that immersive 3DVEs eliminate the separation between machine and user. This is contradicted by Roberts (1999, p445) in a later statement. Roberts' assumptions about how easy it is to work in his 'intuitive' 3D environments are not so straightforward: "In reality, moving objects within a 3D space proved to be more complex, as it is difficult to judge in which plane objects are being moved." James Gibson (1979) would argue that this is because one has to abstract the motion through Cartesian planes of action from one's lived space. Despite Roberts' admissions, it is still a common conclusion of many authors that the problem lies with the tool's interface not the concept; that there is a pressing "need to investigate the development of a [more] simple tool that could assist students in their understanding of the three dimensional built environment" (Roberts, 1999, p445). Many then go on to describe the features of just such a utopian system. Whereas, I see the problem is in the concept of manipulating objects in an arbitrary three-axes spatial system in the first instance. Particularly when one has to *select* an axis to move along (such as in a CAD system). In other words, abstract Cartesian environments are not the same as the lived space that Lefebvre describes, hence *not intuitive.*

Concurrent with claims that people can more easily "understand the consequences of a design when… confronted with a VR model" (Achten et al, 1999, p173) are justifications for development of such systems as educational and supporting "the understanding of VR in the [commercial] design process" (Achten et al, 1999, p172). Klercker (1998) and Stappers et al (2001) discuss the CAVE as providing for just such an intuitive, fully immersive environment, for the uninitiated. They subscribe to the notion that representation of abstract sets of data in three-dimensional immersive environments is helpful in understanding them better. However, this does not always hold. For example, in terms of multi-dimensional information visualisation it is difficult to imagine how a three-dimensionalisation of Minard's graphic of Napoleon's 1812 march into Russia would provide more information than the six dimensions of information that Minard covers (distance, numbers of soldiers, direction, location, time, and temperature) (see figure 7).

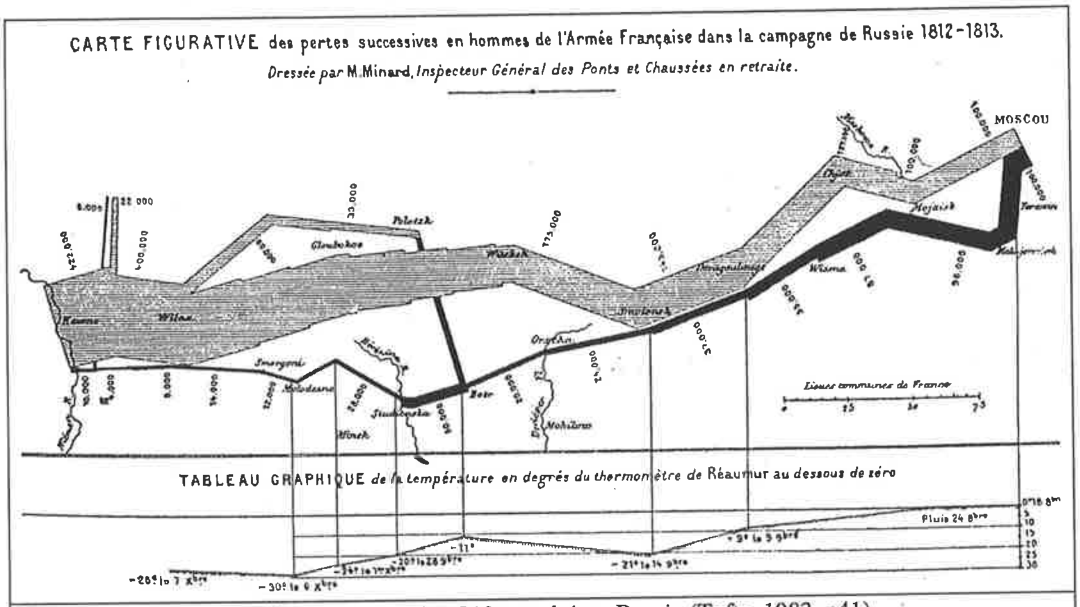

Figure 7. Minard's graphic of Napoleon's 1812 march into Russia (Tufte, 1983, p41).

On the contrary, apart from producing a series of seductive images (what Tufte (1997) calls a visual confection) much would be obscured (by hills and no direct graphical correlation between Minard's dimensions in any single view) (see figure 8).

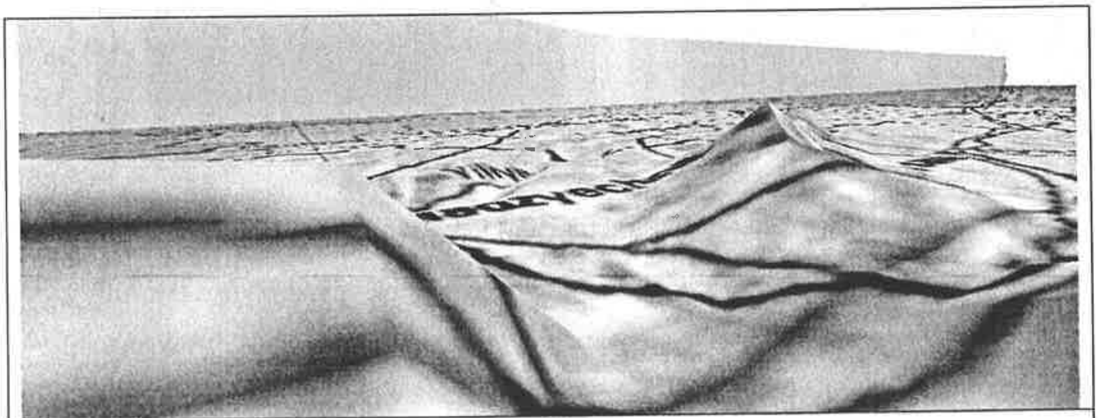

Figure 8. Three-dimensionalisation of Minard's graphic.

Moreover, claims, such as Achten et al's (1999, p174), that, as "architectural design is spatial by nature,…[then] Virtual Reality should… be the natural medium for developing it," negate the different *types* of information traditional perspective drawings, plans, elevations and so on can provide (as espoused by Gombrich and Edgerton). Although Achten et al may not see traditional representation media being completely supplanted by 3D modelling, the problem is one of emphasis. Nevertheless, their claims that the uninitiated are able to understand a 3D impression better than drawings makes sense if we consider they would be more exposed to such imagery through films, TV, the press and so on, than architectural drawings. This also lends weight to the notion that drawings following conventions, hence, not so easy to decipher by the layperson. Indeed, Stappers et al (2001) suggests that a 3D walkthrough could be even more easily accessible by the layperson if it followed the narrative structure of commercial movies or the games genre. Thus furthering the underlying premise of my thesis that a prior-acculturation to contemporary forms of perspectival media is necessary before it can be fully comprehended.

Despite this, or perhaps because of their deep affinity with the media, Strehlke and Engeli (2001) claim that Architects want to work in immersive 3D environments. For Strehlke and Engeli (2001), designing is a function of the representation of perception, and that this is always personal and subjective. In the case of collaborative environments, their solution to the dilemma of how to present this with 3DVEs is to provide another abstract 3D data-space visualisation which shows the collaborators' connected design decisions (see figure 9).

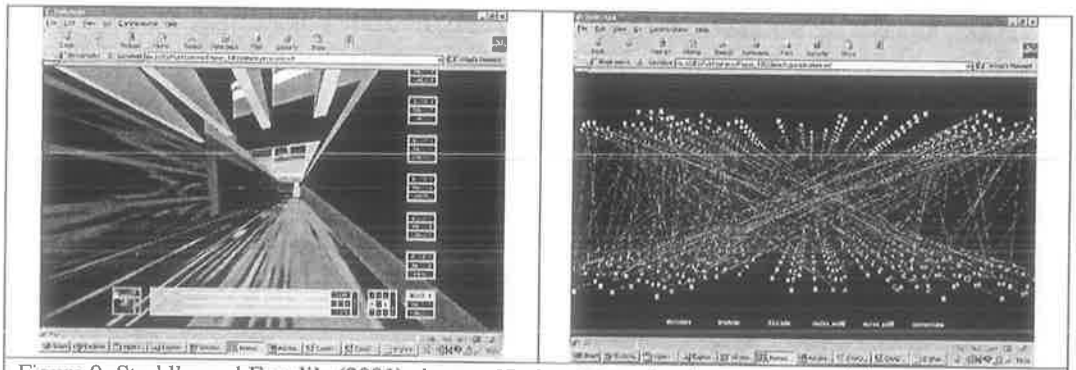

Figure 9. Strehlke and Engeli's (2001) abstract 3D data space showing connected design decisions.

They argue it provides a substitute cultural (design) narrative. Paths in the depicted 3D data-space somehow allows 'the author to guide the reader's perception of space.' But this contradicts their earlier claim that design perception is personal and subjective hence not able to be guided by another's. Moreover if an *author-reader* relationship must be established then this further suggests that the interface is not intuitive. It must be read and thus comprehended, and open to interpretation. Like poetry, novels, paintings, drawings and so on, which also provide for immersive environments, they must also be read.

While Strehlke and Engeli claim their database visualisation stimulates design perception, Suwa et al (1998, p457) make the same claim about drawing. "Sketches serve as a physical setting in which design thoughts are constructed on the fly." Sketches provide for perceptual stimulation which leads to fully visualised imaginations. This is something nearly all the visual perception theorists would agree on. Indeed, Bridges and Charitos (1997) see 3DVEs as an extension of such traditional architectural representation. They describe 3DVEs in terms of the traditional representational model:

- precedent;
- metaphor;
- 'containing elements'; and,
- 'signs and symbols'.

Like Achten et al (1999), Bridges and Charitos (1997, CDrom) also claim that "virtual reality may be… the ultimate medium for producing representations of architectural designs." However, their further claim that it is the "only technology capable of simulating the experience of being and moving within a designed environment" tends to discount the imaginations designers envision before committing their designs to a representation medium, whether on paper, or digitally. According to Flanagan (2001, p214), this emphasis on visually mediated digital technology in architectural practice now tends to be at the "expense of traditional symbolic, schematic, design processes." Vasquez de Velasco et al (2001), in their search for a connection between traditional methods and computer graphics, also identify this trend and recommend using sketching *in conjunction* with 3D CAD to promote students' ability to sketch. They use quick preliminary sketching of a 3D model on the screen to help students predict views in the model before 'going there'. For Vasquez de Velasco et al (2001, p330), while students are "increasingly facile with [3D] digital media, they seem to be losing ground in the use of traditional drawing skills." In the past, they claim, students' practice of analytical drawing techniques, including 'convincing perspectives', helped them visualise and represent design ideas – to exercise their "ability to imagine, and to draw what… [they] imagine" (Vasquez de Velasco et al, 2001, p331). They seem to be arguing that drawing may be a more intuitive mechanism for representing the imagination than current 3D modelling practices. This contradicts what most authors are reporting. Indeed, according to Proctor (2001, p198), "in architectural culture, drawing has provided the process through which visual awareness is developed, validated, and shared with others." He does not see drawing going away. His method appears to agree with Vasquez de Velasco et al's (2001), complimentarily combined, drawing *and* CAD. Proctor sees time spent working with 3D modelling, particularly with wire-frame modelling, as having the propensity for *improving* freehand drawing skills. Schnabel and Kvan (2001, p476), on the other hand, voice the more common claim that 3DVEs provide the "immediate feedback to… users, which is not possible within CAD or traditional [(manual drawing/drafting)] design media."

This brings us back to Strehlke and Engeli's (2001, p173) statement that "to be able to design three-dimensional spaces in an immersed way has become a desire among architects working with CAD tools." Do they mean: *without* CAD tools architects cannot design in an immersed way; or, only architects working with CAD tools *want* to design in an immersed way? To answer this we first need to address in more detail the notion of immersion. Immersion in a 3D VE has come to refer to the experience of 'being in' it. But the notion of immersion as an experience has been around for a long time, such as: Wertheim's (1999) discussion on Dante's *Divine Comedy*; Lefebvre's (1991) discussion on theatrical space; and, Levy's (1995) surrogate urban simulation experience. All tend to refer to narratological immersion rather than visual immersion *per se*. Part of the promotion of immersion and its specific connection to 3DVEs stems from notions of 'presence.' Knight and Brown's (2003) reference to presence as like actually 'being there', as distinct from 'being *in* there', is covered in the work of Slater et al (1996). Slater et al (1996, p165) define immersion as an "objective description of what any particular [3DVE] system provides. Presence[, on the other hand,] is a state of consciousness…consistent with behaviours that would…[occur] in everyday reality in similar circumstances."[5] Hence, immersion and presence in a 3DVE refers not to the narratological construct of the scenes depicted and the viewer's journey through them but rather a visually mediated experience contingent on the dissolution of proprioceptive stimulus by convincing (realistic, perspectival), graphics alone.

To understand this requires some knowledge of the different theories of visual perception (see for example those cited in see subsequent work published by this author). From Slater et al (1996) and others' work (Petric and Maver, 2001; Oxman and Streich, 2001; Proctor, 2001), we see there is an emerging trend towards studying the implications for visual perception in 3DVEs. However, while all these authors address the field in different ways, none contribute to a greater understanding of the visual perception of the root technology – perspective. Instead, almost all cite secondary authors of visual perception, such as Eastman (1975), Arnheim (1974), and Laseau (1980) who subscribe to the cognitive model. The problem with the cognitive model, in this instance, is that it uses drawings to describe drawings as like seeing. For example, Proctor (2001, p193) argues that, "understanding the innate functions of the eye and mind ([in a Gestaltist-like manner]) is a precursor to formulating how the eyes and

[5] A problem with Slater et al's definitions is that they rely on a random selection of people to test their immersion theories, but they are selected from within a group of students, university colleagues, and so on. As such these people are most likely to have had a prior knowledge, indeed anticipation, of the technology to be tested. This means they are already subject to a *positive* prior impression of the experience. We are left wondering if presence would be experienced by those who enter such experiments with a *negative* prior impression of the technology.

visual skills of an architecture student may be trained"; and, Oxman and Streich (2001) see learning in design as the acquisition of the cognitive ability to represent design knowledge, manipulate its representations, and, regarding the content of design learning, design learning is in the processes and media which contribute to it. Quite apart from the question of just how one could 'train the eyes of an architecture student', the cognitive model is still not how we 'see'. We experience the aesthetics of an image in a cathartic manner which does not occur on the retina. Unlike the 'designing with 3DVEs' advocates, the teaching of hand-drawn perspective does not pretend or explicate the notion that the results emulate or replicate how we actually see the world – it is merely seen as a tool with an illustrative purpose. Despite this, there may be merit in following Proctor's Gestalt model for the moment – at least as a means for making sense of architectural schematics. He claims, schematic abstractions are a bridge between perception and thinking. According to Laseau (1980) "sketching and drawing is a principle means for looking. Drawing is the act of abstracting from perception but its effectiveness is a function of skill" (Proctor on Laseau, 1980; 2001, p197). What he is saying here is that when we draw we are compelled to analyse what we 'see,' hence 'look' at, and that this may reveal the cognitive process in action. In this manner the cognitive model may be useful.

In another example, Proctor (2001) uses digital processing of images to reveal what he calls 'the abstractions of perception.' Following Arnheim's (1974) cognitive theory of visual perception, whereby objects are sensed as colour-filled outlines, he suggests the digital manipulation of images can help reveal the perceptual abstractions that we manually construe in our architectural conventions. In other words, when we draw, isolating edges and so on, a software filter (such as the *Find Edges* filter in Photoshop) can do this automatically to a scanned or digital photo. The filter simulates the artistic convention which gives rise to the effect. What this reveals, however, is not a proof for Arnheim's theory but identification of an architectural drawing convention in manual drawing. This is where the cognitive model obfuscates what is instead a chosen convention.

Clearly few of these authors address the notion of the visual perception of the core perspectival technologies they employ. While they try to make sense of the various transitions between traditional architectural representation and the construction of 3DVEs, they do so in order to promote the perceived efficacies of 3DVE over tradition. The danger may be that in the process there is a loss of spatial understanding. What drawings offer that a 3DVE does not

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In other words, part of the experience of a profound presence surely relies on a positive engagement with the (yet) is an agreed symbolic language common among designers. This is despite arguments to the contrary suggesting 3DVEs offer a more transparent, intuitive entry to the architect's imagination by the uninitiated. This is most pronounced in the increasingly important role graphic communication plays in the architect's everyday collaborative practices. An exciting development in architectural design collaboration is the employment of 3D collaborative virtual environments (3DCVEs). Although in its infancy, this form of design collaboration is finding increasing use in design pedagogy as a method for exploring design collaboration in general.

2.2.2 Collaborative Virtual Environments

There has been an exponential growth in interest in the role of design collaboration – an essential component of architectural practice[6]. What design collaboration provides is the social exchange of ideas. It is in the exchange of ideas that collaborators must articulate their spatial concepts. They do this verbally, with gestures, textually, and graphically. Early studies investigated design collaboration which involved file transfers, meetings, telephony, text messaging via fax and email. With the advent of 3DVEs, studies of design collaboration now includes this medium. Computer-generated 3D visualisation has been a commercially viable method for architectural representation since the late 80's yet the use of 3D multi-user VE's is still in its infancy. As such, most research in the use of 3D collaborative virtual environments (3DCVEs) is conducted between research institutions which include student participants and incorporates a pedagogical component. What the 3DCVE provides is the opportunity for a shared design vision in a real-time interactive perspectival environment.

The more prominent, and in some cases ongoing, remote digital design collaborations include:

- Kumamato-Kyoto-MIT Collaboration Project (Mitchell et al, 1998);
- Virtual Design Studios (a generic term used by Russell (2000), Schnabel and Kvan (2001), Matsumoto et al (2000), Proctor (2000), Maher and Simmoff (1999), Wojtowicz and Butelski (1998; 1999), Strojan and Mullins (2000), and others);
- Atelier (Kolarevic et al, 1998);
- E-Talier (Russell and Forgber, 2000);
- Space Pen (Jung et al, 2001);

technology!

[6] The complexity of a building is such that collaboration is an essential element of any architectural project. It involves a larger number of disciplines, operators, and professionals than other industrial processes. Buildings are complex and require numerous separate components which must be integrated into a whole which is also unique from building to building.

- Virtual Campus (Maher, 1999);
- VRAD (Donath et al, 1999);
- CoCoMa (Colajanni et al, 1999); and,
- 3DCollab (Wyeld (2005; 2006), Prasolova-Førland (2006)).

Their 3DCVEs incorporate multimedia visualisation for: 3D conceptualisation, design synthesis, design presentation, desktop publishing, animation, internet and hypermedia authoring.

From a review of these 3DCVEs it was concluded that most authors state the pedagogical benefits of 3D digital design collaboration as the same for students and clients alike. This is used as a justification for its inclusion in the curriculum. To prepare pre-professional students for practice, collaboration skills are essential. But more so is their ability to visualise in 3D. The benefits to the client are twofold: as discussed earlier, there is a common presumption among the authors reviewed that clients, uninitiated to architectural representation conventions, gain more of an insight into the design process or product via its 3D visualisation; and, once in practice, students trained in the use and execution of 3D visualisation tools are better able to make this facility available to their clients.

Early design collaborations (described by Mitchell et al, 1998; Wojtowicz and Butelski, 1998, 1999; and Maher, 1999) were, however, less interested in visualisation *per se* and more on supporting the socialising that underpins collaboration. Over time, however, as multi-user 3DVEs have been increasingly introduced, socialisation has since been de-emphasised. It has been replaced instead with discussions about software and hardware performance. This is something Strojan and Mullins (2000) found in a similar review in 2000[7]. For example, Kolarevic et al (1998), suggest a common design language is generated by the 3D modelling program used (in Kolarevic et al's case it was *Sculptor*); that the software 'supports the direct composition of spaces'. Their focus on the common design project, rather than the group of people collaborating, suggests designing which is detached from the designer. In such cases,

[7] Their "review of VDS in recent eCAADe and ACADIA papers indicates that… most emphasis [is placed] on the communication technology employed. Research is often most concerned with setting up the environment which facilitates the studio. The difficulties in simulating real-time design learning situations in VDS can be compared to earlier years of CAAD research in design education, where most emphasis was placed on the medium itself" (Strojan and Mullins, 2000, p51). My review expands on this to include other conferences and journals but it essentially reports similar findings. "Most evaluations of the effectiveness of technology focus on the technology itself – its costs, its complexity, and its feasibility in particular circumstances, rather than examining the effectiveness of technology as a tool for learning" (Strojan and Mullins, 2000, p52). Despite this claim, they too focus on the shortcomings of the technology: "is the purpose of VDS only the asynchronous interchange of work prepared in separate locations or is …design education furthered? If [so] …how will the innate weakness in communicating… be overcome?" (Strojan and Mullins, 2000, p52).

we frequently see a spatial database used, (similar to that described by Strehlke and Engeli (2001) which shows the linking of decisions between collaborating partners), and a digital pinup board, (similar to that described by Wojtowicz (1994)). Such systems tend to objectify the collaborative efforts, rather than facilitate idiosyncratic behaviour (Kolarevic et al, 1998). If such a goal is explicit from the outset then it is not surprising that, as Donath et al (1999, p457) notes, "synchronous exchanges and communication with other participants… [is not central to a project's] success." Visual verisimilitude has taken the place of social interaction. Strojan and Mullins (2000) claim this is now typical of remote collaboration exercises.

Revisiting the notion of social interaction, and in the context of these remote collaboration exercises the earlier discussion of the spatial concepts of virtual immersion and presence by Slater and others, the 3DCVE has been extended by Clark and Maher's (2001) notions of a virtual 'place'. Clark and Maher (2001) demonstrate the potential of real-time design collaboration within a multi-user 3DCVE in an educational setting. Their challenge was to offer an environment that creates a sense of place where designing can occur. Couched in terms of the 'situatedness' of design, a term coined by Gero (1998; 2003) on Bartlett (1932) and Dewey (1957), the virtual place in their 3DVEs provides for a design 'context'[8]. However, while the context of the virtual design place is discussed, the context of the 3D interface and its concomitant perspectival ideology is not. Following Jonassen's (1994) "constructivism[, which] asserts that we learn through a continual process of building, interpreting and modifying our own representations of reality based upon our experiences with reality" (Clark and Maher on Jonassen, 1994; 2001, p193), their design 'place' is one kind of reality. But where is this reality situated within the 'reality' of the 3D scenes depicted and the apparatus which is necessary to support it? Like the constructed reality of the 'place' Clark and Maher would like us to accept, another reality is constructed in the viewing of, and interacting with, the incumbent perspectival technologies. Within the positivist paradigm that tends to pervade information technology in general, Clark and Maher's (2001, p193) claim that "the Virtual world is an ideal three dimensional environment to develop a constructivist virtual learning environment where students are provided with a sense of place and context, and are able to explore, build and share their learning experience," there is a reliance on a wholesale cultural acceptance of perspectival technologies as neutral media.

As a socio-spatial concept, 'place' is difficult to define. There are many notions of space – those of Lefebvre, Lacan, Romanyshyn, Gombrich, Leibniz, Gibson, Mitchell, Heim,

[8] Gero's (1998; 2003) situatedness refers to the contextual environment which supports the design process.

Damisch, and Perez-Gomez and Pelletier, among others. But place is not just space, it is a socially mediated space. Design collaboration occurs in socially mediated spaces. Hence, Clark and Maher's paper raises some important issues for spatial concepts in general:

- The notion of a visually mediated 'place' (on a computer monitor, in a 3DVE);
- The efficacy of social connections via 3D virtual technologies; and,
- The role of perspective in these.

If we consider that virtual immersion, presence, and place, are all terms which have their physical-world corollaries then place is possibly the most difficult to define – virtual or physical. More particularly, a visually mediated place is difficult to define. Here we come back to the most-cited secondary author on spatial perception – Kevin Lynch (1960). According to Lynch (1960):

- Place is where social interaction occurs. (This can be between individuals or simply the reflections of an individual);
- In reflecting, place is remembered through images;
- Connected to and forming part of place is the legibility of the environment surrounding it and the paths that lead up to it;
- Place is not a space but an experience; and,
- Place forms part of a collective memory or discourse of a community.

All these concepts Lynch describes – social interaction, reflective imagery, paths, experience, and discourse – are supported by collaborative 3DVE's. Hence, it follows that a sense of 'place' *could* occur in a 3DCVE. For Oxman (2001, p357), the underlying technology for 3DVEs, the web, has begun to "provide a level and intimacy of interaction between distributed design collaborators that is unique". However, Cuff (1991, p248) (cited in Mitchell, 1998, p92) reminds us "the most overarching observation is that the [*architectural*] production of places is a social process." Here Cuff is referring not only to the physical production of spaces in the urban context but the importance of a place where design collaboration can occur – to take place. Similarly, the early design collaboration projects of Mitchell, Wojtowicz, and Maher all valorised the importance of social interaction in their discussions on design collaboration. The question remains then, whether the technology really supports the production of places, or whether the filtering of social interaction through the reduced view of a 3DCVE prevents it. According to most of the papers reviewed, few authors regard current computer-supported collaborative workplace (CSCW) technology as able to facilitate the level of intimacy required to overcome the obvious lack of human contact. This is despite Oxman's earlier comments.

2.2.3 The Social Dimension in Remote Collaboration

But why is the technology available not able to facilitate the intimate social contact required for meaningful collaboration to occur when compared to traditional physical contact? The answer may be found in the emphasis by CSCW researchers on the technological capability over socialisation of the various systems used. For example, while early remote collaboration project studios (Wojtowicz et al, 1995; Maher et al, 1995) attempted to "emulate actions and interactions traditionally found in place-based studio work,... frustrations and innovations occurred when in-compatibilities were found between the existing collaborative technologies and" traditional methods (Mitchell et al, 1998, p86). Unlike Strehlke and Engeli (2001) and Kolarevic et al's (1998) objectification of designers' actions by their matrix-like data-base visualisation, early remote collaboration efforts considered the "intellectual power of collaborative design communities... resided in the *interactions* between participants rather than in the display of individual actions" (Mitchell et al, 1998, p87, *my italics*). An important feature of these systems was the incorporation of face-to-face communication. Although it was often later abandoned by collaborators in favour of simple file transfer and so on (this can be attributed to the increased social familiarity over time between the various participants facilitated by the initial personalised content). Gavin (2000) used face-to-face to initiate her collaboration exercises but says her students quickly abandon these personalising features and focused on the project at hand. Russell (2001) makes a similar observation in his collaboration exercises claiming students rarely utilised the facilities available to them for cross-pollination (see figure 10).

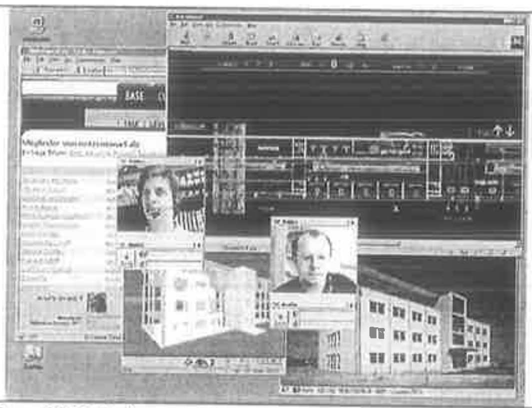

Figure 10. Russell's (2001, p233) design collaboration environment or virtual design studio.

The few exchanges that did occur could not be considered collaboration in the fullest sense. Students tended to work on the information alone; that students were never 'with' another student to discuss the work. The email, newsgroups, and chat sessions were "not enough to sustain any kind of spontaneous discussion. This was in contrast to the physical design studio where spontaneous discussions are the norm and indeed, could be considered as essential to the design studio experience" (Russell, 2001, p234). Drawing on Cuff's (1991) ethnography of an architectural practice, Mitchell et al's (1998) earlier, socially-oriented collaboration project, identified the corresponding prevailing practices and rituals in the system they had set up. These were "loaded with symbolic meanings that expressed the value-laden culture of the office.... [Although] power struggles and design roles were more difficult to concretely decipher" (Mitchell et al, 1998, p89). This is what Johnson (2001) talks about when he discusses the focussed and unfocussed actives described by Heath and Luff (1996)[9]. The importance of face-to-face interaction in collaboration is in the way it unintentionally conveys important content and context information contributing to group cohesiveness and effectiveness. Despite the apparent need for more 'personalised contact', later attempts have abandoned face-to-face contact (Clark and Maher, 2001) or found it to be largely redundant (Gavin, 2000). Whether this is due to the perceived efficacy of the introduction of 'intuitive' real-time 3DVEs as distinct from asynchronous file transfer, or simply the emphasis on the technology over real collaborative outcomes is not clear. Mitchell et al (1998, p89) noted this early on, arguing that with the increasing "use of computers for design work and to build solid distributed design communities with telecommunication technologies, ...[we have] unexpectedly lost, as a side effect, much of the camaraderie and expertise sharing among designers working in a common physical studio environment." It seems, simply improving the technology in an attempt to better represent the design process only serves to highlight the lack of social connectedness. This is something Romanyshyn (1992) identified as a desperate attempt to connect using technology, only to be further removed from the goals of social cohesion. Indeed, despite Oxman's (2001, p358, *my italics*) earlier comments about the unique intimacy the Web affords, she, nevertheless, laments the fact that such technologies do not appear to "support the creative *thinking* in design collaboration, the way designers do." In other words, while it may provide the potential for a social environment it may not support the way collaborating designers think. Perhaps this only occurs in the passive transactions that Johnson identified earlier.

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[9] Heath and Luff (1996) provide an example of this in their description of two railway workers and the sorts of information which passes passively between them when they are able to overhear each other's telephone conversations.

It is these passive transactions[10], that Johnson (2001) claims much of current design education ignores, and Schon (1983) argues is critical to the socialisation process, that the technology is too coarse to support. Hence, in an era which is increasingly reliant on online education models it is important to understand what aspects of the education process might be compromised by such technologies.

What none of the authors' work reviewed in this section addressed directly was how the participants in their exercises perceived or interpreted the perspectival spaces they encountered. More particularly, none of the remote collaboration design studios analysed the communications between participants for instances of the constructed spatial realities their interaction with the various immersive technologies must invoke. Here I detect what I consider to be a gap in the literature and studies of 3DCVEs. This and my review of the historical origins of perspective and its implications for 3DVEs formed the investigative framework for the pedagogical case studies that follow.

2.2.4 Section Summary

In this section I discussed how few authors on the use of 3DVEs in architecture pedagogy pay much attention to the historical origins of the perspectival technologies and the inherent ideologies that underpin them. Most historians, on the other hand, pay little attention to the implications for the contemporary extension of the perspective paradigm by 3DVEs. Indeed, neither the historians nor the 3DVE authors pay much attention to the theoretical underpinnings to the visual perception of perspective.

Most 3DVE authors describe the participants' experiences of their experiments in navigation and interaction not as a spatial mentally-constructed reality but as intuitive. The 3DVEs are used to assist students in making better sense of the spaces depicted in a plan, or to overcome the illiteracy of the public about the normal conventions of architectural drawings. This relies on notions of presence and immersion in the perspective of a 3DVE.

The recent exponential growth in the role of design collaboration provides an opportunity to investigate notions of the role of perspective in design communication practices in a 3DCVE.

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[10] Other passive communications that contribute to the collaboration experience include: acoustic, visual, and olfactory (such as the brewing of coffee signalling a break etc where serendipitous conversations can contribute to the overall project success).

However, this is not addressed in the literature. I address this apparent gap in my pedagogical case studies that follow this chapter.

2.3 Chapter Summary

This chapter discussed the role of perspective in architecture visualisation and pedagogy, concluded with a section on other researcher's attempts to investigate the role of the latest perspective technology – the 3D virtual environment – in architecture pedagogy. From this, the net thrust of this literature review can be determined as: while a key component of architectural expression is contained in the preliminary documentation that comes before construction commences, and central to this is the 'design vision', and while various media lend themselves to representing this vision, the linear perspective remains a most popular form. Moreover, the historical origins of perspective suggest that, embedded within this illustrative style is a particular ideology – the epistemological ontology of a scientific method which has increasingly pervaded our very way of existence in the West since the fifteenth century. Most recently, with the advent of 3D computer graphics (3DCGs), the laborious manual construction of architectural design has largely been automated. The computer-generated perspective image, nevertheless, shares the same (if not greater) ideological impact of its Renaissance inspired origins. The key protagonists identified in this review who promote the notion that perspective not only represents a new way of seeing the world but has fundamentally changed the way we are able to relate to the world around us include Lefebvre, Panofsky, Wartofsky (see subsequent work published by this author), Romanyshyn, Perez-Gomez and Pelletier, Wertheim, and Hockney. While others reviewed are less emphatic in their reverence for the affectiveness of perspective to effect a world-view, those listed above hold that perspective has had a profound affect.

Like Panofsky and Wartofsky, Lefebvre sees the rise of perspective as symbolic of the society's culture it appeared in. More than this, he sees Alberti's grid-wise division of the scopic field leading to the commodification of space in general – the dividing up of, and thus production of, space. Romanyshyn and Wertheim see perspective as central to the incessant march of technological progress since the Renaissance and its incumbent spiritual and social distancing effect. Perez-Gomez and Pelletier identify perspective as the hinge that articulates architectural design and documentation practice as we know it today and its constructive realm. Hockney's view is more prosaic, he refers to the artificial construction of perspective by mechanical means leading to profound illustrative realisms.

The sum of these views, and in the absence of an equally profound counterpoint, is that perspective should feature highly in any investigation of perception of the latest iteration of perspective technology (and the media I chose to use in my investigations) – 3DVEs – an emerging media in architectural design pedagogy. As such, the last section was provided as an insight to see if this was the case with other researchers in this field. Interestingly, what it shows instead is that while the historians may have largely ignored the role of perspective in 3DVEs the architecture visualists who use 3DVEs have also largely ignored the historical origins of the core perspectival technology. And both genres only give passing reference to theories of visual perception of a perspective. This provided me with the impetus to pursue this line of investigation further. In the next chapters I will describe the methodology I used, the case studies investigated, a discussion about the outcomes of those case studies, and finally some conclusions.

3.0 Introduction

This chapter discusses the methodology developed for investigating the research question. The key goals of the research adopted was to engage participants in a series of meaningful, interesting, new, and novel educational exercises recording and interpreting their reflections and spatial conceptualisations. This chapter also discusses the research arena in light of its adaptation of both quantitative and qualitative research methods. A particularly novel approach in this research was the use of games as a motivation for engaging participants in the exercises. Also discussed here is: the design and implementation of the virtual games environments used, and the justification for using VRML as the chosen scripting language to implement these games; the justification for using online chat as both a communicative mechanism between participants and to record that communication for later interpretation; and, the cinterfaces developed for the multi-user environments used.

3.1 Research Arena

The research study described in this thesis included undergraduate students of architecture and masters students of digital media as participants in a series of educational exercises. The student-participants were engaged in meaningful, interesting, tasks where they could 'reflect in action' (in Schon's (1983) terms) in a group setting. As both an educator and researcher the opportunity arose to embed these exercises in the curriculum as a part of my own teaching development (always with the students' knowledge). In this way the researcher could observe design students doing what students do – explore new media. My goals were always to both learn from my teaching experiences and assist the students, on whom my research also relied, to learn through the research process. Although the research and learning goals were different they were not opposed to each other. Indeed, they complimented and in some ways directed each other. Where the teaching curriculum called for a particular area to be addressed this also set the parameters for how a particular research question could be addressed. This, combined with the playful approach to each exercise, appealed to participant-students such that, although they were aware/informed that their actions would be recorded, it was not seen as a disincentive to engage in the task. On the contrary, where undergraduate students might tend to express disdain at being 'used' to 'test' a new curriculum direction, the nature of the game-oriented exercises and their close alignment with an already established teaching program meant these Masters students tended to actively seek a greater role in directing possible strategies for advanced outcomes. This is something Biggs (1999) refers to as students actively taking control of their own learning. Indeed, Biggs (1999) identifies that student participation in the self-learning process is needed to accommodate the increasingly diverse needs of students, suggesting some scope for serious consideration for research-oriented learning within future teaching programs.

While these exercises were always intended to be couched in terms of a qualitative case-study report, they could be viewed as supporting a quasi-experimental methodology. Indeed, this was attempted in an earlier draft of this thesis. However, the risk in any quasi-experimental study is the difficulty in justifying the result in either a qualitative *or* quantitative manner. Hence, under the premise that this research is primarily quantitatively oriented, the quasi-experimental approach was abandoned in favour of a more naturalistic method. This incorporates a case study reporting style which better reflects its social outcomes. Although some quantitative elements remain.

The exercises also offered an opportunity to reflect on and evaluate my own teaching effectiveness. The use of a qualitative rather than quantitative methodology in this research both supported the research needs as well as providing a vehicle for evaluation of teaching and learning practice in general. The qualitative research conducted sought interpretations of social situations. Until recently, using computers in design as a social situation has attracted little research on its qualitative outcomes.

The results of general school-conducted student surveys showed that in all cases the use of these research exercises within the teaching curriculum was well received. This tends to indicate that there is a place for this type of combined education-research in the curriculum. This does, however, hinge on the efficacy of its delivery and on the deliverer as discussed in more detail later.

3.2 Identifying a Suitable Methodological Approach

To identify a suitable methodological approach to my own study I researched how others had approached similar tasks. From the many I uncovered the three outlined here influenced my approach, within a pedagogical context, in the following ways: the exercises I used needed to:

- engage my participants in meaningful, interesting tasks;
- motivate my participants to 'reflect in action'; and,
- encourage them to communicate – engage them in group rather than as individuals – in a virtual design studio setting.

3.2.1 Example Methodologies

While much has been written about the emerging field of collaborative digital designing (Mitchell et al, 1998; Wojtowicz, 1995; Maher, 1995) clearly defined research methodologies are rare. Of particular interest and relevance to this research were the methodologies outlined by Richens and Trinder's (1999) use of *Quake* to establish a forum for publicly exploring design alternatives for a new building on campus at Cambridge; Suwa et al's (1998) digitally recorded investigation into reflecting on the role of sketching in design practice following Schon's (1983) 'reflection in practice'; and, Gero and Maher's (1996) discussion of the cognition of design at the *Sydney Key Centre for Design Computing*. None of their methods, however, offered a template for the research outlined in this thesis. Nevertheless, their experiences influenced and provided a frame for establishing the rules for my own methodology.

In Richens and Trinder's (1999) *Exploiting the Internet to Improve Collaboration between Users and Design Team* they describe a multi-user collaborative online design space using an open internet design forum and how this assisted the design development of a new building in the Cambridge university grounds. They note that "thorough-going 3D design was quite unusual in architectural" practices of the time (Richens & Trinder, 1999, p3). The design brief, used as a basis for their exercise, required the architect to be fully conversant with 3D modelling and all its associated logical extensions. One outcome of their research revealed how "design tools…[are] personal to an architect" (Richens & Trinder, 1999, p3). Hence, a preconceived methodology was not something easily dictated to the client by the researchers.

Richens and Trinder's aim was to investigate the efficacy of an online Virtual World to facilitate design decisions between client, architect, and user. In order to facilitate the easy access and retrieval of dynamic information, Richens & Trinder's (1999, p5) first intention was

> *to build a web server to provide on-line access to a comprehensive library of design information, linked to a bulletin board for gathering feedback. The second…to monitor the effectiveness of such a system, and study how it is used in practice to improve communication between client and design team.*

A version of *Quake* was used to display a walkthrough. The provision of a 3D walkthrough generated in 3D Studio using a VRML viewer was discussed as a later option. The web site proved as problematic as it was helpful in conveying information. For example, a strategy was needed for dealing with the issue of private-public release. It needed to combat questions of confidentiality and control by the architect. Hence, the particular circumstances surrounding the use of a public website determined the parameters of what could be evaluated about it. Richens & Trinder (1999, p15) suggest, "the overall usefulness of the site is best judged by the quality of the discussion it developed."

Their approach helped establish a motive for engaging in a three-dimensional virtual world by design practitioners. Here I could see a vehicle for investigating notions of how the perspectival media used influenced design decisions. I have used a similar format, substituting practitioners for students of design (due also to my overarching interests in pedagogy). In both my use of students and their use of practitioners, the provision of a realistic project assisted in participants applying themselves to the tasks in an appropriately committed manner leading to more meaningful outcomes than if an artificial survey or ad hoc demonstration were used instead. Also, Richens and Trinder's reference to judgements on the 'quality of discussions' solicited by their visualisation tool hinted at a sociologically-oriented qualitative approach that appealed to my desire to work in a naturalistic setting. Just how Richens and Trinder analysed these discussions was not made clear, however.

The research topic for Suwa et al (1998), in their paper *Macroscopic Analysis of Design Processes Based on a Scheme for Coding Designers' Cognitive Actions*, is the role of freehand sketches in early conceptual design processes. Using Schon and Wiggins' (1992) research, their hypothesis was that freehand sketches are "the essential medium for designers to make reflective conversation with their own ideas" (Suwa et al, 1998, p1). Moreover, they argued that sketches play two important roles in design processes: *re-interpretation* and *unexpected discovery*:

- Re-interpretation involving "...associating depictions in sketches with abstract concepts, functional issues, or meanings"; and
- Unexpected discovery "externalising a set of ideas on paper forcing spatial organisation and specificity...which in turn...may lead to new discoveries in an unexpected way...driving exploration of new design ideas...– a key to creative problem solving" (Suwa et al, 1998, p2).

Suwa et al's aim was to investigate the importance of sketches in the initial design process by assessing participants' reflections on their ability to assist in problem solving. Suwa et al divided previous protocol analysis methods into two categories: process oriented and content oriented. Process oriented analysis focused on a general taxonomy of problem-solving. Content oriented analysis focused on cognitive interaction with the designer's own sketches. They proposed a coding scheme of observing video/audio protocols to gain a generalised categorisation of design motions:

> *The task given to participants…was to design an art museum in a given site. Participants were provided with a list of functions to be arranged in the site, the diagram of the site with its dimension and orientation specified. They worked on the task for 45 minutes while sketching on sheets of tracing paper. Their sketching activities were videotaped. After the design task, they remembered and reported what they had been thinking of or attending to in drawing each stroke of their sketches. They were asked to report while watching the videotape of their sketching activities, as the videotape was expected to serve as visual cues for remembering* (Suwa et al, 1998, p3).

While I was inspired to consider the videotaping of students drawing, I also felt it was an unnecessary complication in what I was trying to investigate – observing students interacting with perspectival media. Instead, simply completing a drawing task, and then analysing the results, fitted within my requirements of investigating students interacting with perspectival media in its most basic form – the sketch. It was not so much their actions that I was interested in as their reasons for producing a particular outcome. This did not require video-recording – an informal discussion sufficed (all students were interviewed individually and as part of a subgroup at some stage in the study).

Nevertheless, like Richens and Trinder, Suwa et al's provision of a convincing *motive* and *reason* for engaging in the exercise – remote collaboration and the art museum project – gave participants a purpose in the exercise, hence, they were unaware of its otherwise artificial concoction. Suwa et al's method requires participants to record their thoughts after their actions in an attempt to concretise the design process. Cues derived from watching a video tape whilst they record their actions and Richens and Trinder's suggestion to analyse recorded discussions provided the impetus for me to include the use of an online chat facility in my research methodology for my participants to similarly record and reflect on the process of designing in a virtual environment.

The aim of Gero and Maher's Virtual Design Studio (VDS) was to investigate the potential for design collaboration in a distributed virtual environment both as an adjunct to existing practices (in this sense it is similar to Richens and Trinder's aims) and as a new paradigm in its own right. Gero and Maher's (1996) paper, *Current CAAD Research at the Key Centre of Design Computing*, University of Sydney, outlines the Key Centre's attempts to establish a better understanding of the design process. This is done using a computational analysis of an architect's design motions. Amongst their goals was to "...aid human designers through the introduction of novel methods which have no human counterpart" (Gero and Maher, 1996, p1). They used a computational approach to consider the "...role and application of computer technology in understanding design...[and a] cognitive approach considering formal models of human designers" (Gero and Maher, 1996, p1). Their computational approach attempts to model some aspect of the design process in assisting the process. The two areas covered are automating and aiding the design process. Typically projects included some aspect of both. Four paradigms of investigation were proposed: case-based reasoning (CBR), evolutionary theory, a virtual design studio (VDS), and, design fixation. Of interest to this research is the use of a virtual design studio and engaging multiple participants within it.

The Virtual Design Studio (VDS) is essentially an electronically distributed workspace. It is entered via the internet and/or video conferencing. It provides the potential for synchronous access to design spaces using multiuser software in 3D real-time. The VDS allows for multiple participants with multiple views both literally and intellectually. In general, Gero and Maher's approach to design cognition, using computer database retrieval and three-dimensional Virtual World visualisation, provides for an environment which begins to resemble the modern digital designer's suite of tools. Their use of a 3DVE was particularly interesting. Here was a method whereby I could investigate the role of perspective in design while my participants were immersed in the tool itself. While their research centred on the designer's cognition in terms of design moves (in Schon's (1983) sense), this was not directed at investigation of cognition of the perspectival media itself. This thesis goes some way towards addressing this gap. Although it does not address cognition directly.

What I gleaned most pertinently from these example projects include, from:

- Richens and Trinder, the engaging of participants in meaningful, interesting tasks;
- Suwa et al, the provision of a means and motivation for 'reflection in action'; and,
- Gero and Maher, the notion of engaging multiple, rather than single, participants through a Virtual Design Studio[11].

[11] It is worth noting, however, that the type of motivation that the research participants (ie students in this case) was viewed differently to Suwa et al's method. For example, in Suwa et al's case, participants felt that they were contributing to an actual process within the profession, whereas for the students it was framed as a game. With

3.3 The Research Approach

The three components identified from the example project methodologies (engaging participants in meaningful, interesting tasks; reflecting in action; and, multi-user scenarios) were combined in a pedagogy-research research arena that tended to emphasise the social dimensions these activities encourage. Hence, a qualitative evaluation of case-based research was deemed best suited to achieve the desired outcomes of this research. Nevertheless, the various components necessary to implement a case-based evaluative procedure still include elements of both quantitative and qualitative research. Quantitative analysis was applied where, at times I observed from afar and descriptive surveys were conducted. Qualitative analysis applied where I: conducted in-depth interviews; participated in what I was observing, such as their involvement in online chat conversations; used case studies; and, conducted ethnographic social investigations of participants' rules and behaviour as they saw it.

3.3.1 Participant Observation

A methodological framework which accepted myself as a participant observer (Hammersley, 1983) was adopted to legitimate my role and presence in the exercises. The ethnographic methodology used here was in the tradition of an interpretive ethnography, rules inherently encompassing meaning (Douglas, 1973). All of the exercises both contained rules and allowed for rule making by participants. As researcher-observer and researcher-participant, I derived meanings from the subsequent narratives generated. I incorporated both wide (macro-scale) focus and narrow (micro-scale) focus in the summation of results. At the micro-scale I was concerned with single events, self-reflection, and transformative outcomes. At the macro-scale I was concerned with overall outcomes such as how the results compared with predicted outcomes based on the analysis of the literature.

3.3.2 Case Study Design

At the core of the research were the design, implementation, and review of a series of exercises which sought to throw light on the research question. The exercises were designed to build on each other. They were devised sequentially – later exercises being formed on areas that appeared interesting and important from the outcomes of earlier exercises. All of this was circumstantially couched in terms of the pedagogical requirements of the teaching program. How these exercises were constructed reflects my methodology (see section: How the Constructivist Case Studies were Conducted, and Tools Used in the Case Studies).

assessment attached to it, they still approached the tasks seriously, however, I would expect their responses to be different when compared to how they might approach the task if they were trying to please an actual client.

3.4 To Pursue a Positivist or Constructivist Study?

Before I could formulate a consistent methodology for my investigation I needed first to identify the context of the technology under investigating. Hence, I can state that this thesis takes as core to its central argument that, as the rules for constructing a geometric perspective arose at around the same time as there was a general shift to the proposition-test-observe-record-theory or law process we identify as the scientific method today, and; that geometric/mathematical perspective construction is similarly 'testable', then perspective construction and the scientific method are inextricably linked. Moreover, what is of interest to this thesis is not to test whether perspective construction and the scientific method are inextricably linked but to investigate this within the socio-cultural and historical conditions which gave rise to it. Hence, if we accept the premise that the *scientifically* constructed reality of perspective and its incumbent ideologies are caught in a self-referential cycle or tautology[12], then it is more appropriate to analyse its affect on design students, and their interactions with perspectival media by investigating the constructed realities *this* 'throws up' (in Winograd and Flores (1988) on Gadamers' (1975) terms of the unpredictability of any social investigation).

3.4.1 Positivism or Constructivism?

As noted at the beginning of Chapter 2, much of contemporary evaluation of the use of computing in design practice is pragmatically oriented (Coyne, 1995). It displays an open optimism about the technology which falls within a long tradition of positivist rationalism since the rise of the scientific method. As such, evaluating the use of computing technology in educational settings presents a problem. Learning outcomes are often guided more by their socio-cultural and historical contexts than the positivist rigid pre-formulated and objective framework that a scientific investigation can capture. Hence, I deemed it appropriate to evaluate educational outcomes by investigating the *context* of my participants, and the content of what they are engaged in, in specific real-world activities. More particularly, it was the constructed realities that they expressed in their chats, interviews, and so on that encouraged me to adopt the constructivist methodology among the various qualitative methods available. This was further influenced by the fact that all cases are pedagogically framed. Hence, Guba

[12] Within the positivist paradigm is the notion that scientific methods are neutral, value-free, objective observations of natural phenomena. These claims rest on the performance of *independent* empirical tests which, in turn, rests on the existence of a separate observational and theoretical language, the results of which are 'facts' that determine the truth or falsity of a proposition. This is otherwise a tautological, or circular, argument (Guba and Lincoln, 1989).

and Lincoln's (1989) pedagogically-oriented constructivist investigative methodology was employed.

Guba and Lincoln's (1989) constructivist approach does not preclude a positivistic scientific methodology. Rather, it sees the latter as merely one construction among many for perceiving and making sense of the world around us. It seeks instead to provide a pluralistic overview of the transformative outcomes of the participants' engagement with their learning. This engagement, by necessity, *includes* a pragmatic analysis of the technology used.

3.4.2 The Problem with Scientific Positivism

Initially I explored a positivist position but found that I naturally gravitated to what the participants of my studies were saying and doing rather than what any numerical results could provide alone. For example, as a proof-of-concept exercise I reconstructed Edgerton's test for the universality of perspective construction by (his college students and) my undergraduate design students (see subsequent work published by this author). I constructed a statistical analysis which included data such as gender, ethnicity, and wealth. It compared the results on the ability for students to rank their own sketches of a box from most to least realistic. The statistical analysis was largely inconclusive whereas the comments and justifications the students gave for their ranking order provided greater insight into what they thought was 'realistic' and where they had gained the ability to make this judgement.

An example of how this greater insight sheds new and different light on the topic, that a traditional statistical analysis does not, occurred when one student said the reason he had drawn the box the way he had was not because that was how he had imagined it in his mind's-eye but because what he imagined was that which he had been taught how to draw a box realistically. This sort of personal information would normally be discarded in a positivist study. On the other hand, I felt it added weight to my argument about the influence of acculturation to perspective and so chose this methodological approach henceforth to tease out other issues surrounding how design students read, interpret, and imagine perspectival spaces.

From this, we can say that the problem with scientific positivism is that it uses a methodology which strips what is being investigated of its context. It does this in pursuit of generalisable results. In other words, it is too dependent on formal quantitative measurements to pick up on the other issues that may otherwise influence outcomes. It is a very rigid and robust methodology. In the scientific paradigm:

> *"It follows that what cannot be measured cannot be real.... [Science promises] to provide us with information about the way things really are...[claiming] certain authority [or truth] that is hard to resist.... [Hence,] anything being evaluated that is supported by positivistic (scientific) evaluation is [usually] locked in as the right thing to do"* (Guba and Lincoln, 1989, p37).

It is this strict adherence to its particular methodology, however, that often prevents the very scientific discovery sought from occurring. For example, "in late 1967, Jocelyn Bell, a research student at Cambridge radio astronomy laboratories, noted the persistent appearance of a strange section of [what she called] 'scruff' on the recorded output from apparatus designed to produce a sky survey of quasars" (Latour and Woolgar, 1986, p32). It was her natural inquisitiveness and not a strict adherence to procedures (which would have meant she should ignore this anomaly because it was not what she was looking for) that ultimately led to the discovery of quasars.

More particularly, much scientific inquiry occurs in these laboratory-like settings, and while such settings may improve their internal validity, in terms of external validity, results from one laboratory can only be reasonably generalised to another laboratory. Thus, within the positivist paradigm internal and external validity are transferable (Guba and Lincoln, 1989). For the constructivist, on the other hand, the various shifts in scientific thinking are not so much a progression in thought but simply multiple ways of interpreting natural phenomena – equally valid within their own socio-cultural framework. Hence, acts of scientific perception may simply be constituted by the prevailing social forces of the time (Latour and Woolgar, 1986).

Much of scientific and mathematical investigation relies on inductive logic. But the problem with induction is that it can lead to obvious anomalies. For example, we can infer universal statements from singular statements but it is not logical to presume that having seen any number of white swans, that *all* swans are white. We see this in Edgerton's assumed universality of perspective as a visual method because his college students could 'construct a recognisable picture in less than an hour' (see subsequent work published by this author). It only needs one student who is not able to complete the test to negate the logic in Edgerton's argument. Indeed, in my reconstruction of this test, I found it was not that it was a natural ability, but how the students had been taught how to draw perspective. Nevertheless, in turn, this does not mean that anyone who has been taught how to draw in perspective can draw a recognisable picture, and so on, *ad infinitum*. According to Popper (1992), the problems of inductive logic are insurmountable. Far from being strictly valid, inductive inference can only ever achieve a *degree* of reliability or of probability. Hence, scientific statements can only provide degrees of probability within the upper and lower limits of truth and falsity, invoking an endless stream of justifications.

While it is possible to establish a tradition which is held together with strict rules, such as scientific endeavour, do scientists ever remain within the boundaries of this tradition? Feyerabend (1997) suggests it is in the breaking of the boundaries that discovery occurs. Far from providing objective analysis of the world around us, he appears to agree with Romanyshyn's (1992) 'perspective as thought grammar' (see subsequent work published by this author) and Tufte's (1997) 'scientific illustration both informing and is informed by the illustrator' on the point that scientific language is not merely an instrument for *describing* events (facts, states of affair)[13], but that it also *shapes* events; that its "'grammar' contains a cosmology, a comprehensive view of the world, of society, of the situation of man which influences thought, behaviour, perception" (Feyerabend, 1997, p164).

Kuhn (1996) describes this shaping of thought as a paradigm shift. For example, when our perceptions about the world around us are altered by profound new ways of thinking such as: where Lavoisier saw oxygen, Priestly had seen dephlogisticated air; light as wave or light as particle; where it was once believed that that the reason why water rises in a pump was because nature abhors a vacuum, this was dispelled by the work of Galileo's vacuum pump; or when Giotto introduced a new depth to his paintings, and so on, we may experience a paradigm shift. Whether the way we see the world changes when there is a paradigm shift (as described by Talbot, Romanyshyn, and Edgerton) – that we live in a different world – is open to debate, however. Nevertheless, familiar things *are* seen in unfamiliar ways. This shift in perception is succinctly demonstrated in the duck-rabbit Gestalt illusion (see figure 11). A familiar thing can be seen in two distinctly unfamiliar ways. For example, in the Edgerton test, when the students realised that what they imagined was not pure but how they had been taught to imagine, at first they felt angry, cheated, that their imagination was being manipulated by their education. It is this flip-flopping (like the duck-rabbit-duck Gestalt shift) that distinguishes a paradigm change. Both views are valid. For example, Tycho Brahe's precise observations in the sixteenth century were not used to reject earlier data, although theories attached to this data became untenable. Instead, building on Brahe's data in the seventeenthcentury, Kepler showed that the planets moved in elliptical orbits around the sun. This further refining of Brahe's data did not require a paradigm shift as such. The basic belief system remained untouched. However, instead of thinking about causal relationships Kepler saw functional relationships; rather than think of the gravitational pull of the sun *causing* the planets to stay in orbit, the radii of their orbits, their periodicities, and masses were seen as all related functionally as a system (Guba and Lincoln on Travers, 1980; 1989). This could be compared to the way perspective does not *cause* one to see a 3D scene rather it is based on the functional relationship between the symbolic nature of the representation, one's cultural background and their ability to detect light variations.

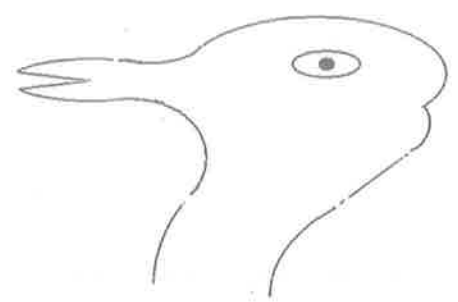

Figure 11. Human Gestalt duck-rabbit illusion succinctly demonstrates a shift in perception.

New paradigms force people to make transformations in their thinking. It is the sudden changes, like the Gestalt switch, in understanding that permits a new solution – a new paradigm to be born or intuited. In this sense, paradigms determine areas of experience too. While the cases I describe in my thesis do not include a paradigm shift as such, they do demonstrate a transition to a deeper understanding of a technology and its potential application in a group setting. The outcomes were, nevertheless, profound enough for both participants and teacher to transform prior understandings of what the technology could be used for and to become a new essential component of the curriculum.

3.4.3 How Constructivism Extends Scientific Discovery

The constructivist method sees the various shifts in scientific thinking not so much as a progression in thought but simply multiple ways of interpreting natural phenomena – equally valid within their own socio-cultural framework. Hence, a study which allows for multiple views may see the way Bell discovered quasars as interpretable in a number of ways by different sociologists. For example, those interested in: norms might enquire how it was communicated within the universality of scientific norms, in other words, was it rephrased or

[13] Language is both a vehicle for voicing and shaping ideas. In this sense, we can say Romanyshyn sees perspective as a language which both represents and shapes ideas.

left out all together and why; and, the social-circumstance researcher might look at what equipment was available at the time which led to the discovery that gave it a special significance. Indeed, under different circumstances the discovery may have been missed or not occurred at all[14]. From these different approaches the technical events behind Bell's observations may help reveal that the act of perception that occurred was constituted by the prevailing social forces at the time rather than any strict adherence to scientific rigour (Latour and Woolgar, 1986).

Moreover, for Lakatos (1976), if we accept the logic of discovery as a heuristic exercise then it is the heuristic style which highlights the counterexamples that lead to discovery, emphasising the problem-situation; the logic which gives birth to the new concept. Indeed, the Hegelian (1969) concept of the heuristic contends that mathematical (or scientific) activity is essentially a human activity. Hence, it follows that certain aspects of scientific endeavour *can* be studied by psychology and others by history. Mathematical or scientific activity, however, alienates itself from the human activity which produces it. It is an autonomous activity developing its own dialectic. It is simply the role of the mathematician or scientist to obey the dialectic of their ideas.

Within Lakatos' central importance of the autonomy of the products of human intellectual endeavour is Popper's (1992) notion that we discover rather than invent intellectual problems. Furthermore, within this notion of Lakatos' product and intellect, and Popper's discovery and invention, is Feyerabend's (1997) thesis that scientific procedures cannot be understood independently of their use. In other words, discovery is a product of the history, social, and personal idiosyncrasies of those who produce it[15]. Hence, reflection on the sociological conditions surrounding scientific discovery are crucial to understanding its methods.

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[14] Alternatively I argue that it would not have been noticed except that it was against the backdrop of scientific precision. Which is the opposite to scientific precision or objectivity against the backdrop of social chaos or subjectivity.

[15] Western science is but one science among many. While, at one time, other cultures had technologies which were far in advance of those of the Western scientific world, today scientific methodologies dominate new discoveries. According to Feyerabend (1997), this is mostly due however to the colonising power of Western nations to impose their ideologies than any inherent superiority in their methods. In this manner, it has ceased to be simply an instrument of research and has, instead, become a tool for political oppression. "Every act of science…[is] also a political act, one that…[structures] power relationships in a particular way and…[serves] to maintain them as the status quo…. Positivism…breaches…ethics and political agency by virtue of its realist ontology and its epistemological claims of objectivity and value-freedom" (Guba and Lincoln, 1989, pp118-119).

For example, where the sociological process is at play includes how scientific discoveries are actually reported. A statement such as: "X observed the first optical pulsar, can be… [seemingly] undermined by use of the following formulation: X thought he had seen the first optical pulsar, having stayed awake three nights in a row and being in a state of extreme exhaustion" (Latour and Woolgar, 1986, p21). Here we see the injection of Geertz' (1975) 'thick description' into the inquiry providing a richer meaning and context to the discovery. Such thick descriptions help contextualise the discovery and give us an insight into the processes that led up to it and reasons why it may even have occurred.

3.4.4 Constructivism as a Naturalistic Method

From the preceding discussion about scientific discovery and how constructivism extends its positivist origins emerge two types of investigation: etic and emic. Etic investigation favours deductive production of independently testable descriptions where the audience validating the conclusions is drawn from a community of fellow observers (the positivist approach). This is distinct from the emic process which favours the emergence of phenomenologically informed descriptions of social behaviours where the audience validating the conclusions is drawn from the participants themselves (the naturalist or constructivist approach) (Latour and Woolgar, 1986).

As the research reported in this thesis was derived from what the participants said, their judgments, and my interpretations of their constructed realities, it relies on the emic process. With its emphasis and setting in pedagogy, the Guba and Lincoln's (1989) constructivist method was chosen among those available. In Guba and Lincoln' (1989, p12-13) constructivist methodology – a form of 'ethnomethodology' – "there *is no reality* except that created by people as they attempt to 'make sense' of their surrounds" Hence, by its very nature it must follow an emic investigatory method. The constructivist methodology draws much of its naturalistic emphasis from the ethnographic practice of "…representing the social reality of others through the analysis of one's own experience in the world of these others…. [It is imprecise and unfocused. It questions] previously unquestioned epistemological assumptions on which cultural representations rest" (Van Maanen, 1998, pix-x). These different, often conflicting, epistemological assumptions give rise to contrasting paradigms such as the (perceived) dichotomy between quantitative and qualitative research methods. Case-studies are often implemented in the latter. Instead, according to Hammersley (1992), we are not faced with a fork in the road, but rather the research process is more like finding one's way through a maze. Bearing this in mind helps the researcher correlate the various field gathered data into a meaningful multi-faceted epistemological framework.

3.5 How the Constructivist Case Studies were Conducted

The constructivist study reported in this thesis relied upon literary and rhetorical devices to establish a 'cultural portrait' in Van Maanen's (1988) terms. In the 'new journalism' style of the 1960's, the kinds of literary and rhetorical devices that are used makes the various case studies read like a novel or short story with scenes, expository passages, and personalised dialogue. This assists the creation of a series of vicarious experiential journeys where the reader gets to 'walk in the shoes' of the individual participants. These literary devices are used to excite the reader both intellectually and emotionally. The reader enters the mind of the characters directly as in the novels of Wolfe, Fielding, Dickens, and Balzac. This is derived from the three main devices:

- scene-by-scene construction;
- recording of the dialogue in full;
- use of first (participant's) and third-person (researcher as narrator);

Due to the distancing from participants through the use of chat to record their conversations, references to gestures, habits, manners, and customs (normally an included feature of the new journalism style of writing) is minimalised. Structural corroboration in the 'stories' contained in the case studies was established by triangulation thus reducing the uncertainty of my interpretations (described in more detail later). As the evaluator, I had to negotiate a consensus on the multivariate meanings behind constructions that the actors (or participants) formed to 'make sense' of the situations they found themselves in. These value-pluralistic constructions were inextricably linked to particular physical, psychological, social, and cultural contexts.

The ethnographer Mary Douglas (1982) describes a methodology for developing an 'inclusive' framework which deals with cultural bias and the problems of comparisons that may arise in such a study by suggesting that the communication systems used provide a vehicle for value-laden meanings. Moreover, embedded within the rules I established for the exercises and those the participants co-opted are the inherent meanings I/they wish to communicate. In other words, as the evaluator, I recognise that the part I played was a larger role than simply that of a technician gathering information. I had to orchestrate the negotiation process, which was core to the evaluation. As an evaluator, I was a subjective partner and a stakeholder in the creation of the data; evaluation data was "simply another construction to be taken into account in the move toward consensus" (Guba and Lincoln, 1989, p45).

What my constructivist inquiry did was to expose the correlation between the participants' and my own constructed realities and a common-sense experience of reality. In broader terms, while we all experienced a physical world that was similar, the 'stuff' of our realities was different. The stuff of our realities was what we made sense of the physical world. This included social constructs which were utilised to make sense of the physical world and impose an order on it. For example, the applications that I developed for this study were programmed on a physical computer in my office. It took up room. It was the same computer used throughout the four years needed to complete the exercises. It was provided by the institution where I worked. The participants could not 'know' about, or understand my 'construction' of this computer in my life until they were required to interact with it in my office – only then did they become part of the constructions and reconstructions surrounding it. Indeed, the relationships needed to be chronicled as our joint 'constructions': values, beliefs, fears, understandings, and so on. In other words, it was not the physical reality of the computer, its context, or the events surrounding it, that were of interest, but the meanings we attach to them – the stuff of our constructed realities.

3.5.1 The Triangulation Process

Triangulation occurred after having had time to review the chat logs for each exercise conducted and I facilitated a short forum with the class as a whole. This allowed me to clarify meanings gleaned from the chat logs. I prepared an agenda - usually outlining my hunches about meanings – and cycled the querying until agreement or disagreement or the various possibilities for understanding seemed to have been exhausted. This followed an iterative process similar to that expressed in figure 12.

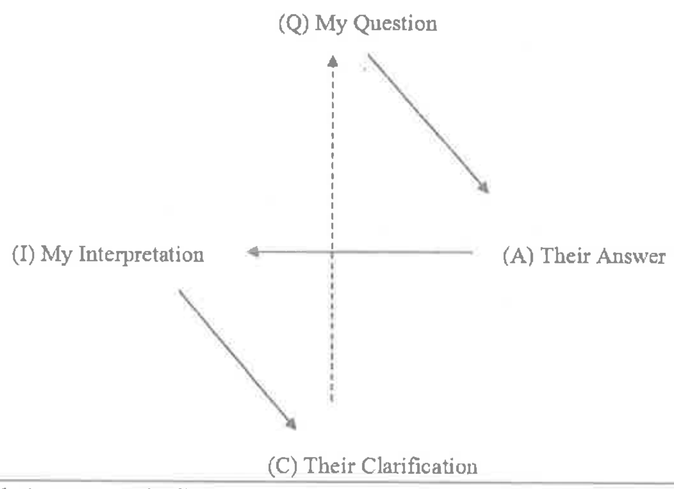

Figure 12 Triangulation process in diagrammatic form.

Triangulation involved:

- My question (initially prepared in advance from chat log analyses);
- Their answer;
- My interpretation of their answer (requiring reconstruction in my mind);
- Their clarification of my understanding, and so on, until consensus was reached or possibilities exhausted or agreements and disagreements were noted.

3.5.1.1 Example of Triangulation

The second form of triangulation was the follow-up clarification forum. The following example includes a chat log that addressed a situation of momentary confusion (participants have been given aliases to protect their identities):

> (Q) I initiated the dialogue by asking the Question Mary, "...did you mean that the x-axis was directed out of the screen?"
> (A) Her answer was: "I thought Bob was looking at the same [arrangement of] blocks as me but [I] knew he was looking at [a] screen so [his] blocks should be flat [or from above. Then]... I got confused between his 'y' and mine."
> (I) My Interpretation was: "...so, you were looking at your blocks from the front?"
> (C) Clarification: "No, above."
> (Q) Here I start the cycle again: "...but then there shouldn't be a problem."
> (A) Her response: "Oh yeah, [but at the time]... I [still] thought they [were] below."
> (I) My new interpretation: "...so, did you mix up what you could actually see [(an elevated rather than planar view)] with what you thought Bob was looking at [(a planar view)]?"
> (C) Her clarification: "I suppose so.... I was kind of looking at the blocks on the table [(with Bob's x,y screen overlayed y up)] and couldn't understand why [he wanted to put] blocks under the x."

While it is difficult to relay the clarity achieved in the actual presence of the interviewee here in text (which includes nuisances, tacit communications, gestures, and so on), it was clear at the time that what Mary meant was that for a moment she had juxtaposed a top-down view of Bob's virtual blocks against an elevated view of her own physical blocks.

3.6 Measures of Research Quality

3.6.1 Issues of Data Credibility

Like an anthropologist or ethnographer, the constructivist is concerned with describing and understanding human nature. I used triangulation to test my emergent impressions (like in an impressionist ethnography) until I was satisfied that my interpretation was valid. It was a kind of investigative new "journalism, in which 'truth' …[could] be elicited from partial and even reluctant sources by processes of cross-checking, triangulation, and re-cycling until convergence …[was] achieved" (Guba, 1978, p13).

More specifically, the constructivist paradigm, sometimes also called the interpretive, hermeneutic, or qualitative paradigm, sees its product or evaluation as also an agenda for negotiation. Epistemologically, within the constructivist paradigm, it is the interactions between the observer and what is observed that creates what emerges from the inquiry. Methodologically it uses a hermeneutic/dialectic process to create newly constructed realities. These constructions are *interpretations* based on experience, some of which are tacit. In this manner, "what there is that can be known…[cannot be separated from] the relationship of the knower and the known" (Guba and Lincoln, 1989, p88).

A constructivist evaluation should include the following steps:

- Identify the full array of stakeholders;
- Elicit the emic constructions from each stakeholder;
- Provide a context and a methodology;
- Generate consensus within and between groups;
- Establish and mediate a forum for negotiation to take place;
- Develop a case study report which provides narrative accounts or vicarious experiences;
- If needed, recycle the evaluation.

The risk in conducting a constructivist inquiry is inherent in the framing of case studies – what to include or exclude.

Constructions elicited should be self-sustaining, grounded in the hermeneutic cycle, and the most informed and sophisticated construction possible (Guba and Lincoln, 1989). A grounded construction must meet certain criteria: it must *fit* and *work*, and have *relevance* and *modifiability*. A constructivist should provide "a vicarious experience of the situation, allowing readers to 'walk in the shoes' of the local actors" (Guba and Lincoln, 1989, p223). Although evaluation data is not generalisable, it "may, however, extend experience vicariously, serve as a metaphoric springboard leading to new insights, or simply add information" to existing understandings (Guba and Lincoln, 1989, p216).

3.6.2 Satisfying the Conditions for a Constructivist Inquiry

Groat and Wang (2002) identify Guba (1981), and Guba and Lincoln's (1998) measures for determining research quality as relating to the naturalistic paradigm. Whereas the positivist paradigm adopts an 'objective' research methodology, the naturalist paradigm adopts a more 'holistic', emancipatory, methodology. Hence, the research methodology I used mostly addresses key standards from the naturalist methodology.

Most aspects of my research methodology appear to satisfy the conditions of Guba's (Guba in Groat and Wang, 1981; 2002, pp37-38) naturalistic (constructivist) inquiry including: "the assumption that generalisations are not necessarily possible in all instances; the understanding that a research design may emerge as the research proceeds; and, the belief that the researcher and the respondent influence and are influenced by each other." For example, in determining 'credibility', triangulation in conferring results was used. Participants agreed as a group on defined outcomes related to self-imposed criteria which was reinforced by my explicit questioning. For example, when I was interviewing a participant about their reflections on the exercise conducted the previous day, they mumbled their mild embarrassment at having been found cheating. Their ordinarily confident responses to my questions were replaced with down cast eyes and a quieter voice. As it turned out, they had not "cheated" as such but simply imposed some rules outside those of the exercise (see Chapter 04 for a more detailed overview).

Criteria was established by consensus with the whole group. Decisions regarding the quality of outcomes in relation to the criteria was then confirmed by both individual participants, the participant group as a whole, and confirmation of my interpretation of those decisions sought from the group, thus completing the triangulation. While central to the conduct of these exercises was their insertion into an existing teaching program, the positive response, by both students as participants and staff alike, hinged very much on me. In the first instance, this was to engender support, and, in the second, demonstrate its value as a learning tool. Hence, 'transferability' to other settings may be questionable. The tools used are not widely available and were customised for this study. Other tools could be substituted, but it is not clear if this would unduly influence the outcomes. The capturing of the thick descriptions (in Geertz'

(1975) sense) within the case studies will assist others' assessment of transferability to other settings. A clear 'audit trail' of documents and the process by which data was collected, analysed, and interpreted supports the 'dependability' of this inquiry (see Appendix E 1-11). The research makes clear the epistemological basis of the study regarding both the notion of perspective as a convention and its affect on students design decisions.

Having established the grounds for satisfying some of the quality standards within the constructivist paradigm, what remains is Guba and Lincoln's (1998) 'eroding of ignorance' standard. The cases are highly structured in their format and layout for the goals of this thesis but, as part of the teaching program the exercises they describe also respond to pedagogical goals. Hence, my interpretations are holistic by nature. They take into account the overall subject aims as well as those of the specific exercise. They discuss the mix of students, including explicit thick descriptions of individual participants. Thus, enough information was gathered to establish the overall make-up of each group. No part of any of the exercises discussed in this thesis had been used in the teaching program prior to this investigation period. Hence, it is thoroughly 'historically situated'[16] by virtue of its novelty and that most of the data collected includes gender, ethnicity, and economic status. In this sense, any criticism that the work does not conform to a pre-established 'signature style or theory' is dissolved in the circumstances of its embryonic and/or trailblazing nature (Groat and Wang, 2002), thus satisfying Guba and Lincoln's (1998) 'eroding of ignorance' standard.

3.7 Summary on why Constructivism was Chosen

The constructivist method was chosen over other types available because it allowed me to work in a natural environment as a teacher and make research observations that led to discoveries without disrupting the pedagogical aims of the exercises through the need for a laboratory setting. The three example studies discussed at the beginning of this chapter provided the motivation for a study which had a core pedagogical component that engaged its participants with meaningful tasks, reflection in action, in a multi-user environment. The participants were design students and the exercises used to form the case studies were part of the teaching program. Hence, by necessity, my approach needed to be as a participant observer. This presented a problem however, because most studies in computer related fields do not usually address the social dimension. I needed to decide if I was going to follow a qualitative or quantitative study. More specifically, a positivist or constructivist study. The problem with the positivist approach is it does not include the participants as active members

[16] See previous reference to 'situatedness'.

of the structuring of the study itself. As students in a positivist study they would be at risk of being simply 'subjects'. I wanted my participants to be part of the form of the study as a pedagogical goal also. As a teaching exercise the study was situated in a natural setting not a laboratory. Hence, it would be difficult to control. Unlike the positivist approach, the constructivist method let me 'listen' to the participants. In this sense, it extended any potential scientific discovery by including its social context. Therefore, in broad terms, the choice was between an etic or emic study. I chose emic because it inculcated the participants at every step. As a type of ethnography the study provides a vicarious experience for the reader through its use of literary 'real-life' rhetorical devices in its style of writing. It captures the reader's interest, relaying the constructed realities of the participants and evaluator alike. Finally, the way I conducted the study meets Groat and Wang's research quality measures for a constructivist study. Importantly, by establishing a practice of research concurrent within the teaching program, this research also created the conditions for a 'transformational response' to research related teaching in general. As a teacher, I felt this was an important outcome for my students.

3.8 Tools Used in the Case Studies

With my reasoning for the use of a constructivist methodology established, this next section discusses the design of the cases. It includes an overview of:

- the pedagogical benefits of using game-like exercises as a motive for engaging design students in research;
- how the virtual environments were designed to support the games used in the exercises;
- a justification for using VRML as the preferred software development platform, and the various interfaces developed; and,
- a justification for using online chat to record the communication between participant players, and how the chat system developed for this study functioned.

It concludes with a brief summary of the topics discussed in this section.

3.8.1 The Pedagogical Benefits of Using Game-Like Exercises as a Motive for Engaging Design Students in Research.

Games were used as a motive for engaging participants' attention in the various pedagogical exercises. As a teacher, the game-like exercises used in this research attempted to redress, through their emphasis on problem solving skills, what Schon (1983, p-vii) describes as Universities' commitment to a particular epistemology that "...fosters selective inattention to practical competence and professional artistry." In other words, while much in the curriculum is directed towards ensuring students are exposed to, and assessed on, their understanding of the core requirements in the professions, attention is often diverted from the actual problem-solving skills which are necessary for their application. In this manner, the use of game-like exercises and their associated 'play' ensured participation in the game and resulted in the exercising of the sorts of problem-solving skills necessary gained from deep learning which leads to transformative outcomes (Biggs, 1999). For example, in the multi-user 3DVE exercises participant-students learned new ways of framing and cooperating within a collaborative virtual design space. They discovered they were able to extend a 'virtual architecture', whereas its physical-world corollary is fixed. Student-participants were empowered to explore spatial concepts through game-play in a CAD environment in ways which they may not have had the skill, hence confidence, to do so in a traditional paper based design studio.

Games promote reflection-in-action (in Schon's (1983) terms): they are useful for enhancing specific skills in a structured yet playful environment; they can contain narratives not dependent on logic; they remove the mysterious; they are a contest dependant upon agreed rules and goals – a contrived social system with prescribed space and time boundaries; and game rules order conduct (Cheng, 1999; Bower, 1974; Caillios, 1961; Dewey, 1957). In a game there is participation and sharing in a common experience. Playing a design game, one explores paths of choices and actions available in the game (Woodbury, 2001). Games require space to be played out. Successful games create their own sense of 'place' – a place where play proceeds. Where multiple players gather, place emerges; rules are agreed upon and are applied requiring fine judgment (Swartz on Bourdieu, 1997). Games allow one to suspend their disbelief, and games provide a structured basis for learning.

Different types of games were used in this study. The common differentiation between them was the number of players involved. There were three levels of game playing, those requiring:

- a single player: the introduction of a VR component into the History and Theories course (although this particular case study was not used to support the thesis);
- two players: where two participants were physically separated whilst working on a common goal, communicating with each other via online chat; and,
- multiple players: where multiple players interacted with each other in a multi-user virtual environment.

The last category can be traditionally defined as a type of game where either a team wins or an individual wins. Unlike in a traditional game setting, however, in the games described in this research players relied on each other for their individual success. Although not working together as a team, nor pitted against each other, they all had a similar goal. The games were structured such that individual success could be expected by the players. Indeed, mere participation guaranteed success. As a pedagogical exercise, assessment criteria was based on participation and reflection. Hence, participation could be considered a measure of success. The expectation of success is something Biggs (1999) identifies as facilitating deep learning outcomes.

The game-like exercises took place in both physical and virtual environments. In the physical environment, both 2D sketching and 3D model making were used. In the virtual environment four levels of interaction in a browser interface were included:

- single-user interaction with predefined objects;
- multi-user navigation;
- multi-user navigation and manipulation of predefined objects; and,
- multi-user navigation and construction of a virtual environment whilst collaborating with remote partners.

To achieve the goals of these systems a means was needed for 'exploring' and manipulating objects in 'real-time'. While CAD systems are good at the defining and static representation of 3D form, and the production of static images to be linked in an animation, at the time of these exercises, available CAD systems were not good at the shared real-time interaction needed. Hence, the open-source, easily-scripted, real-time interactive 3D virtual environment VRML was employed. It was chosen because it satisfied all the conditions outlined above.

To familiarise the students with scripting in VRML, a short course was conducted prior to the exercises. VRML scripting was introduced in a series of short seminars. They included discussion about the game construction elements incorporated in the exercises, such as:

- the interface;
- use of java;
- use of vrml; and,
- how a client/server model works.

Some basic construction in VRML followed the seminars.

Overall, the games demonstrated fun, negotiation, a limited view of the overall process, trust, group dynamics, and rule-based design in its clearest form.

3.8.2 Design and Implementation of the Virtual Games Environments

The virtual games environments, including the chat facility, were developed specifically for this research. This was because existing systems (Quake, FormZ, IRC) were either too cumbersome to operate efficiently on the existing network, were cost-prohibitive, did not support the functions required (such as recording of online chat, multi-user real-time navigation), or were not flexible enough to be customized for each exercise (the insertion of a base model such as the Barcelona pavilion, abstract avatars, Heads-up Display (HUD) controls and so on). Hence, the construction and implementation of a multi-user Virtual World and online chat interface using Java, VRML, and CGI (hosted on the school's server running Apache) provided the flexibility and control sought whilst maintaining the robustness and general accessibility of a generic web interface such as Netscape and Cosmoplayer.

3.8.2.1 Justification for using VRML

VRML offered benefits to this study beyond its easy scripting language, java flexibility, and support for multi-user functionality. The primitive rawness of its solid modelling, sans shadows and reflections, tended to separate the visual code from its content, as Gombrich (1972, p91) suggests:

> *The easier it is to separate the code from the content, the more we can rely on the image to communicate a particular kind of information.... [By filtering] out certain kinds of information and to encode only those features that are of interest to the recipient, ...a selective representation that indicates its own principles of selection...[is] more informative than...[a realistic] replica.... Leonardo da Vinci's anatomical studies are early examples of deliberate suppression of certain features for the sake of conceptual clarity.*

VRML does this more so than the realisms of traditional CAD animations or even computer games (such as Quake). This was necessary for the raw conceptual clarity sought in this research.

VRML allowed the participants to focus on the forms generated and their method of generation rather than the inherent realisms of the more elaborate CAD packages they were used to. Its 'rawness' relied less on *chiaroscuro* tricks and more on their recognition of simple colour-filled surfaces compiled to represent objects in a void. It thus, completed the Euclidean-Aristotlean-Descartian concept of pure geometry in a three-dimensional void-space.

In a sense, it represented the pure dynamic of a mathematically precise perspective (without shadows and so on).

The *real-time* ability to navigate virtual space in VRML offered the opportunity to dynamically manipulate the perspectival controls of viewpoint and field-of-view. Real-time navigation of virtual space allowed the participants to go 'places' which the rendered still images and controlled frame animations of CAD programs do not. When it came to narrating their design actions, viewing a traditional animation of a computer model might give me an insight into their design, but it was a controlled insight – they controlled what I could see. The real-time virtual worlds, on the other hand, let me wander off the path. I could say 'what is over there?' and go there to see for myself. I, the receiver, was thus 'empowered'.

Where Richens and Trinder's (1999) use of Quake (a popular high-end 3D computer game played on a PC) provided a more realistic environment than VRML, it suffers from a lack of rapid prototyping. Furthermore, I considered the realism of Quake would provide a distraction from the core investigation – the role of perspective, not chiaroscuro, in 3DVEs. Nevertheless, Richens and Trinder's choice indicates a perceived need to fully immerse participants in an interactive environment which was not restricted by its 'frame'. Although they did not address the affect it had on one's sense of space as a result of interacting in a real-time perspectival environment directly, it seems they intuitively chose this method rather than others available to them because of its ability to give a richer spatial experience. However, a 3D model from a CAD package and importing it into Quake Arena is not a straight forward process. Many steps are needed before one can navigate the proposed design in a meaningful manner. This places considerable limitations on the development cycle time from concept to visualisation adjustment and re-importation.

To overcome the difficulty in providing a rapid visualisation environment – transferring CAD models into suitable environments for real time navigation – what I needed was a real-time navigable virtual-environment programming or scripting language protocol that supported a distributed multi-user interactive environment. While there are a number of languages which support this function (directX, OpenGL, various game engine SDKs, and so on), they suffer from varying degrees of support and platform dependence. In any distributed environment one finds differing performance on differing platforms. The language needed to be platform independent and useable on machines with varying performance characteristics.

I chose the Virtual Reality Modelling Language (VRML) because, as a scripting language that runs above JAVA, it was essentially platform independent. Furthermore, the base VRML specification supports scripting to JAVA classes and as such supports sockets, hence, networked multi-user capabilities. Much work has been advanced by the Sony Research Labs in creating stable multi-user interactive environments based on VRML. Furthermore, the VRML language is text based. In other words, files created for viewing in a VRML browser can be opened by any text-based editor. There is no proprietary license over the language and most VRML viewers are Freeware (CosmoPlayer, Blaxxun, Cortona, and so on). Because the language is open and able to be edited in any text editor, this meant the researcher and researchees could gain an understanding of the code's structure very quickly. Based on JAVA, VRML proved to be straightforward and easily comprehensible using common terms and recognisable procedures/declarations. Where VRML differed from other CAD languages was its openness. Moreover, most CAD programs support exporting VRML formatted files. In turn, this meant modeling could occur in a known CAD environment, with models subsequently transferred to a VRML browser for interactive viewing. VRML offered the transfer protocol sought for transforming CAD models into navigable real-time virtual 'worlds'.

In summary, VRML was chosen as a visualisation medium over others, primarily because of its simplicity and openness, as it:

- structured instances in a visual mode;
- coped with complexities through its simplicity;
- represented form more clearly by removing the distracting niceties of reflection, shadow and fixed-sequence animations associated with traditional CAD;
- is an International Standards Organisation (ISO) supported format; and
- allows visualisation of objects which CAD packages export as VRML models as a preferred file transfer protocol (Oxman, 1999; Jozen et al, 1999; Do, 2001).

Nevertheless, VRML can be sluggish if the scene contains too many polygons, and, typical of most multi-user Virtual Worlds, it is difficult to find a sustaining motive for its engagement apart from being forced do so for grades, being part of a pre-existing single interest community, for game rewards, or when it is used as part of a commercial practice.

3.8.2.1.1 VRML as a Single-User Interface

The single-user interface used in the first case study employed a VRML script incorporating predefined objects with plane sensors and a Heads Up Display (HUD). The plane sensors allowed for movement of the objects in the x-z plane. The HUD was used for inserting and removing objects from the scene. The overall interface was executed through the CosmoPlayer plugin for Netscape 4.7. Participants executed the application by activating a hyperlink on the course web page. The HUD used switch sensors attached to the objects displayed to insert and remove identical objects in the scene. It did this by executing the VRMLfromString command embedded in a JavaScript function within the parent VRML file. Once executed, the HUD switch then toggled the newly created object's visibility and plane sensor. In this manner, it appears to the user that the object can be removed and replaced at will. Once inserted, the object's plane sensor allowed it to be moved around. The main CosmoPlayer navigation controls include: walk, examine, pan, and zoom (see figure 13). Collision detection ordinarily prevented users from passing through objects. Although, some of the navigation controls negated this effect, and holding down the shift key whilst navigating meant the user could override the other controls and pass through objects.

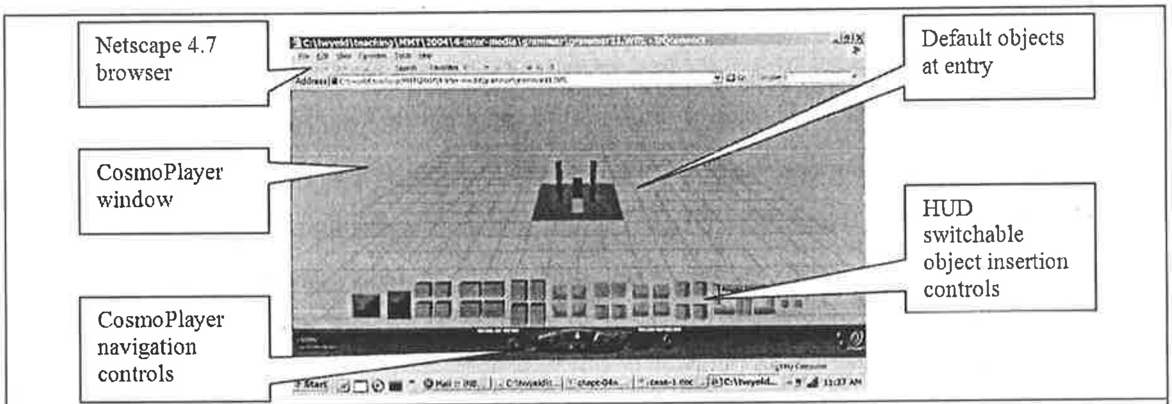

Figure 13. Single-user interface.

3.8.2.1.2 VRML as a Multi-User Navigation-Only Interface

The multi-user navigation-only interface used a server written in Java to support multiple avatars and navigation in a predefined scene only. Unlike the single-user interface, in this interface objects could not be manipulated. However, participants could see each other as an avatar. Predefined avatars were assigned by the server as individual participants executed the application by activating a hyperlink on the course web page. The interface was executed through the CosmoPlayer plugin for Netscape 4.7. Navigation controls were the same as for the single-user interface including collision detection functionality (see figure 14).

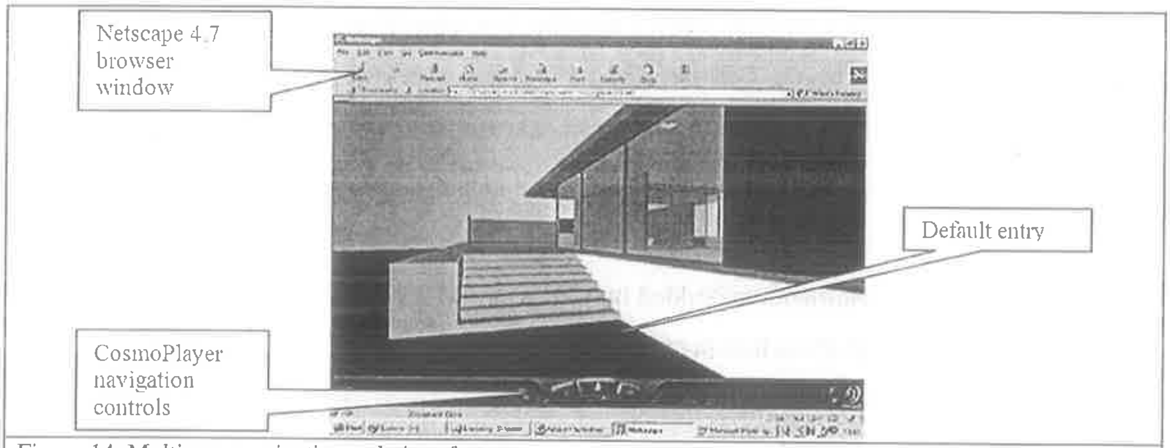

Figure 14. Multi-user navigation-only interface.

3.8.2.1.3 VRML as a Multi-User and Predefined Object Server System

For the exercise that included multi-user navigation and predefined object manipulation an Object Server System was created. The system used updates the transforms of the objects explicitly allowing their transform values to be shared across multiple browser sessions. The application was accessed by activating a hyperlink on the course web page. Users were represented by an avatar that was assigned by the application's server. The standard CosmoPlayer controls were used. Manipulation of the objects was the same as that for the single-user interface without the HUD. The difference here was that all users could manipulate the same objects and see when others manipulated them too. A toggle switch was provided to turn the plane sensor off to avoid interference when trying to navigate the spaces created (both sensors use the mouse cursor to activate their functions) (see figure 15) (see subsequent work published by this author for an overview of the code developed for this application).

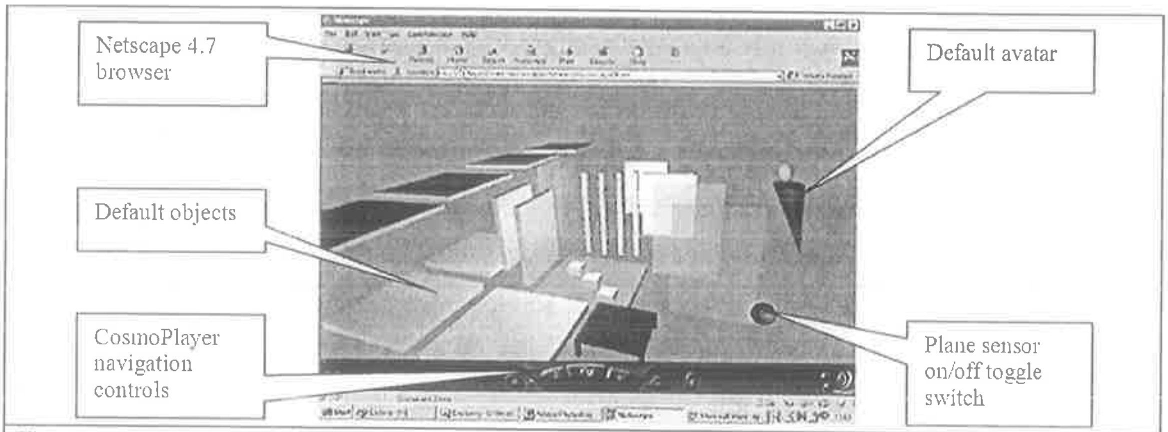

Figure 15. Multi-user predefined object server system interface.

3.8.2.2 Justification for using Online Chat

The online chat channel medium was instrumental in forcing participants to interpret their thoughts through a textual medium, thus, translating their tacit knowledge into text. The recording of their reflections helped also in its interpretation – it helped them to frame their problems (Schon, 1983). Furthermore, it enabled the participants to reflect upon their own knowledge, which was concretised by writing it down (Polanyi, 1967). Founded on an interpretive ethnography, the observation methodology – use of a chat log – was germane to its textual production (Atkinson, 1990).

Face-to-face conversations expose countless things about the other person over which one has no conscious control. When reading text, on the other hand, everything seen is a *product* of a person's mind. Face-to-face conversations rely on what Godwin (1998) describes as sensory bandwidth. When film makers such as Woody Allen or Steven Spielberg produce black-and-white movies they are attempting to narrow the bandwidth – to focus the message. Similarly, video in comparison to a 70mm movie is generally appraised more for its production value than for its content. This follows McLuhan's (1995) adage that the 'medium is the massage'. The idea that *too much* data, or over use of bandwidth by a movie, is demonstrated by the way whole novels can fit on a single floppy disc. Yet the movie versions of these novels, often regarded as inferior to their texts, require much greater storage space. From this we can see how text can convey more message with less bandwidth. In particular, online-text creates "complex webs of metaphors and allusions that deliver vast cognitive bandwidth over minimal informational bandwidth" (Godwin, 1998, p44).

Online chat was chosen as the medium for establishing dialogue between researcher-participant, and participant-participant for three reasons. Firstly, it engaged participants in the problem space in a way that eliminated most other distractions – a telephone conversation, tape recording, or participants being in the same room, would have allowed for nuances in the spoken word or facial expressions which would be difficult for the researcher to record. Secondly, chat forced participants to concretise, in Polanyi's (1967) terms, their thoughts by writing/typing them down. They had to think deeply about how and what they needed to communicate. This meant, in most situations, richer, more meaningful communication occurred. The researcher also was compelled to couch his comments in terms of what best described the situation he wanted to convey. At times this proved doubly difficult as, for many of the participants, English was a second language. Thirdly, by recording all conversations as text, the researcher's task of collating the vast volume of field data collected was made easier, as I could analyse the chats at a later date. It was thought this would be more efficient and less prone to error than the alternative proposed by Suwa et al (1998) – the transcription of video or tape-recorded conversations.

A key component of this part of the research methodology was also the way participants engaged in what Schon (1983) calls 'reflection in action' whilst chatting online. This occurred when they were thinking "about what they were doing while doing it. Reflecting on past problem analysis helped frame a current problem.... [By becoming aware of framing a problem they also became] aware of the possibility of alternate ways of framing" (Schon, 1983, pp275-310). Participants were framing and reframing the design problematic in a collaborative atmosphere communicating possible solutions by chat. When they reflected-in-action they did not keep means and ends separate as in a scientific investigation, but defined them intellectively as if framing a problematic situation. Exercising with design moves, participants played "a game with the situation in which...[they were] bound by considerations relevant to the three levels of exercise-exploration, move testing, and hypothesis testing" (Schon, 1983, p153). As such, participants struck up a reflective conversation with themselves and their co-participants. They reflected-in-action on the "construction of the problem, the strategies of action, or the model of the phenomena, which had been implicit in...[their] moves" (Schon, 1983, p79). Drawing and talking are parallel ways of designing, and together make up what Schon calls the language of designing. Hence, the combination of modelling and chatting was used in this research to strike up a conversation between collaborating designers.

3.8.2.2.1 How online Chat Functioned

Most Internet Relay Chat (IRC) channels provide a common format including a nominated ID ('name') and a chosen 'themed' chat room. One enters the current session, scrolls through the conversation to see what has been typed recently, enters the conversation, or proceeds to a private adjunct conversation. Participants get removed after a predetermined time if they do not participate.

Conversations on commercial chat channels (such as worlds.com) relate mostly to anarchism, sex, or music and make extensive use of jargon. Unbridled passions flow easily. Territoriality is evident in the cloistering of participants, and the acronyms and emoticons used. Hence, some participants are simply ignored or excluded from the conversation.

The CGI-scripted online chat[17] facility used in this research was isolated from the mainstream internet. As such, it could be run in the background while participants focused on the task at hand. They could leave it for a time and come back to it – look over the last few sentences and join in – without missing anything. Where more than two participants and the researcher were logged on at the same time, participants could generally conduct multiple separate conversations with different participants or indeed multiple conversations with the same participant, all at the same time. This was both facilitated by the main chat interface and the ability to move to private chat 'rooms'. The use of acronyms made conversations flow more easily and added an element of surprise, further engaging participants. Unlike the associated Virtual World, which demanded all of the participants' attention (as does the telephone to a lesser degree, prohibiting multi-tasking), chat could be left for some time, only to come back and find one's place, quickly regaining the thread of conversation (see figure 16).

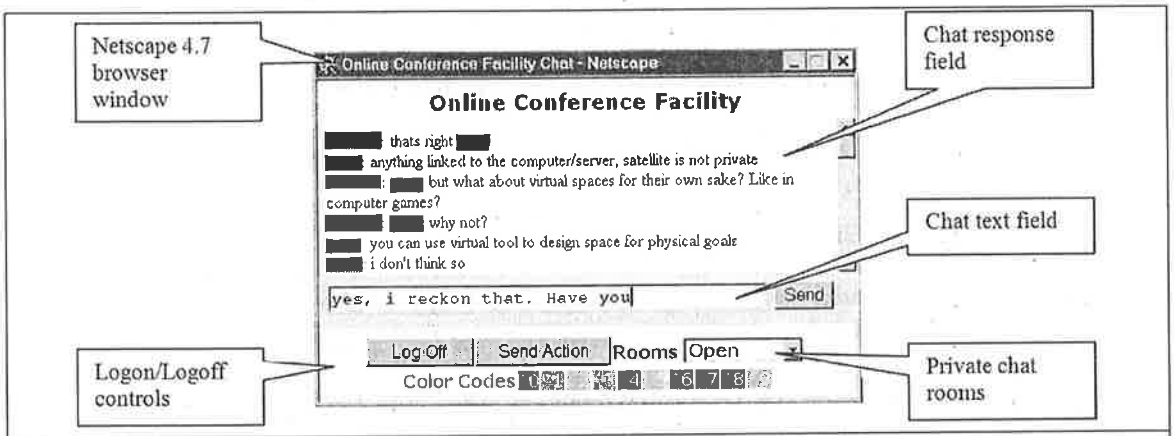

Figure 16. Online CGI chat facility interface.

3.8.3 Summary on Tools Used

This section discussed the tools used in the case studies. It opened with a brief overview of the pedagogical benefits of incorporating games as a motive for engaging the students in the exercises. I discussed how games as a motive helps students develop problem solving skills leading to deep learning with transformative outcomes. Different types of games were employed in this combined pedagogic/research study. They included: single, double, and multiple player games. The players worked together towards individual outcomes. I then discussed the types of environments developed for the games. The students were required to familiarize themselves with VRML and java scripting at an introductory level of understanding before attempting the games. This gave them a more comprehensive appreciation of the types of environments they would encounter and why I used the tools I did. My justification for choosing VRML was because of its ease of use, scripting, and graphic

[17] Unlike VRML multiuser Virtual World client-server applications, for which the raw code is not generally available on the internet, CGI online chat scripts are readily available across the internet for editing and

rawness. I hoped its graphic rawness meant the students would not be distracted by the niceties (shadows, textures, shading and so on) of the CAD environments they were more used to. Moreover, its rawness provided a visual clarity that meant I could assume that the results of their explorations would be more about the 'perspectiveness' of the space than chiaroscuro illusions *per se*.

A detailed account of the actual environments developed was provided. It included the features of the single-user, multi-user navigation-only, multi-user object-manipulation, and, multi-user object-manipulation remote collaboration, environments. This was followed by an overview of why chat was used instead of taping or videoing; how it forced participants to concretise their thoughts and made it easier for me to collate the data collected. Unlike the VRML interfaces, the chat interface was familiar to all the participants. Hence, it did not require a detailed explanation to the participants or in this section. Collectively the tools developed build on each other and help define clear shifts in their functionality. In turn, this helped me to use them to address specific research questions.

3.9 Chapter Summary

I chose to use a constructivist methodology for my study because it was to be conducted in a 'natural environment'. My pretensions towards a democratic study demanded that my participants were inculcated at every step along the way. This, I felt, was important in the self-directed learning pedagogy that I support in my teaching. My teaching was also the natural environment from which I would derive much of my research data. Hence, I saw my research as part of my student-participants' learning outcomes also. The case study reporting style reflects this capturing of real-life episodes in its use of conversational style literary devices. This also completes the democratic study style by inculcating the reader through their vicarious immersion in the unfolding narratives of the case studies as they are told by myself and through the voices of the participants.

The study used inclusive game-like learning environments. The games were used to promote problem-solving skills in a risk-free experimental environment. Part of the overall democratic approach included introducing the students to the background technology used to develop the tools of study. This demystified how they were developed thus fostering a deeper engagement with how they could be used. It also overcame the anticipated disdain students ordinarily express when forced to work with 'inferior' technologies. However, once they understood

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customizing, hence it was not deemed necessary to include an analysis of the code used here.

why I chose VRML – mostly for its visual clarity – it was not raised as an issue. Its visual clarity was explained in broad spatially exploratory terms, and how this was crucial to understanding spatial concepts beyond the artistically realistic world-scenes they were more used to creating in CAD. It also made the necessary staging of the various game-like exercises clearer. At no time, however, did I explain what outcomes I expected from these explorations. Indeed, the nature of the study is such that I had no clear idea of what to expect – only that a particular issue related to a specific research question was being investigated. What the issues and the research questions were was not discussed.

As a teaching and research exercise the remote collaboration exercises were designed to bring into sharpest relief their combined aims. When the students helped their remote partners they were in effect performing the role of teacher. As Biggs (1999) identifies, learning occurs through teaching – students need to know their 'stuff' well to be able to teach others. Finally, the use of chat both helped the participants to concretise their ideas, and me to collect those ideas in a systematic way.

In the next chapter a series of case study exercises are described. Where possible (within the constraints of the pedagogic aims) each exercise builds on an issue raised by the previous exercise. Collectively, they map out a progression in spatial conceptualisation from simple manipulation of objects in a VE, a shared VE, to remote collaboration in a VE.

4.0 Introduction

This chapter contains the rationale, aims, recording of experiences, and analysis of the three core case studies that underpin this thesis. It sets out how and why these case studies were conducted, their pedagogical settings and outcomes. Each case study builds on understandings from the previous. Together they provide a rich source of analysed data which is discussed in more detail in the chapter that follows this.

4.0.1 Overview of Stakeholders

The three case-study exercises described in this chapter formed part of a course on Virtual Technologies within the broader scope of a Digital Media Masters program. The Digital Media Masters program focuses on experiencing and understanding the practices of using Digital Media in design and other professional areas within the scope of architectural or design practice. This includes: working in a design office; learning how to use new kinds of digital media: CAD, GIS, VR, QTVR, DVD; reviewing and developing skills in image making, desktop publishing, web page making and other areas, and discussions of the role of digital media in urban modelling and planning, landscape architecture, and product design. The Virtual Reality component, discussed in part here, introduced students to: coding for Virtual Worlds in VRML; navigation in a virtual world; and interaction in a multi-user virtual world; navigation and interaction with shared objects in a virtual world. These components form the basis for the series of case-study exercises which follow.

4.0.1.1 Participants

The exercises were conducted in 2002 and 2003. There were thirteen students and three teachers across the two years (four students in 2002, and nine students in 2003). All students had English as a second language. There were five female students and 8 male students. They all came from privileged backgrounds (see table 4.1).

Table 4.1. Distribution of student participant backgrounds, their observed personality traits and prior digital media experiences.

Cohort	Alias	M/F	Age	Ethnicity	Personality Traits	Prior Digital Media Experience.
2002a	Mary	F	28	Indonesia	Smart, inquisitive, applied, engaged	Graduate architecture student, average 'self taught' digital media experiences
2002a	Bob	M	27	Colombia	Smart, pushy, lazy, cheeky	Graduate architecture student, average 'self taught' digital media experiences
2002b	Julie	F	28	China	Bright, dedicated, diligent, inquisitive, quiet,	Graduate architecture student, limited digital media experiences
2002b	Sally	F	32	Sri Lanka	Bright, active, brash, applied	Graduate architecture student, limited digital media experiences
2003	Helen	F	30	Indonesia	Diligent, brash, engaged	Graduate architecture student, limited digital media experiences
2003	Trevor	M	32	Indonesia	Bright, talented, diligent, active, pushy, arrogant, opinionated	Graduate architecture student, above average 'self taught' digital media experiences
2003	Rod	M	28	Singapore	Talented, artistic, diligent, distracted	Graduate music student, above average 'self taught' digital media experiences
2003	John	M	29	China	Bright, talented, dedicated, diligent, passive, engaged	Graduate architecture student, above average 'self taught' digital media experiences
2003	Troy	M	27	Korea	Bright, diligent, applied	Graduate architecture student, above average 'self taught' digital media experiences
2003	Jack	M	30	India	Bright, talented, dedicated, diligent, applied	Graduate architecture student, average 'self taught' digital media experiences
2003	Denis	M	29	India	Bright, talented, cheeky, applied	Graduate architecture student, average 'self taught' digital media experiences
2003	Peter	M	27	India	Bright, lazy, cheeky, distracted	Graduate architecture student, average 'self taught' digital media experiences
2003	Ann	M	27	India	Inquisitive, active, distracted, applied	Graduate architecture student, average 'self taught' digital media experiences
2003	Tony	M	~50	UK	Distracted, engaged	Professor
2003	Dean	M	~45	Australia	Distracted, engaged	Senior Lecturer
2002-03	Theodor	M	38-39	Australia	Inquisitive, actively engaged	'Masters' architecture student, above-average 'self taught' digital media experiences

Of the three teachers, there was Dr Dean Bruton (director of the Digital Media Masters program), Professor Antony Radford (head of school at the time) and myself. Dean and Tony played only a minor role in the second case study, with minimal impact on the overall outcomes. On the other hand, I, the author of this thesis, was a participant-observer in all the case-study exercises. As such, my views, experiences, and conclusions form an integral part of the overall findings in these case studies.

4.0.1.2 Anonymity

To preserve the anonymity of the various participants in these analyses their names have been replaced with aliases. My name, and those of the other teaching staff have not been replaced.

4.0.1.3 Researcher Profile

I am a Caucasian, Australian-born, male researcher who was 38-9 at the time of the study. I hold two undergraduate degrees in Architecture, both with Honours, and a Masters of Regional and Urban Planning. I had no formal training in digital media. My digital media knowledge is as a self-taught 'code-hacker', sufficient to have worked as a CAD manager in a large architectural firm, and be part of a small group of IT consultants to local government in remote areas of the State of South Australia (developing websites, interactive CDroms, GIS database installations and so on).

My interest in 3D modelling was sparked by work as a work-experience junior architect in a medium sized firm. In 1995, with a staff of fifteen this included one CAD draftsperson. He was employed on a specific job which specified digital drawing production. He was using AutoCad to replicate what many others in the office were producing manually. I couldn't understand why he didn't model in 3D and produce 2D drawings from the model. I conducted some research into this concept in my own time and discovered early development in the virtual reality markup (or modelling) language (VRML). While only in its infancy at the time my thoughts regarding simple 3D modelling to 2D plans was transformed to interactive real-time 3D environments. I quickly modelled some of the proposals in the office but the principals of the firm were not interested in following this as a design and documentation method. To me, it seemed an innately more logical process for the architect than what I could see going on around me in that office. More than a decade on, the reality of this vision is far from realised. Hence, part of this study was always going to be an investigation into the efficacy of this method for practise.

As with most studies of this nature, the scope has been narrowed beyond the point where whether the notion of a real-time 3D interactive design platform for architects is feasible could be addressed in this thesis. However, I did enter this study with the notion that 3D virtual environments could be an innately logical method for design and documentation in the architect's practice. What it was that was innate or logical was not clear though. It occurred to me that a prior understanding of perspective imagery was usually referred to as a given, intuitive, or not in need of explaining (much as my subsequent literature review reports). Hence, I adopted my knowledge of interactive 3DVEs and (by the time this study was started) extensive ability at scripting in VRML, to the case studies described here to investigate if this were the case. Along the way I have not lost sight of the basic premise that 3DVEs are perspective by nature and that they would reveal this as a fundamental function in the way my participants used and described their experiences with them. However, in the 'doing' of this thesis I have discovered there is much more to the communication of spatial concepts than the question of perspective's intuitiveness. Those discoveries are contained in the following analyses.

4.0.2 General Overview of the Case Study Settings

The settings for each case study were slightly different. In almost all cases participants were physically separated and could only communicate with each other via online chat during the collaborative phase of the exercise. Typically the facilities used included the terminal in my office, a terminal on the next floor down in the staff library, and a third terminal two floors below my office in the digital media Lab. In case study 02, two staff office terminals on different levels, and the Computer Science's Computer Assisted Virtual Environment (CAVE) were also used. The layout for the digital media masters program included two separate computer labs on the same level, Lab A and Lab B. both labs included HP PC Intel 2GHz, with 256 RAM, and a 20GB hard drives installed. For the case studies 01 and 03, Lab A was chosen because it was physically separated from Lab B where most students had their personal spaces set up. This meant Lab A could be used in isolation without interference from, or disturbance to, the other students during an exercise session. In the second case-study exercise, for the 2003 cohort, with nine students, three teaching staff, and only five terminals available students were grouped in pairs. This meant there were at least two students at each terminal at the same time. All students were active in the second case-study exercise at the same time. In the first and third case studies, students worked in pairs but at separate terminals and only two students were actively involved in the exercise at any one time. The two teaching staff used their own terminals.

4.0.3 How to read the Chat dialogues

All the chat dialogues are included in the appendix E. The excerpts used in the analysis of the following case studies come from those dialogues. Reading the chat dialogues as a whole or in part is not a straightforward task. There are many instances where more than one conversation is running concurrent (see chat excerpt 0.1).

Chat Excerpt 0.1

262 Tony: Need to be a touch typist - otherwise people disappear while you're talking to them
263 Tony: I'm following theodor
264 theodor: that's true - it comes with practice
265 Peter: Lunch Time guys !!!!!!
266 Jack: well the wall is just a screen not structural
267 Tony: Where's lunch - in this world or the other one?
268 Jack: n i think there is a mistake in ur model
269 Peter: in me BAG
270 Helen: hahahaaha (DMM, 07/05/03, 11:30-13:10)

A topic may be broached at one stage of the chat and before a thorough response is forthcoming a new topic is begun. This can be confusing when attempting to read the chats retrospectively. However, during the exercise sessions this did not seem to pose a problem because participants could maintain a mental thread of the various conversations and respond with the appropriate pointers. When reading the chats in retrospect the reader should look for these pointers. The most common pointer was to identify the participant by name one was directing their question to or expecting a response from (see chat excerpt 02).

Chat Excerpt 0.2

150 theodor: Rod how will you communicate your arrangement?
151 Rod: ok
152 Rod: send snapshots to Troy
153 Rod: can he see me?
154 Rod: Troy can u see me?
155 Troy: no i can't see u !!
156 theodor: you can't send snapshots to each other!
15 theodor: Troy does not have a webcam! (DMM, 16/05/03, 11:30 - 13:50)

7

While I was involved in the chat exchanges and contributed to the ensuing discussions, I tried not to direct actions or responses other than when I felt a conversation thread which was pertinent to my research could be further teased out by continuing the conversation. It was at these times that I encouraged the relevant chatter to elaborate further (see chat excerpt 03).

Chat Excerpt 0.3

94 theodor: Helen i noticied you are loking at the model from above

95 Helen: yes

96 theodor: does this make it difficult to move the pieces?

97 Helen: it's casier for me (DMM, 16/05/03, 11:30 - 13:50)

The chat logs form the raw data for analysis in the case studies that follow.

4.1 Case 01: Physical versus Virtual Object Assembly

4.1.1 Introduction

According to neural network theorists (Gordon, 1989), how we distinguish physical objects from virtual objects (those depicted in a picture) follow similar physiological conditions to the recognition of outlines and filled in differences with shades of colour providing cues for depth in perspectival images; a mechanical action; in Gibson's (1979) ecological optics the same occlusions and invariants occur in pictures as they do in the physical world; and the cognitive scientist Gregory (1966) claims we need to 'learn to see', hence we also need to learn to read a perspective. In this first case study I am investigating how students of design communicate spatial concepts when performing similar tasks in virtual or physical environments. Hence, the various visual perception theories come into play in this study. To address this, participants were required to perform a similar task using either physical blocks or virtual blocks. The analysis of the number of possible grammatically correct permutations of an Australian Federation villa provides a vehicle for exploring the differences between performing the task in the physical world and a virtual world. My task was to detect how they communicated their design moves.

4.1.2 Why a Federation Villa?

In Radford's (1994) paper *Local Architectural Language and Contextualism*, he discusses the grammar of suburban housing in a particular street in Adelaide. Consisting mainly of typical 1900's Australian Federation villa style houses, their pattern-book derivations represent an almost complete collection set of built permutations (see figure 17). Their grammar or features considered as a whole within a recognisable design language provide a lexicon for investigating further possible and desirable permutations. In this exercise the syntax developed by the arrangement of individual pieces comes together in a topological way representative of a 'block grammar'. This was used as a motive for exploring the correlation between its physical and virtual understanding (see Figure 2). The 'block grammar' theme was chosen among other possible themes because it appeared to contain an easily achievable outcome and was a simple collection of discrete objects able to be rapidly modelled in most CAD software. It also has considerable aesthetic value as an exercise (an important consideration for a teaching program wanting to retain relevance and interest). It is also an easily determined practical task.

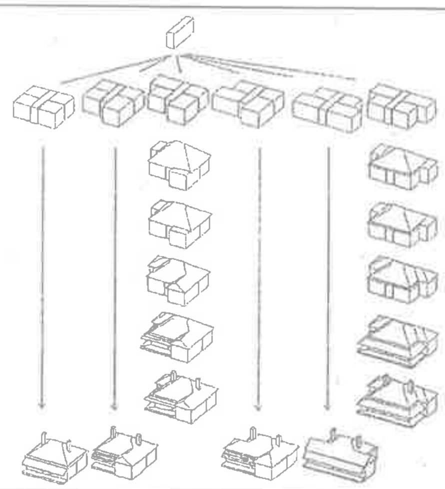


Figure 17. 'Block Grammar' for a suburban house in Adelaide showing possible (though not exhaustive) permutations which generate an urban streetscape (Radford, 1994, p170).

4.1.3 Pedagogical Aim

The pedagogical aim of this exercise was to introduce students to a form of remote collaboration or cooperation (a secondary pedagogical aim was to provide a cursory introduction to shape grammar).

4.1.4 Research Aim

The research aim of this case study was to record how students communicate spatial concepts.

4.1.5 Setting

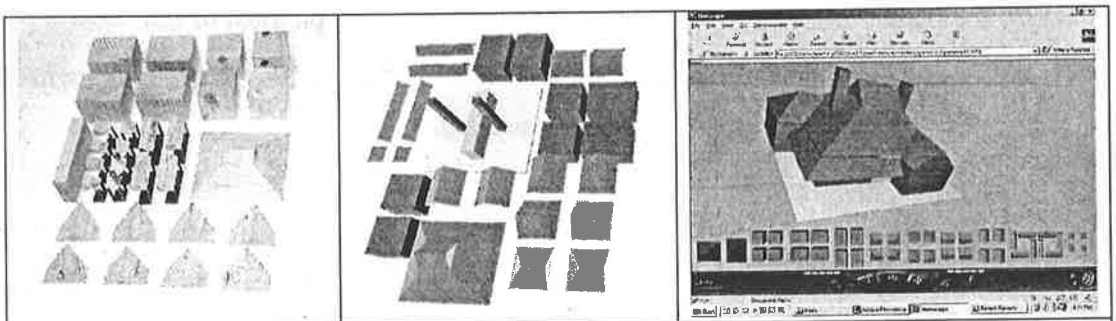
Participants worked in pairs and were located in different rooms on the 3rd and 5th levels of a 5-storey building, the researcher was in another room on the 4th level. They could only communicate via an online chat screen. In 2002 there were only two students (1 male and 1 female) and the researcher. The three of us were located at different terminals in different rooms on the third and fifth levels of a five-storey building. We could only communicate with each other via an online chat interface. In 2003 there were five students (4 male and 1 female), two staff members (both male) and the researcher. Participants could chose from one of the two separate installations in offices on the 3rd or 5th level, and either the physical or virtual 'kit-of-parts'.

The pairs were required to determine the maximum possible permutations for the 1900's Australian Federation villa described by Radford given either a physical or virtual kit of parts. They were shown both at the beginning and asked which they would prefer to work with. One participant worked with the physical kit-of-parts while the other worked with its 'virtual' counterpart (see Figure 18). Both participants were required to cooperate in reaching consensus on how many permutations were possible.

The rules for constructing the villa forms were:

- There can be no more and no less than four rooms surrounding a central corridor;
- All rooms must be completely covered by a roof; and
- Verandahs should be placed where appropriate.

With the physical kit-of-parts, participants could turn the blocks over, smell, (taste), feel them, and eventually assemble the various shapes on a masonite base plate – sliding verandahs up to room blocks with extended gables or hip blocks over the main roof, thus completing a 'house'. The virtual kit-of-parts did not allow participants to turn over, smell or feel the blocks. They could, however, rotate or roll their view to see 'under' or 'behind' the blocks and their assemblages. They could also zoom in on the spaces created, thus, view them at a one-to-one scale. 'Clicking' on the representative blocks on the Heads-Up Display (HUD) panel triggered, larger, movable, blocks to 'appear' in the virtual world (see Figure 18). By using the plane sensor associated with these blocks, participants could move, but not rotate, the blocks in the x-z plane. Blocks could pass through each other allowing for possible configurations outside that prescribed by the rules or possible with the physical blocks alone.



a) Physical wooden blocks.	b) Abstract virtual blocks.	c) Screen grab of virtual blocks interface with Heads-Up Display (HUD) in Netscape.

Figure 18. Block grammar kit of parts.

4.1.6 Assessment Criteria

Students were assessed on their individual contribution to the joint exercise. The criteria used to determine their grades included:

- Was the student able to reach consensus with their partner on how many permutations are possible?
- Did the student establish a common protocol for communicating their ideas across the chat channel?
- Did the student contribute directly to their own learning by creating effective, progressive screen-grabs or web-cam shots which they then reflected upon?

For each criteria the possible marks ranged between:

0 = no

1 = with help

2 = without help

3 = expertly

4.1.7 Method

A series of steps or stages were incorporated into the exercise and subsequent analysis of the data collected. Three participants (including myself) were located in separate rooms. As well as following the chats as they proceeded I took brief notes on my preliminary assumptions of what I could glean from the chats. At the conclusion of each exercise I asked two pre-prepared questions using the chat interface:

- Describe your experience of working with the physical/virtual model and how this might compare to that of the other's work with the virtual/physical model.
- How do you think you would have seen things differently if you were working with the virtual/physical model instead of the physical/virtual model?

I met with the participants immediately following completion of the chat exercise. This enabled me to ask further questions to clarify points raised in the chat sessions. Sometimes this required yet further clarification. In such cases a subsequent meeting was organised either the same day or at least on the following day. Hence, feedback triangulation took place within the chat environment, straight after the exercise and in the following days. This took three forms: the student-student chat conversations, the student-teacher chat and interview conversations, and the student-teacher-student chat and interview conversations (see example of Triangulation section in Chapter 03).

4.1.8 Participant's Experiences Recorded in the Chat Logs

The following chat log excerpts were extracted from the full chat logs from the 2002 and 2003 sessions contained in the appendix E. While many of the same issues were raised by both the 2002 and 2003 cohorts and recorded in their chats, the 2002 cohort's chat logs seem to contain the richest detail. Hence, the 2002 chat log is used extensively in this analysis with 2003 chat log excerpts inserted as counter points or to demonstrate similarities across the two cohort's experiences. The various partnerings are shown in table 4.2

Table 4.2 Table showing physical and virtual blocks partnerings.

Year	Physical blocks partner	Virtual blocks partner
2002	Mary	Bob
2003	Helen	Trevor
2003	Rod	Troy
2003	Jack	John
2003	Denis	Peter
2003	Ann	Denis

4.1.8.1 The Chat Dialogues

Immersed in the task, participants spent most of their time trying out all possible permutations. Rather than seeking an orderly solution, they tended to try different 'designs' assuming the possibilities would be quickly exhausted thus arriving at 'the' solution (see figure 19(a)). However, getting oriented with the virtual and physical blocks emerged as the key problematic to achieving their design communications for both the 2002 and 2003 cohort. For example, in chat excerpt 1.1, Helen (from the 2003 cohort) was explaining to me the difficulty she was having moving the virtual blocks around – they seemed to 'disappear'.

Chat Excerpt 1.1

89 Helen: but it's difficult to move it
91 theodor: why are they difficult to move Helen?
92 Helen: [I] dont know
93 Helen: sometimes i lost them
94 Helen: so i have to find it (DMM, 30/04/03, 12:14).

During this part of her session, Helen emailed me a screen-grab of what she could see in front of her. From the image, I noticed she had the view tilted, so she could look at the blocks from above (see Chat Excerpt 1.2).

Chat Excerpt 1.2

97 theodor: Helen i noticed you are looking at the model from above
98 Helen: yes
99 theodor: does this make it difficult to move the pieces?
100 Helen: it's easier for me
101 Helen: ... i can see all of ... [the pieces] (DMM, 30/04/03, 12:16).

Not only did it appear to be easier for her to move the pieces around from above but she could more easily see the 'layout' from above and visually plan for her next move. The 2002 cohort similarly adopted this 'above view'. They used it to get an overview of their designs. But orienting themselves about either the virtual or physical blocks was still problematic for both cohorts. The first strategy they tried included forming a letter from the alphabet. For the 2002 cohort, it was the letter 'H' (see Chat Excerpt 1.3)

Chat Excerpt 1.3

8 Bob: it is like a letter H (DMM, 7/5/2002, 11:25).

Still in the designerly mode, use of the letter 'H' seemed to prompt exploration of new rules, not a part of the initial prescriptive set. For example, there emerged the perceived need to use a verandah block to cover 'holes' left over from designing the Villa in a 'H' shape (see Chat Excerpt 1.4a and figure 19(b)).

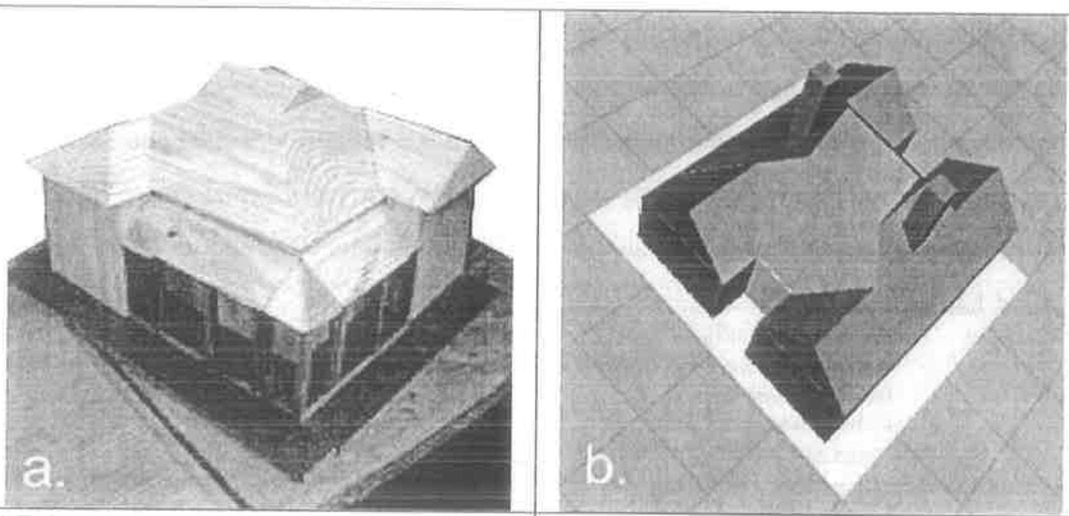
Chat Excerpt 1.4a

30 Bob: did you cover the holes [left between extended rooms] with verandahs? (DMM, 07/05/02, 11:34).

Sometimes this caused confusion. It was not always clear what orientation the other was referring to. This is where iterating the various moves became crucial to a final design action (see Chat Excerpt 1.4b).

Chat Excerpt 1.4b

39 theodor: so you are talking about the |-| model and about filling the gaps so it should be like |=|? (DMM, 07/05/02, 11:20-13:10)



A Federation Villa assembled from the wooden blocks or physical kit-of-parts.	'H' configuration using the virtual kit. Note the 'hole' left over between the extended the gables forming a 'H' configuration.

Figure 19. Assembled blocks.

The 2003 cohort also investigated shape as an orientation strategy (see Chat Excerpt 1.5). But it did not seem to prompt any further exploration of the shapes formed.

Chat Excerpt 1.5

385 Denis: now im going to use the square on the left and the rectangular on the right to create an l-shape (DMM, 30/04/03, 13:16).

However, prior to this, they did debate what the 'real' goal was for the task I had set them. One pair suggested the task was about creating a vocabulary, set of rules, and language from the visual information as a method for communicating their design ideas (see Chat Excerpt 1.6a).

Chat Excerpt 1.6a

249 John: maybe Theodor… [wants] us to create a language to describe what to model
250 John: like vocabulary and rules
275 John: we should change the visual info into human language, like text
276 Jack: yes, but how do we [do] that?
277 John: it would be better if it is in Chinese (DMM, 30/04/03, 13:02).

Most of these meaning-making explorations about the task tended to return to the core issue of finding a communicable set of rules or guidelines. While this was mentioned by all partnerings, most did not actually establish any rules (see 2003 Chat Excerpt 1.6b).

Chat Excerpt 1.6b

160 Rod: we have to establish some rules then

226 John: maybe we should setup some rules first

600 Denis: theo is there a rule for how the roofs sit next to each other?????
(DMM, 16/05/03, 11:30 - 13:50)

On the other hand, those that did formulate rules tended to focus on an orientation rule. This was consistent across both the 2002 and 2003 chat logs analysed. For example, in Chat Excerpt 1.7, Bob chose to pursue a centralised y-axis strategy.

Chat Excerpt 1.7

35 Bob: let's try this one
37 Bob: put the large ones, on y axis, underneath x axis
38 Mary: underneath x axis?
48 Mary: the x axis is looking at you?
49 Mary: at your computer monitor? (DMM, 7/5/2002, 11:41).

But at first this seemed to be confusing for the partner with the physical blocks. Bob then attempts to explain to Mary what he meant (see Chat Excerpt 1.8).

Chat Excerpt 1.8

50 Bob: let me explain [it to] you
51 Bob: up[per] right corner y axis with the large one
52 Bob: down right corner x axis with the large one
54 Bob: left down corner -y axis with the large one
58 Bob: and left upper corner -x axis with the large one
62 Mary: i am confused
75 Mary: ...[does] y axis mean along the corridor ?
76 Bob: yes along the corridor (DMM, 7/5/2002, 11:55).

Mary was still confused until Bob revealed the y-axis was actually aligned with the corridor – a central and fixed feature of the Federation villa meta-design. In the 2003 cohort the corridor was similarly chosen as an orientation strategy (see Chat Excerpt 1.9).

Chat Excerpt 1.9

433 Peter: start by placing the corridor
434 Denis: u place 4 rooms in combinations and tell me and then ill recreate the here

435 Peter: place it in the middle of the floor plate
436 Denis: done
437 Denis: done
438 Peter: now place two square on either side of it
439 Denis: then?
440 Denis: we're supposed ti have 4 rooms not 2
441 Peter: done?
442 Peter: ok i shall add another two
443 Denis: fine so 4 squares on all 4 corners
444 Peter: take two rectangular shapes and add them to either side of the corridor
445 Peter: yup four squares
446 Peter: two on either side of the corridor
447 Denis: yeh done
448 Peter: cool
449 Denis: 4 squares are ready
450 Peter: now lets put a roof over these
451 Denis: now which roof r u using?
452 Peter: lets put the big roof
453 Denis: ok
454 Denis: done
487 Denis: lets try something else now (DMM, 30/04/03, 13:59).

For both these pairings, once the corridor had been established as a point of reference for orienting their subsequent designs. They re-focussed on trying different designs.

4.1.8.2 Reflective Dialogue

Within the chat environment, and at the end of each session, I asked prepared questions of my captive audience. The first of these was to ask each partner "what difference do you think there is between working with the virtual blocks and the physical blocks?" In the 2003 cohort Jack described how they felt and John described being confused (see Chat Excerpt 1.10)

Chat Excerpt 1.10

233 Jack: in physical model you can feel the change
236 John: it is a little confusing (DMM, 30/04/03, 12:57).

The response to the same question for the 2002 cohort solicited a more considered response (see Chat Excerpt 1.11).

Chat Excerpt 1.11

233 theodor: and Mary i want you to describe your experience of working with the physical model and how this might compare to Bob's work with the virtual model.
236 Bob: ...it [would be] better to have a code [(strategy)] first to communicate [our ideas such as which] ...axis [we are working on]
237 Mary: it is really nice working with the physical model, but [the] first time was difficult for me to understand Bob's command with the axis
238 Mary: i agree with Bob, [it would have been better if] we had [the] same perception about [an] axis code [before starting]
242 Mary: Bob started to use the term axis in relation to xyz etc but this got confusing
243 Bob: it is not confusing!
244 Mary: yes [it is Bob] becoz you didn't mention it the first time, about the y axis
245 Mary: is it along the corridor or not?
247 Mary: yes! [it is Bob, because] ...you can see the axes in the vrml screen
248 theodor: what axis can you see in the vrml screen Bob?
249 Mary: but you have to imagine i didn't work with vrml screen!
251 Bob: it is clear that this is a 3D modelling tool [and] all 3D modelling tools work under [the same] axis language

252 Bob: and moreover i like it because it was a real time animation or modelling
253 Mary: but if we work in form z [(a different, non-real-time, CAD modelling package)], it has different axes (DMM, 7/5/2002, 12:49).

Their reflections tend to suggest it was easier to ascertain the axial relationships with the virtual blocks than the physical blocks. Despite John's expressions of confusion, the consensus across both groups was that it was easier to get oriented in the virtual environment than using the physical blocks.

4.1.9 Chat Dialogue Analysis

The day following each session, I organised an interview to clarify issues raised in the chats that had not been addressed during the session. With most of the participants from the 2003 cohort present, I asked them why they spent so much of their time trying different design permutations rather than discussing an orderly solution, or working it out on paper fist. The overwhelming response was that they "didn't think there were [going to be] many different designs so… [it should be] quick to find the solution." Nevertheless, it is interesting to note that they considered the possibility that there was a solution – albeit a design solution. However, that they were not concerned that they did not find this solution was indicative of the 2003 cohort's overall superficial engagement with the exercise. Indeed, chat excerpts 1.6a and b seem to demonstrate how they thought that somehow the 'real' purpose of the exercise was hidden.

The 2002 cohort, on the other hand, pursued a design solution more exhaustingly. They seemed to be more seduced by the colour and infinite scalability of the virtual blocks, and the tactility, smell and noise of the physical blocks, to see the task as anything but a design exercise. It did not occur to either cohort that it was simply a mathematical problem – solvable on paper.

4.1.9.1 Self-Imposed Rules

The designerly approach to the task by both cohorts often masked their ability to stay on task. Their design-priority saw, new, self-imposed rules emerge which were not a part of the prescribed set. For example, there emerged the perceived need to use a verandah block to cover 'holes' left over from designing the Villa[18] (see Chat Excerpt 1.4a and figure 19(b)).

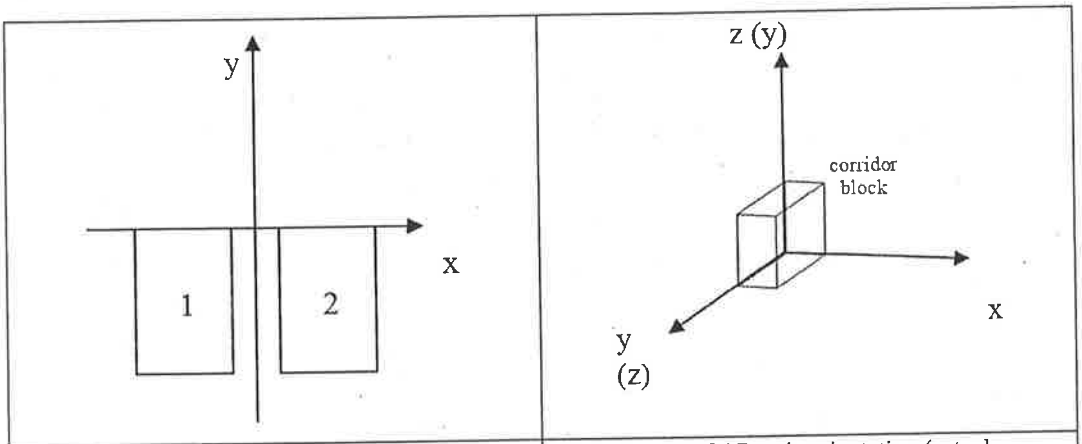
[18] In fact, my use of the phrase "verandahs should be placed where appropriate" proved to be a source of confusion – 'appropriate' meant something different to individual participants.

Their perceived need to cover the holes left over from one of their designs revealed also a strategy for communicating their design ideas – the use of the letters of the alphabet as a form generator. In the 2002 cohort it was the letter 'H' (see Chat Excerpt 1.3), and in the 2003 cohort it was an 'L' shape (see Chat Excerpt 1.5). In neither cohort, however, was the use of alphabetical shapes pursued at length. Instead, other strategies were tried. In 2003, one pair suggested the task was about creating a vocabulary and set of rules from the visual information (see Chat Excerpt 1.6a). However, this was also not pursued at length.

4.1.9.2 Getting Oriented in the Design Space of the Virtual and Physical Environments

Getting oriented was clearly a priority for communicating their design ideas. When Helen (from the 2003 cohort) emailed me a screen grab of a problem she was having with manipulating blocks in the virtual environment (see Chat Excerpt 1.1), I noticed from the image she was viewing her blocks from above. When I asked her the next day, at the organised interview, why this was so, she answered it was easier to "work out what's going on and move [the blocks]." This above view was both a design and orientation strategy. From above she could see the layout of the blocks and the shapes they formed.

In the 2002 cohort's Chat Excerpt 1.7 Bob attempted to embed a Cartesian coordinate system in his design communications. Bob put the viewing firmly along the y-axis (the y-axis is that coordinate vector which has its default direction pointing out of the screen in a typical CAD program). Bob was trying to negotiate a strategy with his partner for 'getting spatially oriented'. Following this, I noticed that, for the remainder of the 2002 cohort chats, Bob tended to lead the conversation, design, and orientation strategy. In terms of orientation, whether his domineering personality meant his partner slavishly followed his instructions, or his confidence came from 'knowing' which way was up because the virtual blocks were circumstantially framed by a 3-coordinate axial system is not clear. However, his orientation strategy *was* followed by his partner. For example, in chat excerpt 1.7, when Bob typed, "put the large ones, on [the] y axis," Mary appeared to straightaway recognise the y-axis orientation and asked "underneath [the] x axis?" This suggests there was an above and an underneath for the y axis divided by the x axis. This should make sense, as, ordinarily the two axes bisect each other on a plane (see figure 20(a)).



a) Two blocks under the x-axis	b) Typical 3D CAD axis orientation (actual VRML axes in brackets).

Figure 20. Real and imagined and CAD axial orientations.

However, Mary appeared to be confused by Bob's further reasoning. On the next line, where she says, is "the x axis… looking at you,… at your computer monitor?," did she mean its vector direction was out of the screen? Figure 20b and figures 21a and 21b demonstrate that in no instance can the default x-axis point out of the screen. That she was simply confused was confirmed in the interview organised the day after the exercise.

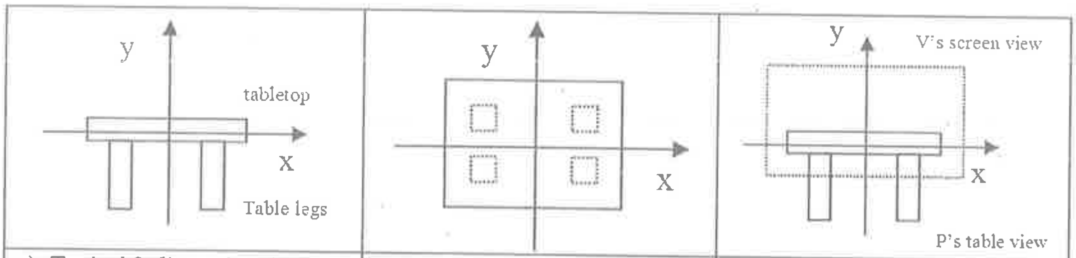
From the interview, it appears Mary had mistakenly conflated her physical reality with that of her imagined 'Bob reality' (not Bob's actual reality – for Mary cannot possibly 'know' this – but her constructed reality of what she 'imagined' Bob's reality to be). The fact that she chose to refer to the *y* axis as having an *above* and *underneath* appear to be terms more familiar to *her* (physically-oriented) environment. She could not see what Bob was seeing, and Bob could not see what she could. Hence, she needed to interpret Bob's instructions *in terms of her own (physical-world-oriented) reality*. Mary had to imagine what Bob was looking at (his screen) and overlay this with what she *thought* Bob could see on his screen. As Mary was looking at her blocks from above this also meant that Bob was looking at his blocks from above. In other words, Mary *imagined* Bob looking from above at his blocks. His blocks would thus be tilted up appearing in the same plane as his screen. Hence, his screen represented a surface in the x-y plane. Furthermore, although her eyes were not positioned at right angles above her blocks (the blocks were on the table below her at elbow height) this is how Mary 'saw' them in her 'mind's eye' (see figure 21b) (as mentioned earlier, this looking or 'seeing' from above occurred also in the 2003 cohort (see Chat excerpt 1.2)). Juxtaposing the tilted-up image that she imagined Bob was seeing with what she could *actually* see (her blocks closer to elevation than plan), then, for Mary, "beneath the x axis" was *physically* beneath her table (see figure 21a); and, her comment, is "the x axis…looking at you?," actually meant 'is the *screen* looking at you?' (and not the x-axis as such) – which for Bob of course it was (see Chat

Excerpt 1.7). For a moment, Mary did not distinguish between the vertical orientation of her physical world as depicted in figure 21a and what she saw in her mind's eye depicted in figure 21b, and Bob looking from above but having a tilted view in his screen depicted in figure 21c.

From this short analysis (and subsequent interviews) I can identify the constructed visual realities or 'visual switches' Mary experienced as:

- for a moment, Mary imagining Bob's blocks (in plan) at right angles to his screen and her 'seeing' this in her 'mind's eye';
- Mary observing her blocks at an oblique angle yet 'seeing' them from above (see figure 21b); and,
- the conflation of the *reality* of her blocks at an oblique angle – closer to elevation than plane – and her imagined screen of Bob's. In other words, she visualised Bob's blocks from above overlayed with her elevated view (see figure 21c).

Although these events only describe for Mary a moment of confusion they still reveal a number of constructed visual realities. All of them relate to 'getting oriented'. The confusion was about whether to orient herself in the physical world or her imagination of her partner's virtual world resulting in a conflation or juxtaposition of the two.



a). Typical 2-dimensional axis orientation in elevation.	b). Typical 2-dimensional axis orientation from above.	c). Conflation of a) and b).

Figure 21. None of these orientations have the x-axis pointing out of the screen.

Turning my attention to Mary's partner working with the virtual blocks, I found the question I needed to address was 'why did Bob choose to orient his view around the y-axis?' Why not some other orientation? Two reasons came to mind: in the first, like Mary, Bob adopted the familiar *x,y* axis bisecting each other on a plane in front of him – the y-axis pointing out of the screen (see figure 20b). In the other, as the instructions state, "there can be no more or less than four rooms surrounding a central corridor," Bob may have simply adopted the corridor as a starting point because it appeared to be initially positioned along the y-axis. Indeed, in the subsequent interview, Bob confirmed this: that it was the central corridor that he 'saw' as pointing away from him lengthways and that this was also how it appeared by default in the virtual environment (see figure 22). This further reinforced the notion of a 'given' axial relationship.

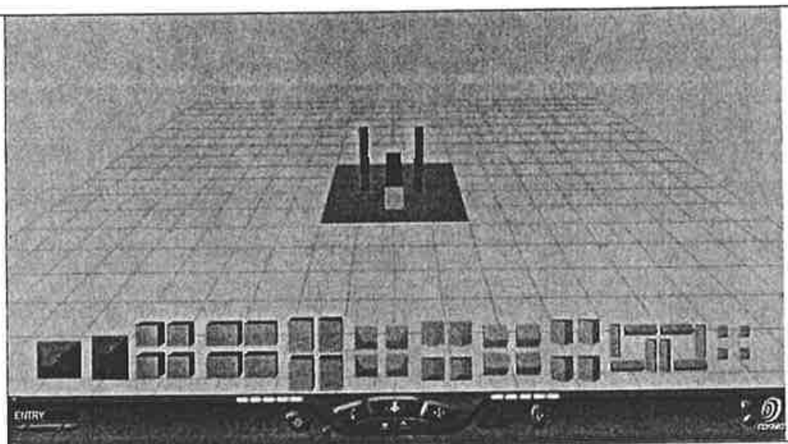


Figure 22. Virtual blocks showing default central corridor and chimneys.

Unlike the physical blocks, which are loose and can assume any default orientation out of their storage container, the virtual blocks start with the corridor 'in place' and running lengthways away from the viewer (it also includes two fixed chimney stacks typical of a federation villa but not included with the physical blocks). This is circumstantially along the y-axis (in fact, it is along the z-axis in VRML, but logically, in a CAD program, it would be along the y-axis (see figure 20b)). It follows then, that, (at least for the participant working with the virtual blocks) because the virtual environment is inherently both orthogonal and a constructed Euclidean space, the corridor falls on the y-axis (or z-axis in VRML) and all other manipulations must proceed from here (see figure 20b). From the 2002 chat excerpt 1.8 it appears that Bob has indeed oriented his axes in accordance with the rules and the default virtual block orientation – ((z)y-axis) along the corridor) (see figure 23).

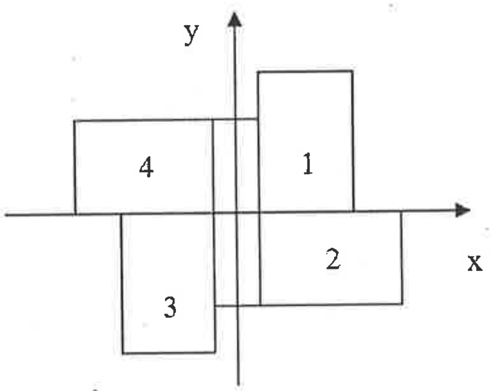


Figure 23. Following Bob's instructions in chat excerpt 1.8 a fan-like form takes shape.

The 2002 and 2003 cohorts seemed to arrive at similar conclusions about the role of the corridor as a logical point of reference for orienting and communicating their design permutations (see 2002 Chat Excerpt 1.8 and 2003 Chat Excerpt 1.9). In the case of the 2002 cohort, once Bob had removed Mary's confusion by revealing that the y-axis should be along the corridor (see chat excerpt 1.8), she seems to have followed his subsequent instructions with ease.

However, there remains the question: how would the instructions have been communicated if they had come instead from a dominant partner working with the physical blocks? Why this did not occur in either cohort is not clear. To investigate how this scenario might have unfolded, I have assembled what I imagined could have been just such a communiqué in the following imaginary chat excerpt with a fictitious participant (FP) manipulating the physical blocks instructing their partner with the virtual blocks:

> FP let me explain it to you
> FP assume the corridor is running away from you
> FP now add a rectangular block, also running away from you, on the right-hand side of the corridor, and to the back
> FP now add another rectangular block, long-side facing you, in front of the first block
> FP next, add another rectangular block, running away from you, or short end towards you, on the left-hand side of the corridor, closest to you
> FP last, add another rectangular block, long-side facing you, behind the previous block

The next day I asked an independent participant (not from either cohort) to follow these instructions with the virtual blocks to confirm this was a legitimate set of instructions. It produced the same outcome as Bob's depicted in figure 23. This, fictitious, chat conversation is clearly a more verbose version than the instructions Bob gave for his partner using the physical blocks. Nevertheless, the real value in this sub-exercise is in the way it exposes the structural relationships of the previous non-fictitious communiqué. For example, the main difference between my physical-world oriented instructions and Bob's virtual-oriented counterpart is that the coordination in this case revolves around the terms: left, right, back, front, towards, behind, facing, closest, away, long-side, and short-side. In all of these descriptors the viewer is implied. In some cases this is explicit – away from you, facing you, short end towards you, closest to you. In others, the viewpoint of a block is cognised in relation to the self (something Piaget and Inhelder (1956) describe as a necessary pre-condition to being able to 'see' in 3D) – behind, in front of, to the side of (another block), and so on. In my physical-world oriented explanation, one can identify the visual switches as: self, object in relation to self, and blocks in relation to each other. As a sub-exercise it helps also to expose the underlying dominance of the inherent axial relationship of the virtual media over the physical media. That this scenario *had not* occurred in any of either the 2002 or 2003 partnerings further suggests that either: every partner that worked with the virtual blocks had a more domineering personality than their counterpart working with the physical blocks; or, the media itself engendered the confidence to lead the exercise/task. In turn, the perceived superiority of the virtual over the physical on the part of the partner working with the physical blocks may also be implicated. In other words, the task 'seemed' much harder to do with the virtual blocks, hence the person with the physical blocks *led by asking questions*, or was *allowed to lead by their partner being passively dominant*. Either way, based on their reflections and my reflections (discussed in more detail later), it tends to suggest the choice of media influenced the outcomes – especially considering the task is essentially a mathematical problem (see Chapter 05 for the mathematical solution).

4.1.9.3 Seeing in 3D, Communicating in 2D

What was of interest to me here was what the spatial experiences captured and communicated in the chat logs could tell me about how the way the participants' pre-acculturation to perspective affected their interaction with both the physical and virtual blocks, if at all?

While most of the communiqués described manipulations in a 2D plane their textual expressions of the 'space of design' tended also to be flattened. Despite the overt three-dimensionality of this exercise, it was as if the third axis was redundant. There was an instance of this redundancy of the third axis in Mary's confusion (discussed earlier). It was only when she tried to communicate her moves, and interpret Bob's instructions, that she needed to incorporate a 3-axes system, and this led to her confusion. Moreover, Mary's double image of her imagining of Bob's view from above, conflated with her own elevated view, – neither of which require a third axis – were all transformations in 2D (see figure 21c). Hence, it could be argued that the nature of the exercise was inherently 2D – transformations about 2-axes only. But, the exercise was equally explicit about generating house forms which were three-dimensional.

Therefore, it seems that, while the insistence on an axial orientation may be a product of the three-dimensional media, most of the visual manipulation was done in the picture plane which does not require a perspectival view. In other words, their cognitive actions were incommensurate with their need to communicate using a 3-axes system. In turn, this suggests the 3-axes communication system was merely one tool among many that could have been used. For example, the exercise could have been conducted entirely in 2D, or numerically as a mathematical exercise. The 3-axes system was simply the tool they were most familiar with as designers of 3D space. Here it can be suggested that the 3-axes orientation strategy was a product of their familiarity with perspectival media and documentation and interfaces which tend to emphasise 3D media. After all, most of the conversation was given over to aesthetic considerations and not with the best way to find a definitive solution. In other words, they were more motivated by visualising pleasing architectural designs than performing the abstract operations necessary to complete the task. It was only when they were focussed on the task-oriented descriptions that their design moves needed to be flattened. Here the visual switches were between 'pleasing architectural form' in 3D and 2D pragmatic manipulations of the actual architectonic elements. This does not imply that they did not 'see' depth in the images of their imaginations, rather that the depth information was redundant, suppressed, or subconscious.

4.1.10 Overall Outcomes

From the collection of chat excerpts analysed in this case study I can make some preliminary interpretations of the overall outcomes of the exercise. Central to this is the notion that there were multiple spatial realities the participants visualised when communicating their design explorations. From these, two emerge as the most significant:

- The language they used was not graphical (using pictures), although it was visual (using words to describe pictorial relationships). It was symbolic and it relied on pragmatic *and* aesthetic considerations typical of design students. (Hence, it would be interesting to try this exercise with non-design students to see what results this produces.); and,
- The need for an orientation strategy was predicated on, at least, a two-axis coordinate system because:
    a) that is all that was needed;
    b) they worked in the 'above' mode; and/or
    c) all the moves were inherently in a two-dimensional plane despite their three-dimensional form. "Because that's how we work" (DMM, Bob, 2002) This raises the question "what is the relationship between a planar working method and the marking out of 3D space?" (this is addressed in the next exercise).

4.1.10.1 Perspective Related Outcomes

Their spatial realities were reported and captured in a highly socialised context. This is where the constructivist methodology adopted makes its main contribution to the study, in a pluralist rather than generalist manner. Constructivism recognises the social sphere of designing; different people provide different results. Hence, it poses more questions than it answers. All one can hope for is a more sophisticated understanding about a specific situation taking into account as many contextual influences as deemed necessary by the researcher with agreement from the participants of the study. I have included here a collection of interpretations specific to this case study regarding what this case study tells me about the affect perspective had on the design moves it describes. The key issues raised may or may not be transferable to other settings. I found perspective appeared to affect the participants' inter-play with the media in a number of ways.

4.1.10.2 Related to Theories of Perception

Participants needed to be able to recognise the virtual blocks in perspectival media. Following Gibson's (1979) ecological optics this is not a problem because the same occlusions and invariants occur in pictures as they do in the physical world; following Gregory's (1966) notion that one needs to 'learn to see', then clearly learning to read a perspective is central to understanding what one sees on the screen; but, following Gordon's (1989) neural network theorists it is a mechanical action that neither needs learning nor is it dependent on similarities with physical environments. Hence, the question is not so much "whether they need to be able to recognise perspective media" but the manner in which this recognition occurs. Bob has to imagine what Mary is 'seeing' and vice versa. Hence, do they visualise in perspective? From the chat log analyses they seem to visualise in pictures, but whether these are perspective pictures, in the sense that they are conscious of 'depth' in the image, is not clear. (This question arose after the students were no longer available for interviewing, so I could not ask them directly.)

4.1.10.3 Axial Relationships

Most transformations were executed in a 2D framework suggesting perspectival depth is *not* necessary. This could be a function of the exercise – predominantly about layered 2D transformations: rooms around a corridor; and, roof extensions on a main roof. Alternately, that they chose an axial coordinate system to communicate symbolically, would tend to suggest they were visualising in 3D but acting in 2D. Moreover, the axial coordinate strategy was perceived as easier in the virtual space because, as Bob typed, "all 3D modelling tools work under [the same] axis language", hence there is an implied coordinate system. This was consistent between the 2002 and 2003 cohorts. Indeed, both the 2002 and 2003 cohort agreed that using the corridor as the y-axis made the most sense and was a good strategy. This was not immediately obvious for the physical blocks. This could be because:

- the participants with the physical blocks were not good at spatial organising;

- the organisational strategy was structured by social norms: a dominant or passive partner;
- the participant with the physical blocks was working in the space of the objects whereas the participant with the virtual blocks was manipulating the controls of an abstract machine;
- my choice of orthogonal blocks – a pragmatic choice because I am (also) acculturated to such choices; and/or
- the 3-axes system is such a dominant feature of a prior-acculturation to a perspectival spatial organisation that alternatives were not considered.

However, my explanation for the redundant depth axis in perspective construction which is replaced by an *innate* sense of depth, means what a perspective is may need to be redefined. This is further inferred by my construction of a fictitious participant (FP) conversation, where FP instructed their partner with the physical blocks on how to construct a form based on FP's physical-world manipulations. In this case, an axial arrangement is still in place, but it is not as objective or detached from the self as in the virtual. This perceived need to organise space along axes to give it substance is what Lefebvre and Romanyshyn suggest one does when one tries to describe space verbally or literally.

4.1.10.4 Related to Perspectival Axes

Finally, whether the communication of design moves between manipulators of a physical and virtual collection of blocks, forming the lexicon for a Federation villa grammar, is affected and/or effected by a prior acculturation to perspectival technologies is not clear. On the one hand, a dominant 3-axes spatial system was dominant in communicating moves, suggesting it is both effected by a pre-knowledge of 3D geometry and affected due to its dominance over other forms of spatial communication. On the other hand, an alternative form of spatial communication was revealed in my fictitious conversation – more personal, topological and haptic. Piaget and Inhelder would describe this as a more natural spatial orientation – not reliant on abstracted axes. It is only when one adopts the axial strategy proposed by the participant working with the virtual (perspectively generated) system that the participant working with the physical blocks makes their design moves within the geometry of the perspective paradigm. That this was so rapidly taken up suggests a readiness and prior preference for working within the perspective paradigm (also reflected in comments about wanting to work with the virtual blocks rather than physical because it appears easier to get oriented, and so on)[19].

4.1.11 On Reflection

I set out to investigate how design students interact with two types of media. I thought, by giving one student a virtual version of some physical blocks and the other the physical blocks, and the only way they could communicate was via online chat, that they would have to devise a strategy for communicating their design moves. I did not know in advance what this would necessarily 'throw up' (in Guba and Lincoln's sense), other than: I had design students working with the medium they are most accustomed to, architectural elements, and that they had to describe their manipulations to each other as they proceeded. The motive for having them physically separated and using online chat was twofold: firstly, to make the job of recording their interactions more precise (instead of using a tape recorder which allows for the possibility of tacit information exchange which is difficult to capture); and, secondly, so they were forced to concretise their thoughts by typing them. A primary assumption was that the virtual environment was a perspectival medium and that *how* the participant working with this medium interacted with it would reveal itself through the exercise. I did not know in advance just how this would occur or even what to look for. What happened of most significance in relation to the core topic of this thesis, how students navigate and interact with 3DVEs, was their perceived need to 'get themselves oriented' in the spaces. This was not contingent on the virtual model. However, the 3D environment of the virtual world did act as a trigger to suggest a strategy. Although, it could also be argued that they would have arrived at an axial strategy without the virtual environment (as suggested by the fictitious chat conversation I provided earlier). Either way, it suggests that an acculturation to a 3-axes system is prevalent. I would not have been able to explore these notions without the process of going back and checking with the students what they meant by particular passages in a chat log, comments at one of the forums, or subsequent chance meetings. It was this triangulation that gave the study its depth.

4.1.11.1 Reflecting in the media

I was not the only participant to reflect on this process. Reflection occurred in the media too. This highlights also one form of the triangulation process mentioned earlier. For example, in

[19] Future research might investigate this further by studying how participants only working with the physical blocks interact, and how participants only working with the virtual blocks interact.

chat log 1.12 I found a conversation reflecting on perceived improvements that could be implemented in future communication exchanges – the need to exchange images rather than just text.

Chat excerpt 1.12

255 Bob: …to make [it] easier we should be able to send some pics or images… to each other

257 Bob: so we can develop [a] better [understanding of what each other sees]

259 Bob: or be clear with the language that we are going to use

263 Bob: I think so because I can see in my screen all the elements so this make [it] easier to 'picture' what I want… and how I want it …and if sketches could be sent too

277 Mary: it is nice and easily to understand but can i try work[ing] with virtual model sometime? (DMM, 07/05/02, 11:20-13:10)

This suggests they were more interested in the 'picture quality' of the exercise, or that they honestly thought it would make it easier to communicate their manipulations using pictures. Other examples of reflecting in the media include those captured in Chat Excerpts 1.10 and 1.11.

4.1.12 Relationship to Exercises Conducted by Others

This case-study exercise can be compared to that described by Schumacher and Radford (1997) and Schnabel (2003). Schumacher and Radford's *Games in Virtual Blockland* used a comparative study of wooden blocks and their virtual counterparts in a CAD program. Similarly, Schnabel's *MAZE* used wooden blocks and their virtual counterparts (in VRML), including plans representing layers cut through a 4x4x4 (blocks) cubic volume. Where their exercises differed from that described in Case Study 02 was that in neither case were there separated participants working with the different media only able to communicate using online chat. In both Schumacher and Radford and Schnabel's exercises all participants had equal access to both media types and a survey was conducted on completion of the given tasks. While these alternate cases were primarily design oriented, there *were* similarities in the experiences by participants of my *Federation Villa*, *Blockland*, and *MAZE*. For example, the contrasting of the Villa's physical and virtual blocks highlighted their differences – tactility, smell and sound, colour and mergability. In a similar manner both Schumacher and Radford and Schnabel's media were differentiated by their physical and virtual properties. Where my *Federation Villa* used wooden blocks, *Blockland* referred to Froebel's wooden blocks and a vocabulary of five simple virtual blocks, and *MAZE* used coloured wooden blocks and a 3D maze-like virtual cube comprising numerous smaller cubes. In *Blockland*, *MAZE*, and my *Federation Villa*, the virtual block-elements opened up possibilities that their physical counterpart could not. In particular, some observations by Schumacher and Radford paralleled mine, such as: the infinite spatial relations created by merging virtual blocks, their ability to defy gravity, and gaining views not possible in the physical world, all seemed to open new avenues of imagination, fun, and discovery. Where Schnabel's maze-like virtual cube differed from my *Federation Villa* and Radford and Schumacher's *Blockland*, was that *Maze* came assembled and could simply be disassembled. When asked to speculate on the usefulness to the task of either 'kit-of-parts', participants from *Blockland*, *MAZE*, and my *Federation Villa* agreed that the virtual kit showed more flexibility and assisted more rapid visualisation of design ideas than its physical counterpart.

Another area where my *Federation Villa* case study differed from *Blockland* and *MAZE* was in the way the information was gathered – the use of chat logs, forum, and interviews – both *Blockland* and *MAZE* relied on a written survey conducted at the end of the exercise. What arose from the analyses of my chats, forum, and interviews, and is most pronounced in its difference from *Blockland* and *MAZE*, was the emergent emphasis on an axial orientation in the virtual spaces by my participants. This was not reported by Schumacher and Radford or Schnabel. My participants' perceived need to communicate succinctly their spatial manipulations between each other seemed to rely on first establishing an orientation strategy. Most of my participants agreed that establishing a communication protocol for orientation was easier using the familiar *xyz* axes of a virtual environment than it was trying to find a common point of reference for the physical kit. This seems to reflect the pre-existing CAD paradigm that most of my participants came to the task with – their culture of on-screen designing seemed stronger than that of physical modelling. It could also be argued that the default orthogonal nature of the virtual blocks influenced the choice of orientation schema. Nevertheless, neither the physical blocks nor the virtual blocks offered any advantage over the other in the *primary task* of determining the maximum number of permutations.

I also noticed that the transition from physical manipulation of the blocks to virtual manipulation and vice versa appeared to be seamless (once an orientation strategy had been agreed to). None of the participants seemed to experience any difficulty in identifying the virtual blocks as representative of their physical counterparts. Where the physical blocks could be turned over and felt to determine their solidity, the virtual blocks were merely their three-dimensional corollary projected onto a flat screen. Indeed, Schnabel (2003, p378) found that while his students were able to complete the task of rebuilding a virtual cubic volume using wooden blocks they were just as facile using only the layered 'plans', suggesting this may be because to "...understand and communicate 3D volumes architects are trained to think and read two-dimensionally... [resulting] in a very particular and 'layered' description of a building." This seems to be reflected in my findings also; that participants understood their 3D manipulations as a series of 2D 'pictures' – at least this is how they tried to communicate them with each other.

4.1.13 In Summary

The main issues raised in this case study exercise related to the role of perspective, planar actions in three-dimensional environments, and the use of Cartesian axes to 'get oriented'. More importantly, a number of spatial realties emerged which do not seem to relate directly to perspectival cues. Central to this is the notion of planar thinking followed by 3D action. This is addressed in the next case study.

4.2. Case 02: Spatial Boundaries in a Multi-User Virtual World

4.2.1 Introduction

The inclusion of others to a shared VE assists one's sense of immersion and presence (Heim, 1998; Slater et al, 1996; Knight and Brown, 2003). Moving through the spaces, one recognises the objects contained because many of the visual affordances generated by the rendered scenes are consistent with one's physical-world expectations (Gibson, 1979). It is only on reflection, however, that one comes to realise this phenomenon. In so doing, one may experience a transformation or paradigmatic shift in the way one understands the media (Kuhn, 1996). In the following case study, these concepts are teased out from the analyses of chat logs and interviews with its participants. Other concepts raised include the notion of the codified form of an architectural plan (Oxman et al, 1987) extended by its perspectival representation (Elkins, 1994), and the emergence of a social space fostered by participants' collective interaction in the 3DVE and online chat (Rheingold, 1994). This case study reports on the navigation of, and communication between, design students in a shared 3D virtual world.

4.2.2 Why the Barcelona Pavilion?

In Oxman et al's (1987) *The Language of Architectural Plans* they discuss the 'elements of plans' for the plans of Mies van der Rohe's 1929 World Exposition German Pavilion in Barcelona.

> *It is the boundaries which define [architectural] space. The nature of boundaries in architecture is complex. There are many types of boundaries from absolute to implied. They may have diverse qualities in the way they denote the physical edges of space.... A boundary may also be implied by such architectural elements as a row of columns, a change of level or a projecting wall.... Part of the elements of plans, is a denotational system for the edges of space.... Implied or transparent boundaries... [contribute] to the experience of the interpenetration of space* (Oxman et al, 1987, p13).

Their discussion is couched in terms of a small exercise used to identify different attributes of the plans. In particular, the notion of boundaries. The idea behind their exercise, to explore the nature of plans, is to identify the absolute and implied boundaries present and the kinds of space they create. Their exercise is about interpreting 3D spatial characteristics from its 2D representation in the codified format of an architectural plan. As such, it extends the exercise I described in the previous section – a comparison of two 3D design scenarios – by including another standard architectural design medium – the plan.

Unlike the first exercise, in this exercise design students get to navigate a common 3D virtual environment (3DVE) whilst being represented as an avatar that other participants can see. Students navigate a 3D model of Mies van der Rohe's Barcelona Pavilion. Apart from its use in Oxman et al's study, the Barcelona Pavilion was also chosen for three other reasons:

- It is a well known architectural icon of early twentieth-century modern architecture, which the students can relate to;
- Being almost entirely orthogonal in nature (except for the sculptures) it is easily reconstructed in a multi-user 3DVE where polygon counts determine performance smoothness; and,
- As it is the subject of the study in Oxman et al's exercise, hence to be consistent with the aims of that exercise, it follows that the Barcelona Pavilion should be used here also. Other architectural icons were considered (such as Palladio's villa *Rotonda*, Corbusier's villa *Savoy*, and Murcutt's *Simpson-Lee* house) for similar reasons (mostly orthogonal and well known) but the plans for the Barcelona Pavilion had already been analysed by Oxman et al making it a ready resource for inclusion in my exercise.

Just how they communicate their experience of navigating the space of a reconstructed Barcelona Pavilion in a 3DVE with each other is what was of interest to my study.

4.2.3 Pedagogical Aim

The pedagogical aim of this exercise was to introduce students to communicating about, and navigating, a multi-user 3D virtual environment.

4.2.4 Research Aim

The research aim of this case study was to record how students communicate to each other their experience of navigating a shared 3D virtual environment.

4.2.5 Setting

In this exercise a multi-user 3D virtual environment was used. Participants could access the CosmoPlayer interface which supported the multi-user real-time 3DVE through a Netscape browser. An online chat interface was included also. Participants were assigned an avatar alias by the 3DVE server. Navigation was actioned by keyboard arrow keys only. Upon entering the 3DVE, all participants were presented with a scaled model of the Barcelona Pavilion. The model of the Barcelona Pavilion was scaled in accordance with an avatar having an entry height (eye-height) of 1.5 units. In other words, the volumetric ratios of the original Barcelona Pavilion should appear to be consistent with the original physical spaces when compared with those encountered in the virtual environment.

In 2002 there were only two students (1 male and 1 female) and the researcher. The three of us were located at different terminals in different rooms on the third and fifth levels of a five-storey building. We could only communicate with each other via an online chat interface. In 2003 there were eight students (7 male and 1 female) and the researcher. Participants could chose from five separate installations. The five terminals were all housed in different rooms of the same building. They included:

1. A PC in my office on the fifth level;
2. A PC connected to a projector in a colleague's office on the third level;
3. A PC connected to a projector in the media lab A on the third level;
4. A PC connected to a projector in the media lab B on the third level; and,
5. The computer-assisted virtual environment (CAVE) in the computer science school's lab on level two of the same building.

In 2003 participants were organised into four groups of two each. The groups of two shared a single terminal. All groups were online in the 3DVE at the same time. Groups could chose which installation they wanted to participate from. Each installation supported at most two students (except my office where only I was present). In all installations the only communication with other installations was via the online chat interface. Participants explored the 'three-dimensionalised' plan of the Barcelona Pavilion. Their task was to communicate effectively and arrive at some consensus about the validity of a bounded space (in Oxman et al's terms) in a Virtual World.

Before entering the 3DVE they were all required to draw a freehand plan of the Barcelona Pavilion. On it they identified the real and implied boundaries (see figure 26 & 27). They were required to reach consensus across all participants on their identified real and implied boundaries on the plan. This part of the exercise was conducted in a single room with all participants and researcher present. They did not use chat and their conversations were not recorded. I focussed more on the results of their drawings than on what they said. Although I did query them on a few points when they were debating and reaching consensus on agreed boundaries and the spaces they contained (this is covered in more detail in the *Analysis of the Hand-Drawn Plans* section). The rules for completing the 3DVE component of the task were:

- From inside the 3DVE Barcelona Pavilion identify the 'real' and implied boundaries;
- Compare these to those you identified on your plans; and,
- How are they similar or different?

Participants were required to reach consensus across all groups on their identified real and implied boundaries in the virtual environment.

4.2.6 Assessment Criteria

Students were assessed on their individual contribution to the overall group or class exercise. The criteria used to determine their grades included:

- Was the student able to reach consensus with the rest of the class on the real and implied boundaries in their hand-drawn plans of the Barcelona Pavilion?
- Was the student able to reach consensus with the rest of the class on the real and implied boundaries in 3DVE version of the Barcelona Pavilion?
- Did the student contribute directly to their own learning by creating effective, progressive screen-grabs which they then reflected upon?

For each criteria the possible marks ranged between:

0 = no

1 = with help

2 = without help

3 = expertly

4.2.7 Method

A series of steps or stages were incorporated into the exercise and subsequent analysis of the data collected. These steps included: a discussion about Oxman et al's paper; the freehand drawing of plans; identification of the boundaries; moving off to the separated areas for the 3DVE part of the exercise; and, regrouping after. As well as following the chats as they proceeded I took brief notes on my preliminary assumptions of what I could glean from the chats as they unfolded. I then met with all the participants immediately following completion of the 3DVE exercise. This enabled me to ask further questions to clarify points raised in the chat sessions. Sometimes this required yet further clarification. In such cases a subsequent meeting was organised either the same day or at least on the following day. Hence, feedback triangulation took place within the chat environment, straight after the exercise and in the following days. This took three forms: the student-student chat-recorded conversations, the student-teacher chat-recorded and interview conversations, and the student-teacher-student chat-recorded and interview conversations.

4.2.8 Analysis of the Hand-Drawn Plans

All participants were required to produce freehand sketches of the Barcelona Pavilion indicating the various boundaries they found. They were given a copy of the plans to work from (see figure 24).

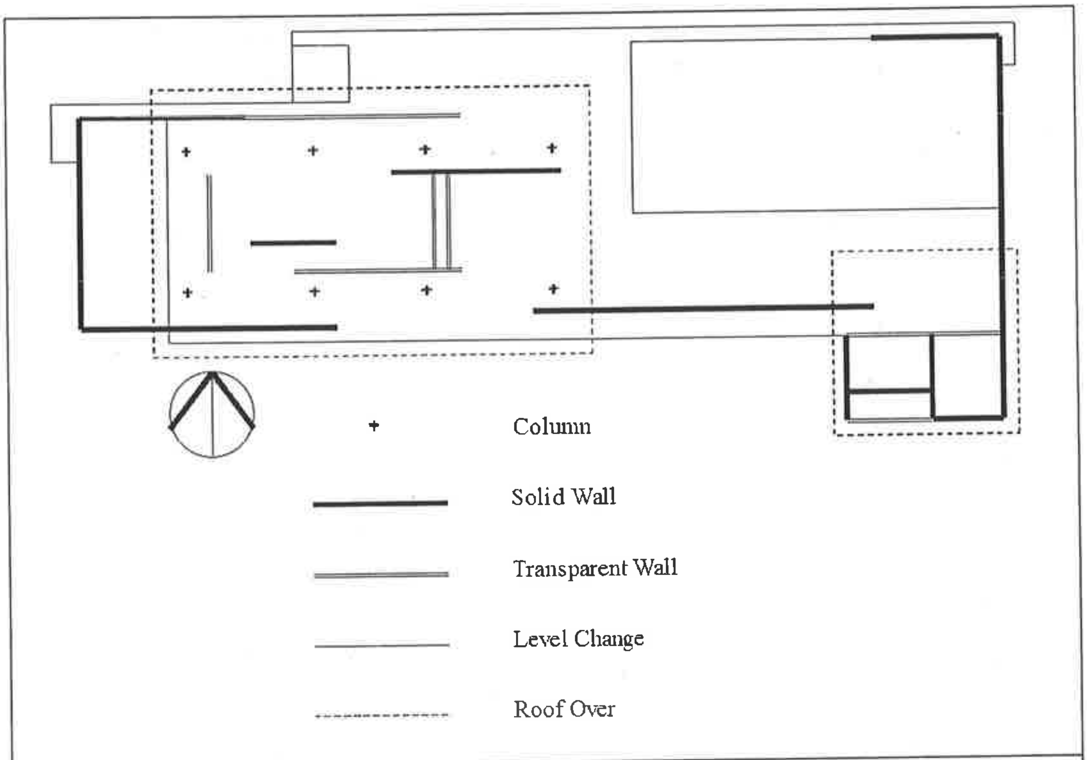


Figure 24. Rudimentary plan of Mies Van Der Rohe's Barcelona Pavilion.

The participants identified three types of boundary conditions in the Barcelona Pavilion:

- implied boundary as a row of columns (see figure 25 (a));
- absolute boundary as a wall, screen, or window (see figure 25 (b)); and,
- implied boundary at a convergence of terminated wall/column row (see figure 25 (c)).

Note, other combinations of these may also satisfy boundary conditions.

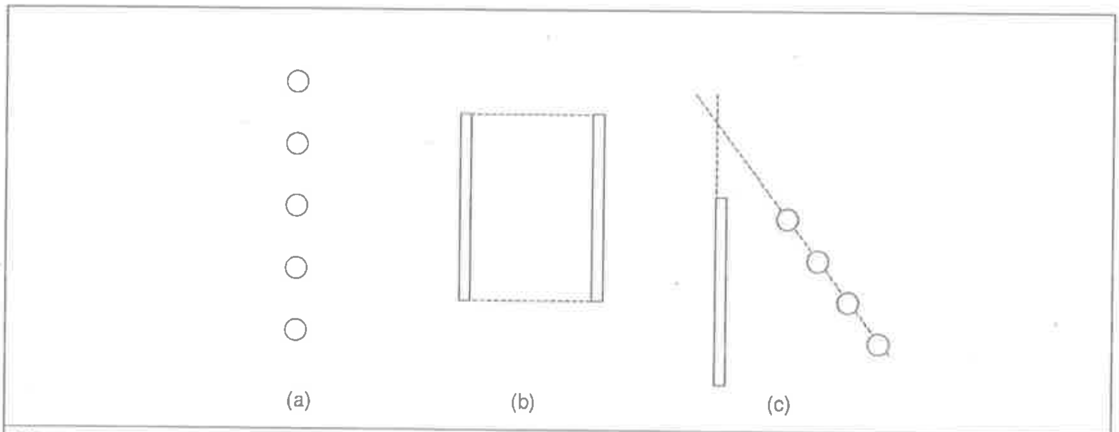


Figure 25. Oxman et al's boundary conditions as identified by student-participants.
Absolute and implied boundaries: (a) implied boundary as row of columns; (b) absolute boundary as wall; and, (c) implied boundary at convergence of terminated wall/column row.

As a class, in both 2002 and 2003, students were asked to nominate an exemplar sketch which encompassed all their agreed boundary conditions (see 2002 sketch figure 26, and 2003 sketch figure 27). There were no significant differences between the 2002 nominated drawing and that of the 2003 class.

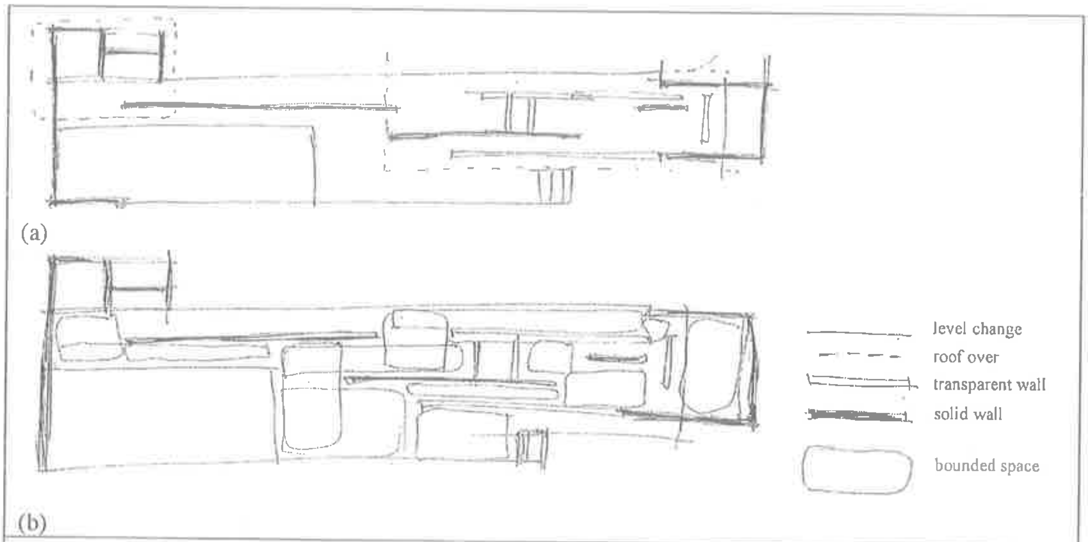
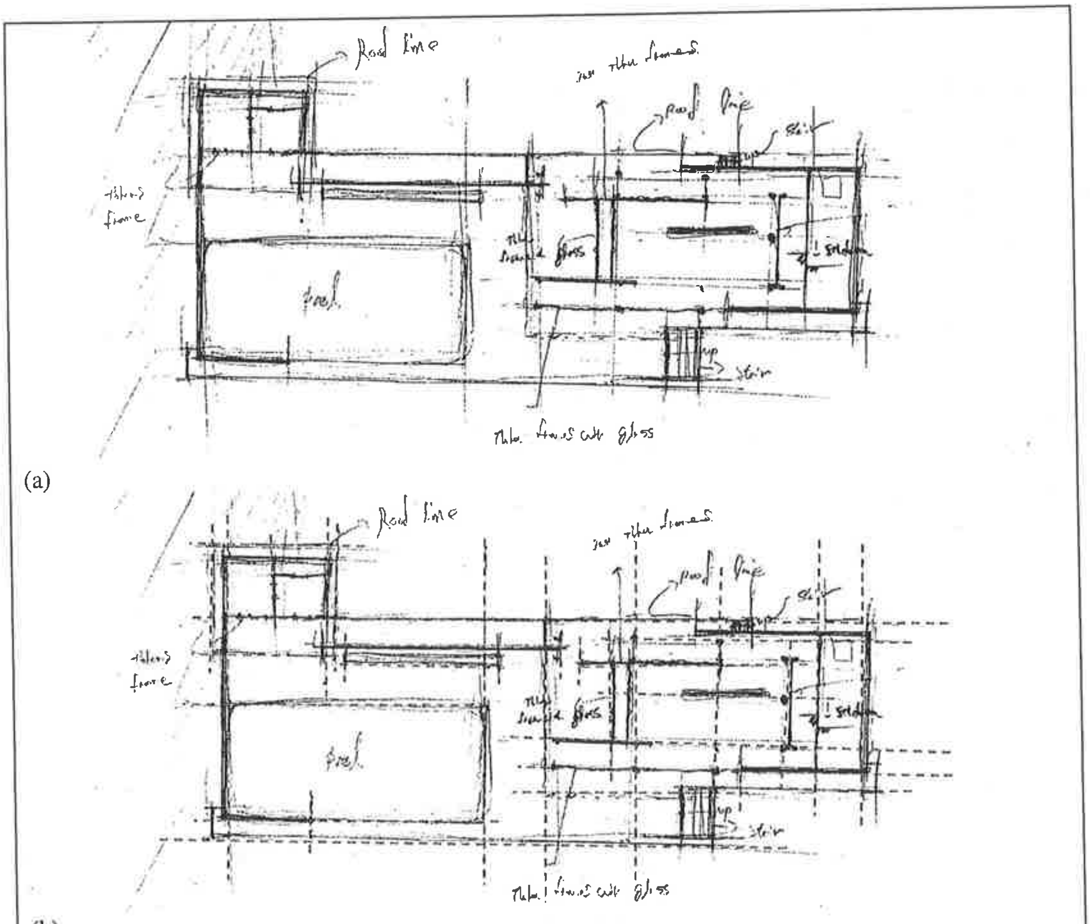


Figure 26. (a) 2002 group's nominated exemplar architectural plan (note columns missing). (b) 2002 group's nominated exemplar plan showing agreed upon bounded spaces.



(a)

(b)

Figure 27. (a) 2003 group's nominated exemplar architectural plan (note columns both in wrong locations (see correct plan figure 24) and indicated by dots only). (b) In my analysis of the plan (dashed lines) the spaces seem to have been divided up by their implied geometric drafting conventions rather than any thorough analysis of actual boundaries.

Common to both the 2002 and 2003 nominated drawings I noted that despite identifying and reaching consensus on the three types of absolute and implied boundaries described in figure 25, which include the columns, all either ignored the columns, incorrectly placed them in their analysis of the plan, or indicated them as dots only (not as '+' shaped cross-sections). When asked why they had identified 'the columns as constituting an implied boundary but ignored them in their drawings' the common reply from both the 2002 and 2003 cohort was that they 'couldn't see how the columns affected the space.' Hence, they were able to identify a row of columns as a boundary condition in the codified format of the given plan, but when they came to indicate them as such on their own plans, they either did not, or de-emphasised their effect. This may be because when they had to actually visualise the space, and their presence in it, the row of columns did not register as a boundary. This seems to have been confirmed by responses to my next question: "what is the row of columns if it is not a boundary?" The common reply (for both the 2002 and the 2003 cohort) was, 'it is just one [(single)] thing you can bump into (not like a wall).' This suggests that there was a shift in their conceptualisation of the problem. On the one hand, in plan, relationships, such as a row of columns constituting a boundary can be formulated. On the other hand, it did not seem to hold when it was mentally visualised as a 'real' space. How this was interpreted in the virtual space of a 3DVE was played out in the second part of this exercise – navigation of the Barcelona Pavilion in a multi-user 3DVE.

4.2.9 Constraints on Navigating the Virtual Barcelona Pavilion

While drawing the plans, participants had to imagine the three-dimensional spaces that the coded lines of the plan given suggested. The 3DVE, on the other hand, provided an already modelled space which followed the coded-volumetrics of the plan. The first required some crafting skills in interpreting and preparing the plans and then imagining and identifying the real and implied boundaries. The second required the participants to be able to read the images on the screen as three-dimensional spaces containing objects while simultaneously manipulating the keyboard keys to navigate the spaces. In the 3DVE they did not have to 'imagine' the spaces. The spaces were a given spatial construct.

Navigation of the spaces was restricted by the collision detection node – a function of the application's programming. The collision detection node prevented the participant's avatar from 'falling' through the floor, 'flying' through the roof, or 'gliding' through the walls. It also meant that it was possible to 'climb' the stairs and other objects. The foot of the stairs was the default entry point for all participants when they first entered the 3DVE (see figure 14 in Chapter 03). With collision detection it was also possible to 'sidle' up to the end of a wall/window/column and gauge its relationship to an adjacent wall/window/column. Similarly, one could fall off the edge of the pool, climb onto, and jump off of, the roof and so on. With collision detection turned off, it was possible to pass through objects and investigate the interstitial spaces not normally possible because they were otherwise too narrow to get between. With gravity turned off, they could fly around, gaining an overall view of the model.

4.2.10 Participant's Experiences Recorded in the Chat Logs

The following chat log excerpts were almost all derived from the 2002 group. The full chat log from which this analysis is derived is in appendix A.1, A.3, & A.5. Although both the 2002 and 2003 chat logs were analysed, most of those used here as examples were chosen from the 2002 chat logs because they provided the richest source of boundary critique. The 2003 chats largely did not add but simply repeated much of what was raised in the 2002 chat logs. In fact, many examples gleaned from the 2002 chat logs were not discussed in the 2003 chats. For example, the spontaneous hide-and-seek game (discussed later) only occurred in the 2002 session. Why this is so, considering there were more participants in the 2003 session is not clear. However, this would not account for the lack of a spontaneous game such as hide-and-seek from occurring. Alternatively, their may have been too many competing personalities for any one to dominate and steer the class into such a side event. The 2002 chat log was chosen also because it provides a continuous narrative that allows the reader to vicariously join the participants' journey of a shared spatial discovery. What is of interest to this thesis here is how the design students reconciled their analysis of a 2D plan with its 3D corollary in a shared virtual environment.

4.2.10.1 The Chat Dialogues

In the 2002 chat logs I found that personalities seemed to play a part in who led the exercise. In the 2003 chat logs it was mostly chaotic, hence no one personality surfaced as dominant over others. For most of the 2002 session, Bob seemed to be playing a lead role in exploration of the spaces and his partner Mary followed his lead. The only time this situation was reversed was at the beginning. At the start of the session Mary attempted to lead Bob by suggesting the default entry – at the bottom of the stairs – was the first boundary (see figure 28). Bob's passivity in the first Chat Excerpt (2.1) is contained in his simple 'yes' response to Mary's suggestion. However, as the narrative of the rest of the 2002 chat log unfolds Bob's personality tended to dominate the remaining conversations – Bob initiated conversations and Mary responded to his prompting.

Chat Excerpt 2.1

3 Mary: let's start
4 Mary: Bob i think the stair is the first boundaries
5 Bob just entered this channel
6 Mary: hi
7 Bob: hi Mary i'm at the bottom of the stairs
8 Mary: u tried to pass me
9 Mary: Bob i think the stair is the first boundaries
10 Bob: yes (DMM, 14/05/02, 11:30-13:15)

In Chat Excerpt 2.1 Mary was describing the bottom of the stairs as the first boundary. In 2003 the stairs were also described as satisfying one of Oxman et al's boundary conditions. In this case the experience of 'climbing' the stairs was expressed as a jerking motion (see Chat Excerpt 2.2).

Chat Excerpt 2.2

362 Jack: yes i could feel the jerk when i climb up or down the steps
363 Jack: you all can try this (DMM, 07/05/03, 11:30-13:10)

Much earlier in the 2003 session Jack had expressed his disappointment at not being able to 'perceive' a change of levels as he navigated the space (see Chat Excerpt 2.3)

Chat Excerpt 2.3

42 Jack: there is no perception of levels
43 theodor: what do you mean by levels Jack?

56 Jack: [the] change of levels cannot be felt (DMM, 07/05/03, 11:30-13:10)

Jack seems to be expecting a different experience.

In the 2002 Chat Excerpt 2.4 the terms Bob is using to communicate the pool edge as a boundary are expressed also in experiential terms.

Chat Excerpt 2.4

14 Mary: i walk along the pool
15 Mary: is it a boundarie
18 Bob: yes otherwise you can fall off (DMM, 14/05/02, 11:30-13:15)

Like Mary in Chat Excerpt 2.1, Bob seems to be thinking about the boundaries as 'real' obstacles with physical-world consequences. For example, in Chat Excerpt 2.5 he beckons Mary to 'come and… see… the spaces *under* the roof.'

Chat Excerpt 2.5

30 Mary: where do u want [me] to move now[?]
31 Bob: so come and lets see to the spaces under the roof (DMM, 14/05/02, 11:30-13:15)

But, in Chat Excerpt 2.6 it appears that Bob has shifted his thinking from three-dimensional experience to using the sorts of terms I would expect him to use to describing spatial schematics at the level of a plan.

Chat Excerpt 2.6

47 Bob: for me the boundaries are the horizontal planes
49 Bob: the space flows through the walls
55 Bob: so as I say before the horizontal planes are the principal boudaries
56 Bob: what do you think?
60 Bob: the roof and the floor
61 Mary: yes (DMM, 14/05/02, 11:30-13:15)

In the next Chat Excerpt (2.7) he switches back to describing experiential spaces. Bob locates an object – a column – in the centre of the space he finds himself in.

Chat Excerpt 2.7

64 Bob: hey guys if you come over where i am you can see a column in the middle of a room (DMM, 14/05/02, 11:30-13:15)

The terms 'over here', 'middle', and 'room' are all experiential terms. He seems to have gained a sense of 'himself' in the space. For example, in Chat Excerpt 2.8 Bob beckons Mary and myself to come over to where *he* is.

Chat Excerpt 2.8

73 Bob: now if you come over to the corner where i am
74 Bob: and the purple wall yes?!
75 Bob: you can see the column lines up with the end window
76 Bob: you have to be looking the same way i am
77 Bob: do you think the way they line up creates a corridor?
78 Bob: the column is an implied boundary (DMM, 14/05/02, 11:30-13:15)

He seems to be relating the objects in the space to himself. For example, in Chat Excerpt 2.8 it is clear his position in the corner enables him to gauge the relationship of the column to the wall thus extending the wall into a 'corridor'. As his chats continue, it becomes increasingly clear that Bob was indeed 'getting a feel' for the spaces. Next, he was 'feeling' boundaries all around him (see Chat Excerpt 2.9).

Chat Excerpt 2.9

86 Bob: there are boundaries everywhere
88 Bob: the windows, the columns, etc the interesting thing is how they connect to each other
90 theodor: what is the connection you are talking about Bob?
91 Bob: [it] is a boundarie but at the same time [it] is related to the other space
92 Bob: the walls yes
93 theodor: how is it related?
98 Bob: the walls project the space making it flow into the other [or adjacent space]
100 Bob: there… [are] boundarie[s] everywhere but the boundaries interlap with each other (DMM, 14/05/02, 11:30-13:15)

Virtually standing next to Bob in the 3DVE I could determine that, from Chat Excerpt 2.9, he was talking about the way a wall could obscure from view another space. He carried on with this overlapping and interconnectedness of the discrete bounded spaces and the relationship to the bounding elements in his next statements (see Chat Excerpt 2.10).

Chat Excerpt 2.10

107 Bob: with your back to the two glass walls you can see the orange wall and the window beyond
111 theodor: do you mean (Bob) that the orange wall seems to be extended beyond its obvious ends to the other walls?
112 theodor: and that this creates a new space?
114 Bob: and from the orange space the one you are [next to] now and the other beyond the window there is [a] boundary but all of them connected
115 Bob: and the one in the back (DMM, 14/05/02, 11:30-13:15)

But there was something different about the way he was now describing the spaces. He seemed to be describing imaginary spaces. I tried to visualise what he was saying but struggled to conceptualise it clearly. I tried to stand where he stood but I did not feel I could see what he wanted me to see.

Next he wanted me to experience the interstitial spaces he had encountered (see Chat Excerpt 2.11).

Chat Excerpt 2.11

116 Bob: and the little space between the columns and the blue-purple wall near the stairs?
124 Bob: you need to get really close [to] the gap (DMM, 14/05/02, 11:30-13:15)

From Chat Excerpt 2.11 it appears that he was experiencing the interstitial spaces as 'gaps' and 'little spaces' – he was 'getting into' these spaces. He tried to communicate these 'discoveries' to Mary and myself (see Chat Excerpt 2.12)

Chat Excerpt 2.12

146 Bob: this is very interesting you feel inside
147 Bob: this is really a virtual world
148 Bob: the extension of our consiousness (DMM, 14/05/02, 11:30-13:15)

In a Chat Excerpt (2.13) from the 2003 cohort, this notion of 'feeling' the interstitial and other spaces was also expressed.

Chat Excerpt 2.13

303 Tony: i was trying to sqeeze between the columns and the wall but I must be too big

315 theodor: i think tht Mies' spatial intentions can be felt in this virtual space

318 theodor: though i am less certain about what is missing until i [can] go to the original physical space (DMM, 07/05/03, 11:30-13:10)

Immediately following Bob's expressions of tactility in the spaces he was exploring he triggered a spontaneous game of hide-and-seek for the 2002 cohort (see Chat Excerpt 2.14).

Chat Excerpt 2.14

160 Mary: i'm here now
161 Bob: i'm hiding!!!!
162 Bob: see if you can find me!!!
163 theodor: come back
164 Mary: i show u
165 Mary: i saw u
166 Bob: not now!
167 Mary: gotcha (DMM, 14/05/02, 11:30-13:15)

I was also involved in this game of hide-and-seek. What I noticed was that, while hiding, it was difficult to see where the others were and my spatial awareness seemed to contract. It was different to the expansive spatial awareness that I felt when moving through the space.

Following the hide-and-seek game, and as we were winding-up the session, Bob expressed a desire to use the 3DVE as a tool in other design activities. In the last Chat Excerpt (2.15) Bob reflected on his total immersion and the potential for designing whilst immersed in a 3DVE.

Chat Excerpt 2.15

234 Bob: of course we can design and at the same time live the space that we are creating

235 Bob: I think that showing someone through your space virtually is different from just having them look at the screen over your shoulder (DMM, 14/05/02, 11:30-13:15)

His reference to the 'screen over the shoulder' was about the CAD arrangements he was more accustomed to using for discussing computer-mediated design issues.

4.2.10.2 Where the 2003 Cohort's Experiences Differed from those of the 2002 Cohort's

While many of the experiences the 2002 cohort reported were similar to those of the 2003 cohort, there were differences. Where the 2003 cohort's experiences differed from those of the 2002 cohort's was in their expressions of god-like omniscience, and anguish when they appeared to get 'stuck' in an object in the 3DVE. For example, in Chat Excerpt 2.16, unprompted, Jack explains to me his delight and surprise at being able to see himself (or his avatar) in the virtual world.

Chat Excerpt 2.16

45 Jack: that is not possible in the real world
46 theodor: Jack what is not possible in the real world?
49 Jack: to see ourself (DMM, 07/05/03, 11:30-13:10)

Jack had selected the third-person viewing option for his avatar.

In Chat Excerpt 2.17 I have collected other examples of expressions of omniscience from the 2003 cohort chats.

Chat Excerpt 2.17.

170 Mies: I am God
171 Jack: why can't we walk thru the walls?
172 Mies: I can see all of you from up here

180 Dean: I am inside Helen's head – [but there's] nothing there!

208 Tony: I'm practising walking on water (DMM, 07/05/03, 11:30-13:10)

By contrast there were no examples of the 2002 cohort expressing feelings of omniscience.

The other area the 2003 cohort differed in their reported experiences from those of the 2002 cohort was in their expressions of anguish when 'stuck' in the 3DVE. Getting trapped in objects – not being able to move in any direction – caused much consternation for the victims. For example, in Chat Excerpt 2.18 a small group moved into the pool zone and appeared to get stuck. In Chat Excerpt 2.19 the same thing happened to Helen, and this was repeated by Tony in Chat Excerpt 2.20.

Chat Excerpt 2.18

85 DJ: Game over we are trapped in the pool
150 Jack: please help me i got stuck// (DMM, 07/05/03, 11:30-13:10)

Chat Excerpt 2.19

248 Helen: i am in front of you Jack
251 Helen: but i cant move
252 Jack: frozen angel
255 Helen: whaaaaaaa *crying*
257 Helen: yeeeeeeeeee
258 Helen: i can move now
260 Helen: that's weird (DMM, 07/05/03, 11:30-13:10)

Chat Excerpt 2.20

336 Tony: I'm out now scary to get stuck (DMM, 07/05/03, 11:30-13:10)

4.2.11 Chat Dialogue Analysis

In the 2003 cohort there were eight participants. The 2003 session was chaotic. In the 2002 cohort there were three participants which included myself. The 2002 session was more orderly. However, a clear personality dynamic emerged in the 2002 cohort. In the 2003 session, no one personality surfaced as dominant over the others. In the 2002 cohort, apart from in the first Chat Excerpt (2.1), Bob's voice tended to dominate the chat dialogue. Bob initiated conversations and his partner, Mary, responded to his prompting. Whether Bob's dominance of the 2002 chat dialogue was a function of a smaller cohort when compared to the 2003 cohort is not clear. However, this did not seem to have a great bearing on my interpretation of either cohort's interactions with the spaces. Although, there is a disproportionate recording and analysis of Bob's communications. Nevertheless, much of what he raised was also raised by participants in the 2003 session. In fact, I felt Bob raised more, and more interesting, issues than what was raised in the 2003 session. Hence, the 2002 chat dialogue forms the core of the following chat dialogue analysis.

4.2.11.1 Gibsonian Affordances Delivered by the 3DVE

In the first of the 2002 cohort's Chat Excerpts (2.1) Mary identified the stairs at the default entry as the first condition which satisfies one of Oxman et al's 'bounded spaces'. But, while it appeared that the stairs Mary was referring to were indicated also on this cohort's nominated hand-drawn plan as a boundary, the individual steps were not identified as discrete boundaries. Rather, on their plan the bounded space was indicated by a round-cornered rectangle which encircled all the steps as a single contained space (see figure 26). However, the fact that Bob said "I'm at the *bottom* of the stairs" suggests the boundary they wanted to identify was the external edge of the first step. As such, it follows that subsequent steps should also satisfy this condition.

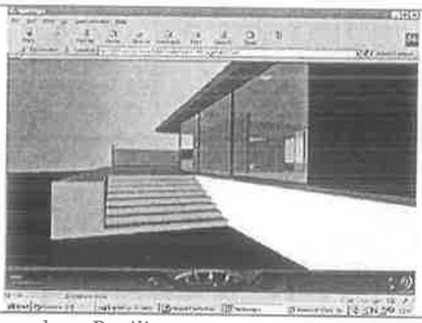


Figure 28. Entry to the Virtual Barcelona Pavilion.

This was the first indication that their use of round-cornered rectangles to corral bounded spaces on the plan may not carry over to the 3DVE version of the plan in all situations; that there was the potential for an incongruity between how they had visualised bounded spaces in plan and how they encountered those same spaces in its 3DVE version. There use of a round-cornered rectangle is a well established code or convention in spatial planning. However, such 'areas' are not so easily demarcated in the 3DVE. Mary and Bob almost needed to 'feel' their way around to identify the boundaries. Hence, whether they identified the first step as a boundary due to the apparent tactile feedback from the interaction with the 3DVE (climbing stairs registers as an abrupt change in level which is followed by a series of sudden upward movements as one 'climbs' the stairs) or the initial perception that the stairs constituted a boundary based on their prior knowledge of stairs is not clear from the chat log alone. In the organised interview the day following this exercise, I asked Mary (as she had been the first to identify the stairs as a boundary) why she thought the stairs were a boundary. She responded that, at first "I knew straightaway [that] the stairs is a boundary and then I could see it go up in [a series of] bumps." This 'bumpiness' or 'jerkiness' as one ascends the stairs was also explicated by Jack in the 2003 cohort (see Chat Excerpt 2.2). In both cases it tends to suggest that they both relied on their prior knowledge of stairs and that the behaviour of the interactive 3DVE confirmed this by reacting in the manner they expected. Indeed, in Jack's case, very early in the 2003 session he had clearly expected tactile feedback from the 3DVE (see Chat Excerpt 2.3). When I asked Jack in the organised interview the day after the 2003 session why he expected 'a change in levels to be felt' he responded that this was his experience in Quake, and "it should be the same [here]." That the 3DVE seemed to respond in a predictable or expectant manner indicates that they were mapping their physical-world knowledge onto their virtual-world experience or expectations and prior experience with the 3DVE media – such as Quake. Their experience was mediated by both the perspective tool used for navigating the steps and the actions it executed in response to their interactions with it. In this sense, the illusion created of 'climbing' stairs was two-fold: visual, and how it conformed to a cognitive affordance (in Gibson's terms) of how that visual stimulus 'should' behave when climbing stairs.

In the next Chat Excerpt (2.4) from the 2002 cohort the terms Bob used to communicate the pool edge as a boundary seemed to support these cognitive expectations. It reflects the dual illusion of cognitively confirmed behaviour attached to the visual stimulus. In expressing this, he used experiential terms. This is different to the codified terms he used to describe the same spaces depicted in the plan-drawing component of the exercise. The terms he used in the 3DVE were experiential in the sense that the appropriate codified planning term, 'change of level', would be less expressive or evocative of an experience than the term he chose: to 'fall off [a ledge]'[20]. In Bob's case, here was a glimpse of how he was thinking. Like Mary in Chat Excerpt 2.1, he was thinking about the boundaries as 'real' obstacles with physical-world consequences. Unlike Jack, however, because he chose to use an experiential term – 'fall off' – rather than a descriptive term – 'change of level' – it demonstrates how different this thinking was to how he approached the task of constructing and analysing his 2D plan. In a

[20] Interestingly, Jack used the term 'change of level'. Perhaps this is an instance where a term normally used to describe a symbolic marking on a plan was realised in a 3DVE, yet describing also a physical-world feature. Its use is at once confusing in its conflation across three spatial realities – plan, 3DVE, and physical-world – yet clear in its intention. This is one of the few examples where all three spatial constructs share a common term that also makes sense across all three.

sense, with the planning exercise discussed earlier, it was a conscious shift to imagining the space in three dimensions, whereas with the 3DVE experience he appears to be already in that imaginative 'mental space'. He was in an 'imaginative realm' where he could make judgements about his environment without having to abstract it from a code and apply it to a fictitious scenario, because it provided appropriate physical-world affordances (in Gibson's sense). Hence, the 3DVE Barcelona Pavilion was real enough for his imagination such that he could instead concentrate on the problem-solving task at hand without him having to re-cognise its content or context. In this sense, where Bob was mentally 'in' the space of the 3DVE, Jack was still mentally external to the space, analysing the interface. This differentiates the two approaches to both the task and their early levels of immersion in the 3DVE – both Bob and Jack's recording of their experiences at a change in level occurred very early in their respective sessions[21].

Bob's emphasis on experiential rather than Jack's descriptive terminology was continued in Chat Excerpt 2.5. In Chat Excerpt 2.5 Bob asks Mary to 'come and see the spaces *under* the roof.' His use of the term 'under' implies he is visualising in 3D. For, in the nominated plan, the roof is indicated by a dotted line and referred to as 'roof over'. The main difference here is, when looking at the plan he was always above the roof. Hence, using a dotted line to indicate 'roof over' is incongruous with the way he *actually* visualised the spaces described pointing instead to a convention. It is worth noting that in no cases of the hand-drawn plans from either cohort were the extents of the roof identified as a boundary (see figures 26 & 7). This may be because the roof line was more obvious as an obstacle in the 3DVE than in the plans alone. Only in the 3DVE did it present itself as another boundary for creating contained spaces. The plans, on the other hand, represent flattened two-dimensional spaces. They imply height by the fact that a human needs to be able to stand upright under them. But, in-plan the top is 'open', Bob could 'see' into the spaces below. This becomes more apparent where, despite Bob's inclusion of a dotted line for roof-over in his plans, he seemed to have simply ignored its significance until it was obviated as an *actual* barrier in the 3DVE.

4.2.11.2 Mentally Switching between 2D and 3D Spatial Constructs

Despite the inherent inaccuracies their codifying of the three-dimensional bounded spaces implied – depicted on the two-dimensional surface of the plan as a two-dimensional round-

[21] It is worth noting also that, throughout the chat logs Jack recorded, the reference to the jerk he experienced climbing the stairs, right at the end of the session, was the only time he used an experiential term. This is despite his reasoning for this based on his experiences in Quake (discussed in more detail later).

cornered rectangular schematic – they still seemed to want to map their expectations of their two-dimensional mapped boundaries onto their 3D experiences of the 3DVE. For example, in Chat Excerpt 2.6, where Bob refers to the 'horizontal planes as the principle boundaries', it appears he has reversed his earlier use of experiential terminology and instead reverted to the sorts of terms I would expect him to use to describe spatial schematics at the level of the plan. The horizontal planes he was referring to – the roof and the floor – are just that: planes or surfaces without depth. These are the same entities that can be deduced from the plans directly. The day following this exercise I asked Bob what he meant by this statement. He responded with: "I wanted to record the boundaries on my plan, so I was… [looking at] my plan." In other words, he had his plans next to him and instead of talking about the horizontal planes in the 3DVE he was actually trying to make a direct comparison with those planes (the roof and floor in the 3DVE) and his plan. To do this in the 3DVE he would have had to collapse the three-dimensional space of the 3DVE to its flattened planar form in the plan. Instead, he chose to look at the plans. What occurred was a shift, from 2D visualisation to 3D visualisation and back. This mental flip-flopping is a paradigmatic shift (in Kuhn's terms) in his visualising of the spaces. He appeared to be translating the plans into the 3DVE extruded version and back again with some facility. However, the translation was neither straightforward nor without its influence on the original. In other words, moving from one to the other meant he had to adopt the code of one *or* the other. In this case, the code of the plans dominated. But, the roof and floor in the 3DVE do have depth. Which is correct? In this instance, both are coded, one is a schematic code and the other a perspectively visual code. Although, the latter appears to better describe the actual spaces – volumes, voids, and depth – than the other. Here, it appears Bob was caught up in his architectural training which forced him to think through the problem-solving exercise at the level of the plan (this is why he referred to the plan directly), yet he had access to a richer visual description of the spaces depicted for analysis. It is interesting to note that he claims this was the only time he referred to his plans directly whilst navigating the 3DVE (this was revealed at the organised interview the day after the session). Henceforth, he chose to continue his analysis focussing on the perspectival media alone, claiming "it [was] easier to see the boundaries." This suggests there was no direct isomorphic correlation between what was depicted in his plan and what he was experiencing in the spaces of the 3DVE. Moreover, that the 3DVE was better for identifying spatial boundaries by 'bumping' into them than what he needed to 'imagine' from the plan alone.

4.2.11.3 Notions of Presence in the 3DVE

Bob's turning away from the plan and re-emphasis on the experiential nature of the 3DVE alone is captured in Chat Excerpt 2.7. In it, Bob locates an object – a column – in the middle of his bounded space. The terms he used, 'over here', 'middle', and 'room', are all experiential terms. In this case, the last term, 'room', is what he used to describe the bounded space he found himself in. 'Room' implies he perceived himself as surrounded by boundaries – ceiling, walls, floor, and so on – in a contained space. To achieve this perception he would have to have had a sense of 'self', or presence, in the space (see Slater et al (1996) and Knight and Brown (2003) on notions of presence in chapter 02). His sense of presence in a room was triggered by the 3DVE, but his interpretation of the spatial characteristics of the images on his screen as a 'room' was more than merely a space of containment. In Lefebvre's terms, it was a lived space. Hence, Bob was describing a lived spatial experience contingent on his presence in a 3DVE. Despite a brief return to the more descriptive terms[22] I noted of Jack's approach to the spaces – where Bob describes the elements of his rooms in Chat Excerpt 2.8, comprising walls, a window, column, corner, and so on – this notion of his 'mentally-mediated' presence in the 3DVE was expressed in increasingly strong terms as the chat dialogue progressed, such as, in Chat Excerpt 2.8, his use of the egocentric 'I'. In the remaining Chat Excerpts (2.8, 2.9, 2.10, 2.11, 2.12, and 2.14) he uses other devices to indicate his presence, including: 'project' and 'flow'; 'back to the wall'; 'need to get really close'; and, 'you feel inside'.

Bob's sense of presence in the 3DVE was most clearly expressed in his use of the egocentric 'I'. For example, when Bob beckoned Mary and myself to come over to where he was in Chat Excerpt 2.8 his use of 'I' in the context of the construction element corner places his 'self' firmly in the space of the 3DVE. Similarly, his use of the term 'corridor' in the same chat excerpt indicates his experience of a lived space. Moreover, Mary and I were witness to his presence in the space because he beckoned us as if we were actually 'there', with him in the space. His presence in the space was mediated by both the perspectival view that he controlled and the social interaction he could engage in (because there were others in the space willing to communicate with him). His presence was also due to the social interaction extended by the

[22] It was during this brief return to the non-lived, descriptive spaces, of his 3DVE experience that I noticed from his earlier chat (Excerpt 2.7) the way he located the column in the centre of his room as just another object not effecting a boundary as such, tends to vindicate his (and most other participants') earlier stance on the columns not effecting a spatial boundary when he was analysing his hand-drawn plans. Although, this could also be because when he visualised the columns from the plans he was similarly not mentally 'present' in the space and hence had no direct experience of how the column effects a boundary as such. However, in chat excerpt (2.8) he contradicts this same position referring explicitly to a column as an implied boundary. Hence, within a very short script he seems to be both experiencing the space as a personal mentally-mediated lived space and as an externalised descriptive space much like a plan, only in 3D. The former is contingent on his sense of presence, the latter merely conventional identification of specific elements in a spatial setting.

chat communication, hence he also had a presence in the chat environment (this is a form of presence beyond what Slater et al and Knight and Brown describe).

The notion of his presence in the space of the 3DVE was further cemented when he implied that the objects in the scenes bore a relationship to him personally. For example, from Chat Excerpt 2.8 it was his position in the corner that enabled him to gauge the relationship of the column to the wall thus extending the wall into a 'corridor'. His presence was implied in this relationship in the way he wanted Mary and myself to join him in the corner and experience the same spatial relationships he was able to deduce from it. What was interesting also about this case was that it demonstrates how he had to imagine the column extending the end of the wall and the column. Referring back to my earlier discussion about his reluctance to identify the column as part of an implied boundary in the planning exercise, here, at first, I thought he was trying to force the issue, out of a sense of duty to identify columns as an implied boundary. This would have been because it was simply part of the rules of the exercise and here was a convenient example he could use. However, as he continued, it became increasingly clear that Bob was indeed 'getting a feel' for the spaces, and what constituted a boundary *was* contingent on the level of 'presence' he perceived in the space, and he was indeed convinced the columns did imply a boundary condition after all. This was a marked shift from the position he maintained in relation to the columns on the plan. In the next Chat Excerpt (2.9) he was 'seeing' implied boundaries all around him.

4.2.11.4 'Feeling' the Spaces of the 3DVE

Seemingly surrounded by implied boundaries, Bob requested Mary and myself to join him. First in the corner, then with our 'backs' to the wall, and finally to get 'really close to the gap' between a column and the purple wall. He wanted us to experience what he could see. Virtually standing next to Bob in the 3DVE, he described the interconnected spaces he could see. He was telling us about the way a wall could obscure from view another space. When we 'walked' up to and looked around it, the space we had just left behind supposedly flowed into the next – the same wall and its alignment with another beyond created a new bounded space. In other words, following Bob's reasoning, there was no need for a column or other wall, the end of a wall itself could be imaginatively extended to, or overlap, the space beyond.

He continued with his descriptions of the overlapping and interconnectedness of the discrete bounded spaces and their relationship to bounding elements in Chat Excerpt 2.10. But there was something different about the way he was now describing the spaces. His spatial characterisations appeared to be different to both the coded form in plan and the general realisation of an extruded plan (how one sees a plan in 3D in one's imagination) as discussed earlier. Now the spaces Bob was describing were not spaces I could see for myself. It was not always possible for me to adopt the same position as Bob to be able to 'see' the spaces he was referring to. Now he was describing his own imaginary spaces triggered by the cues he got from the bounding elements in the 3DVE. I tried to visualise what he was saying but struggled to conceptualise it clearly – I felt I needed to be where he was to be able to see what he could see but could not. Despite this being a key feature of the whole perspectival paradigm, even if I did stand where he stood, it did not seem to guarantee I could see what he did. It was not sufficient to trigger the same imaginative visualisations he was having.

This introduces a new concept – the notion that the 3DVE was not able to communicate imagined visualisations, only realised imaginations as actual spaces in the 3DVE. This is perhaps where a plan appears superior. As Gombrich (1982) notes, a diagrammatic representation such as a plan encodes a particular kind of message; that once the conventions are known it is more easily communicated to the initiated (see see subsequent work published by this author for a more detailed discussion). The 3DVE, on the other hand, did not appear to have a clear communicative convention attached to its use. Hence, while the imagery was consistent, design intentions appeared different for Bob and myself. It was not a convenient mechanism for communicating a common vision. After analysing this particular chat log I came to the conclusion that, one way for me to understand Bob's intentions would have been for him to indicate in plan what he was talking about. This, an agreed representational convention, is a common language we could have used. However, even this well-established method may not have provided me with the *depth* of his insight – for this, I would still need to re-visualise his 2D markings as 3D space. This is both the dilemma and facility of perspective and its concomitant schematic accompaniments (plans, elevations, sections, etc). They may have helped Bob communicate his architectural vision in a coded, schematic form, but not the vision itself. In other words, despite proclaiming to simulate a reality, the simulated reality one normally experiences when observing codified plans, elevations, sections, perspectives, and so on, is differently imagined from individual to individual. It could therefore be argued that in this case the perspectival media used here did not help communicate any more information than a plan alone could. In this sense, the extruded-plan-as-perspective in the 3DVE version of the Barcelona Pavilion was simply an extended schema with its own visual code (something Elkins (1994) argues in Chapter 2) peculiar to each individual; not the universally accessible simulation of a physical reality so many authors argue (see the views of

Edgerton (1991) and others in Chapter 2). I argue that what differentiated the 3DVE perspective from its planar form in the plan was simply its ability to provide for a digitally-mediated *experience* of the plan in three dimensions instead of two. How this extends the schematic code of the plan was exposed in Chat Excerpt 2.11.

In Chat Excerpt 2.11 Bob referred to the interstitial spaces as 'gaps' or 'little spaces'. From this it appeared that the interstitial spaces of his plan could not be explored, represented, or coded, rather they needed to be experienced – as gaps or little spaces. It is in Bob's descriptions of the interstitial spaces he discovered in the 3D model that I noticed him move farther away from his earlier two-dimensionalisation of the spaces as horizontal planes to the imaginary spaces beyond – what could be simply deduced from what he could see in the 3DVE – to 'getting into' the (interstitial) spaces. It was this shift in conceptualisation that is when it seemed to dawn on Bob that what he was experiencing was quite profound. (Different to drawing the plans and then mentally visualising the spaces depicted.) This prompted him to communicate his 'discoveries' with the rest of us, such as in Chat Excerpt 2.12.

His use of evocative phrases in Chat Excerpt 2.12 such as 'you *feel* inside' and, it is like an 'extension of our consciousness', were similarly expressed by the 2003 cohort. For example, in Chat Excerpt 2.13 Tony describes the sensation of 'squeezing' between the columns. In the same Chat Excerpt I reflected on how I 'felt' I could understand what Mies' design intentions were from my experience navigating the 3DVE version of his Barcelona Pavilion[23]. Collectively, this indicates both our level of immersion in the spaces and increasing familiarity with being immersed in the 3DVE.

4.2.11.5 Playing Virtual Hide-and-Seek in the 3DVE

It was Bob's seemingly profound immersion in the spaces of the 3DVE, his presence and the way his feelings of presence facilitated his ability to topologically map out the space-forming boundaries around him, and the very storytelling about this experience, that caused him to feel compelled to narrate his discoveries to Mary and myself. His 'euphoria' seems also to have triggered the next event to unfold – a spontaneous game of hide-and-seek; a game that hinges on the concepts of presence and immersion in the 3DVE (see Chat Excerpt 2.14).

[23] Although, on reflection, and after having completed this analysis of all the chat logs, I realise this was a naïve statement; that the design intention I was referring to could never come close to Mies' actual vision. In fact, I alluded to this in my provisional statement which immediately followed the earlier statement, 'that I could not be sure until I had actually visited the physical pavilion.' (Although the 'actual' pavilion is itself a reconstruction, not the original) (It would be interesting for future research to complete this task and compare my impressions).

The fact that Bob thought of hide-and-seek among the many different games possible was not surprising. It resonates with Mary and Bob's primary task of identifying boundaries. After all, in a game of hide-and-seek one needs a boundary to hide behind! This game was a succinct reminder of the level of immersion that we all experienced. For Bob, Mary and myself, having become familiar with the spaces, we were attempting to use our spatial knowledge to 'find a place to hide' and to find the person hiding (see figure 29). Finding a 'place' to hide was contingent on the forming of our individual spatial memories as well as our combined social interaction (see the work of Lynch, Cuff, Tversky, and Dourish on spatial memory and its connection to social interaction in Chapter 02).

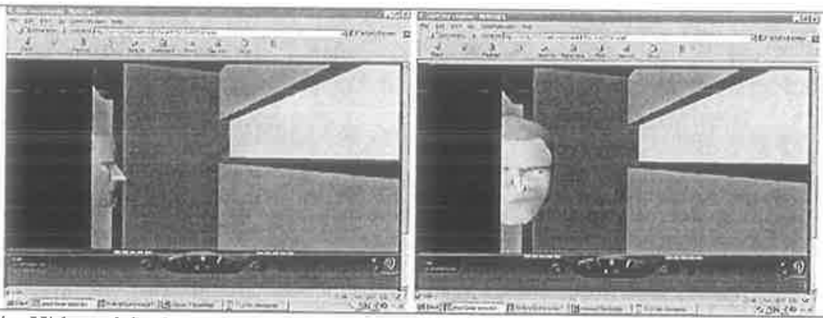


Figure 29. The Hide and Seek game. Found!

At one stage, whilst hiding in this game of hide-and-seek, I noticed not only could I not see where the others were but my spatial awareness seemed to contract to an internalised mental space. This was different to the expansive spatial awareness that I had felt when moving through the space. This spatial contraction was as much to do with my withdrawal from social contact (a necessary condition of 'hiding') as it was about my static position in a confined, hidden, space. The mentally contracted spatial experience that accompanied these actions was like being immersed in a telephone conversation. In a telephone conversation, one's sense of their immediate physical environment seems to contract, encompassing only the sphere of the conversation -- in a Gestalt-like internalised mental space. When I asked Bob, the next day at the organised interview about his experiences in the hide-and-seek game, he indicated that he felt a similar contraction in spatial awareness. This spatial reality was also similar to what most of the participants recorded as feeling when they were imagining the spaces of their hand-drawn plans. Here then was a new spatial construct. The conscious awareness of a contracted spatiality. From the expansiveness of the 3DVE experience to the closed concentrated spatial experience of either imagining the spaces of a plan or hiding in an enclosed space of the 3DVE.

4.2.11.6 The 3DVE Design Exploration Experience Compared to CAD

The various stages the journey of this exercise took for Bob culminated in him expressing a desire to use the 3DVE as a tool in other design activities. In Chat Excerpt 2.15 Bob reflected on his total immersion and the potential for designing whilst immersed in a 3DVE. In this final chat excerpt, he compared his 3DVE experience with the more typical 'over-the-shoulder' critiquing of CAD design (a metaphoric reference also to the over-the-drawing-board critique). He considered the 3DVE potentially a more efficient tool for sharing his design ideas. He was speculating on how the tool that he had just spent the last hour exploring could be used as a real-time design tool. Both Bob and Mary agreed that being able to cluster in a corner of the 3D Virtual World, and know that everyone else was in exactly the same location and looking the same way you were, meant you knew they were looking at the same thing. They postulated that this may be a better way of collaborative design discussion than having a co-collaborator looking over your shoulder at a monitor displaying a CAD model. Or worse, if the co-collaborator is remote, with only a CAD model to look at, the level of synchronous communication was seriously diminished. Instead, the act of virtually moving from location to location 'within' the design was a clearly coordinated, 'shared' experience. This is despite my earlier frustration that simply being able to adopt the same location as Bob in the 3DVE did not guarantee I could decipher his imagined spaces or design vision. Hence, for Bob and Mary, the real-time perspectival 3DVE as an 'ideal' design environment seemed to prevail over what was actually experienced.

4.2.11.7 How the 2003 Cohort's Experiences Differed from those of the 2002 Cohort's

Where the 2003 cohort's experiences differed from those of the 2002 cohort's was in the 2003 cohort's expressions of god-like omniscience, and anguish when they appeared to get 'stuck' in an object in the 3DVE. While the 2002 cohort did report both these occurrences, the 2003 cohort's time in the 3DVE session seemed to be consumed by them. This may also have been because with so many participants there was little time for them to explore other issues.

The 2003 cohort's expressions of god-like omniscience seemed to permeate much of their reported experiences of the 3DVE. They seemed to marvel at the 'power' they had over their virtual world and virtual selves. This was only disrupted when, for (them, at the time,) inexplicable reasons, they got stuck or could not move in any direction. At times, this was expressed as feelings of anxiety in the chat dialogue.

In the first example of feelings of omniscience, in Chat Excerpt 2.16, unprompted, Jack explained to me his delight and surprise at being able to see himself (or his avatar) in the virtual world. He had control over his alter ego in the form of an avatar. When I asked him the next day at the organised interview how he felt seeing himself in the 3DVE he excitedly replied "I [am] used [to] this in Quake, but in… [the 3DVE] I was with my friends, and its [a] different [kind of] control…. It's in [an] architectural space [I am familiar with]…. I [can see myself] in the design. " Jack felt empowered by seeing himself in a design space, and delighted in its architectural familiarity.

Several other examples of these 'feelings' of omniscience were captured in Chat Excerpt 2.17, such as:

- Mies (aka Peter) claiming he was 'God';
- Jack lamenting the fact he could not 'walk through walls'. (In fact, he could, he had just not yet discovered the appropriate control option);
- Mies (aka Peter) announcing he 'could see all… from up here'
- Dean's virtual exploration of the 'inside of Helen's head' (the 3DVE has a clipping plane with one-sided rendering hence once inside an object it appears to be empty and transparent); and,
- Tony practising walking on water.

All of these expressions of omniscience indicate a fascination with the level of control they could exercise over their presence in the 3DVE. In the smaller 2002 cohort the novelty of this control was quickly exhausted and the assigned task was instead pursued in earnest. When I discussed this with the 2003 group as a whole the day after the exercise, the overwhelming impression I got from them was, for most, this was the first time they had explored such media and were astonished at how 'real' it felt. When pressed further to explain what they meant by 'real', Peter responded: "it was like an out-of-body experience."

Peter's notion of an 'out-of-body' experience was further confirmed when they appeared to get 'stuck' in an object in the 3DVE. Getting trapped in an object jarred them back into the physical-world reality whereupon they frantically tried to locate the controls that would set them 'free', or they sought assistance from the other participants. There were many examples of them getting stuck. The three that stand out include:

- in Chat Excerpt 2.18, where a small group moved into the pool zone and appeared to get stuck. (The water level was below the surrounding ground level, so, unlike the stairs which are spaced at an appropriate level which can be 'climbed', the pool edge could not be easily circumnavigated);

- in Chat Excerpt 2.19, where the same thing happened to Helen. (What was interesting about this case was her visceral relief at getting 'free'); and,
- where this was repeated by Tony in Chat Excerpt 2.20, when he proclaims: 'I'm out now.... [It's] scary to get stuck.'

In each, their chats betray their feelings of anguish followed by elation at being freed. When I discussed this with them as a group in the organised interview the next day, I noticed that, as they relayed their various stories of entrapment and escape, their facial expressions showed mild fear followed by relief. Clearly this was an emotional experience for them. That it was emotional was confirmed also by the way, following there story-telling there was lots of nervous laughter demonstrating their embarrassment at showing emotion to each other in a public forum.

4.2.12 Overall Outcomes

From this collection of chat excerpts I can make some preliminary interpretations of the overall outcomes of this exercise. Central to this is the notion that there were multiple spatial realities the participants visualised when communicating their design explorations. Three emerge as the most significant. The spatial reality of visualising their design communications:

- at the two-dimensional level of the plan:
  - its imaginary 3D extrusion, and
  - its 3D extrusion and simulation in a 3DVE;
- in the personal imagining of spaces generated by alignments present in a particular and personal view from within the 3DVE (not always easily conveyed to others); and,
- in the comparison of these with the more static, less inclusive, CAD environment.

How these multiple spatialised experiences relate to the core perspectival technology used is discussed in more detail in the next chapter.

4.2.13 On Reflection

I set out to investigate how design students report their experiences of working with a plan and its 3D extruded corollary in a shared virtual environment. I thought, by getting the students to identify the real and implied boundaries on a plan and then analysing a 3D virtual space for the same features, and (in the case of the 3DVE) the only way they could communicate was via online chat, that they would have to devise a strategy for communicating their spatial discoveries. I did not know in advance what this would necessarily 'throw up' (in Guba and Lincoln's sense), other than: I had design students working with at least one medium they are most accustomed to, architectural plans, and that they had to describe the boundaries they found in these and its 3DVE counterpart. The motive for having them physically separated and using online chat was the same as in the previous exercise. A primary assumption was that the shared virtual environment was a perspectival medium and that *how* the participants worked with this medium would reveal itself through the exercise. I did not know in advance just how this would occur or even what to look for. What happened of most significance in relation to the core topic of this thesis, how students interact with and navigate the perspective of a 3DVE, was the variation in communicating spatial concepts between the plans and the shared 3DVE. Three core spatial realities emerged: that within the code of the plan; that depicted by the 3DVE; and, the imaginatively visualised mental space, somewhere in between. This last spatial reality was also different between visualisations invoked by the plan and that invoked by the 3DVE. What it tells me is that their visualising is just as important as the codes used to describe it, be that code schematic or as a perspective. I would not have been able to explore these notions without the process of going back and checking with the students what they meant by particular passages in a chat log, comments at one of the forums, or subsequent chance meetings. It was this triangulation that gave the study its depth.

4.2.14 In Summary

This exercise demonstrated how the representation of multiple participants in a shared 3DVE assists the suspension of disbelief necessary to be immersed in the perspective media beyond its simple spatial navigation. Hence, on the one hand, the 3DVE provided a perspectivally-mediated spatial experience which relied on the user's ability to recognise the spaces and objects depicted. On the other hand, that this was shared with 'others' represented as avatars and the chat communication channel increased their sense of immersion and presence in the 3DVE. This tends to support Heim's (1998) increased 'felt quotient of immersion' with the addition of others to a virtual world.

Moreover, as a task-oriented exercise, stumbling around in the space, bumping into walls, falling over steps and so on, participants became more acutely aware of their interaction with the space and each other over time. It was like learning to walk again. From these interactions with the space and the objects in it and each other, they were able to reach consensus on the 'real' and implied boundaries which define the spaces within the Barcelona Pavilion. By interacting with other participants in a remotely hosted multi-user 3DVE, they often forgot they were at a computer terminal and instead concentrated on the task at hand. The level of abstraction did not seem to detract from their experience of being immersed with fellow participants.

Participants experienced an extension of their 'self'. They were represented by an avatar in the three-dimensional Virtual World and an alias on the chat channel. Their shared 'selfs' created, albeit briefly, a virtual community. According to Rheingold (1994) whenever a group of like-minded individuals gather a community is formed. By entering into this exercise participants shared Wertheim's (1999) consensual hallucination. They accepted the Virtual World as a surrogate for the real world in Gombrich's (1978) terms, and in so doing, they not only invoked a common Cartesian space but also a social space in Lefebvre's (1991) terms.

In this exercise, participants where only able to interact with each other. In the next exercise the participants were not only able to interact with each other but also with the objects contained in the 3DVE. In this exercise participants entered the realm of the perspective picture 'come to life'. They could control the view in ways that the renaissance artisans could only do statically. More than this, they shared the space they subjectively experienced with others. In Brunelleschi's terms this would have been like being able to literally occupy the position of the reflected eye in his pinhole-mirror demonstration.

In the next exercise, this concept is extended to include not only manipulation of the viewpoint but the objects contained in the scene – to 'paint the scene', by playing with the objects of its inspiration. Where Cotan, Velasquez, Vermeer and others constructed elaborate stage sets for their painterly compositions, in the next exercise the stage sets are constructed from within the picture-space itself.

4.3. Case 03: Shared Interaction with Virtual Objects in a 3D Collaborative Virtual Environment

4.3.1 Introduction

Much has been written about collaborating in online environments (see Chapter 02 for a comprehensive overview). Most, however, address online environments as a mechanism for displaying the results of decisions taken. More particularly, until recently, most collaborative three-dimensional virtual environments (3DCVE) were actually shared 'models', such as those produced by 3DMax, AutoCAD, Microstation, and VRML file transfers providing for the manipulation of objects by individual users in an asynchronous manner only. More recently 3DCVEs have emerged which support synchronous navigation and object manipulation, such as the popular ActiveWorlds (AW). However, in AW objects are 'owned' by individual collaborators. They can be copied by others but the original can only be transformed by its owner. Other interactive 3DCVEs that provide synchronous communication and object manipulation are beginning to appear in the literature (see Chapter 02). However, at the time this exercise was conducted they were still rare. Where the tool described in this exercise differs from others was in the way the objects were not created and owned by individual collaborators, rather they were preformed and shared in a collective design exercise. As a custom-built application it allowed rudimentary object manipulation, avatar presence, and access to a CGI online chat interface (see Methodology Chapter for a more detailed overview of the tools used).

The suit of tools described here allowed for a group of design students to enter an online 3DCVE and collaborate on a single design project with shared objects communicating via online chat. The motivation for participants to cooperate with each other was the requirement to jointly assemble a recognisable building. The agent of the self or 'I' would be constituted as an integral part of a 'we' or holistic collaborative design outcome (Taylor on Bourdiuer, 1999). Collaboration would entail cooperation and agreements on conduct. In this sense, it extends the first two exercises by adding the ability to share the 3DVE and the objects contained.

Collaborating in a 3DCVE typically involves multiple players in a networked interactive medium using avatars as agents to represent each participant. The 3DCVE design space provides a 'place' for design exchange. The importance of place in a virtual learning environment is in its provision as the basis for a meaningful and authentic contextualisation where knowledge construction, collaboration and conversation are facilitated. A sense of place enables learners to construct their own learning (Clark and Maher, 2001). The context of this exercise was the design and assembly of a virtual pool house. Represented by an avatar, each participant's role in this game-like pool house assembly exercise was mediated by the agency and efficacy of their avatar as part of a collective endeavour. In this exercise, investigating notions of privacy was used as a motive for participants to immerse themselves in a 3DCVE.

4.3.2 Why a Pool House?

The notion of privacy is something that differs from culture to culture. For example, in the Netherlands people often leave their curtains drawn and encourage the passer-by to peer in; in Australia we design houses with large windows and open verandahs to capture the sunlight and view but frown upon intrusions from unwanted glances. In most places around the world, however, getting changed into a bathing costume is consistently a private affair. Indeed, many elaborate constructions exist for just this purpose (the beach huts on Brighton beach in Victoria, Australia, come to mind) (see figure 30).

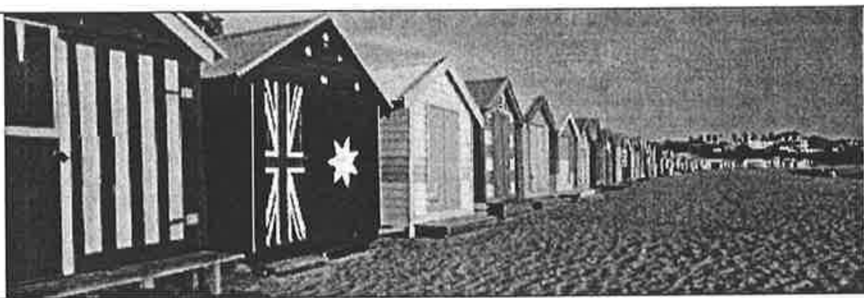


Figure 30. Beach huts on Brighton beach in Victoria, Australia, used for changing into bathing costumes (and other purposes) (photograph: Matt Lauder (2004), source: www.totaltravel.com.au, March, 2006).

As such, a private space within a pool house is an easily conceptualised ideal. Aesthetically, it is appealing also on the grounds that what a pool house evokes is the notion of a small enclosed space with few design demands. The key elements are: a pool of water to bathe in; something to sit on; and, somewhere to get changed. The last element raises the issue of how to design for a private space within the pool house. There are few opportunities within these criteria for disagreement on a shared design outcome.

4.3.3 Pedagogical Aim

The pedagogical aim of the exercise was to introduce students to real-time online 3D designing in a shared immersive environment.

4.3.4 Research Aim

The research aim of this case study was to record how students communicate their experiences of collaborating on a single design project in a shared 3DCVE.

4.3.5 Setting

In this exercise a multi-user 3D virtual environment was used. Participants could access the CosmoPlayer interface which supported the multi-user real-time 3DVE through a Netscape browser. An online chat interface was included also. Participants were represented by an avatar that was assigned to them by the 3DCVE application. Participants had full use of all the navigational devices provided by the CosmoPlayer controls. Upon entering the 3DVE, all participants were presented with a collection of eight different types of construction elements (see figure 15 in methodology chapter):

- 4 x mauve roof plates;
- 3 x grey floor plates;
- 1 x blue transparent water element;
- 3 x grey stepping stones;
- 1 x brown low table;
- 4 x turquoise transparent window planes;
- 4 x mustard wall panels; and
- 4 x grey cylindrical columns.

In 2002, as in the previous two case studies, there were only two students (2 female) and the researcher. However, these two students were different to the two students from the first and second cases in 2002. In 2003 there were eight students (7 male and 1 female) and the researcher. All were located at different terminals in different rooms on the third and fifth levels of a five-storey building. They could only communicate via the online chat interface. Unlike in the second case study, participants could chose from only three separate installations. The three terminals were all housed in different rooms of the same building. They included:

6. A PC in my office on the fifth level;
7. A PC in the media lab A on the third level; and,
8. A PC in the media lab B on the third level;

In this exercise they worked in groups of two. Within the participating pair, each partner could chose which installation they wanted to participate from. Each installation supported at most one student (except my office where only I was present). In all installations the only communication with other installations was via the online chat interface. In 2003, once a pair had completed the task a new pair would start. The application was restricted to three participants at one time (myself and the group of 2 students). Participants were given typically one hour to complete the exercise. Participants manipulated the 24 shared virtual objects in the 3DCVE.

The rules for completing the 3DCVE task were, using the construction elements provided, construct:

- a pool house; and
- a separate private space for males and females to change into swimming costumes;
- use the chat channel to communicate with other users in the scene.

Participants were required to communicate effectively and arrive at some consensus about the design validity of a 'private space' in a Virtual World.

4.3.6 Assessment Criteria

Students were assessed on their individual contribution to the group exercise. The criteria used to determine their grades included:

- Was the student able to reach consensus with their partner on the validity of a 'private space' in a 3DCVE? and;
- Did the student contribute directly to their own learning by creating effective, progressive screen-grabs which they then reflected upon?

For each criteria the possible marks ranged between:

0 = no

1 = with help

2 = without help

3 = expertly

4.3.7 Method

4.3.7.1 Overview of Process

A series of steps or stages were incorporated into the exercise and subsequent analysis of the data collected. These steps included: moving off to the separated areas for the 3DCVE part of the exercise; and, regrouping after. As well as following the chats as they proceeded I took brief notes on my preliminary assumptions of what I could glean from the chats as they unfolded. At the conclusion of the exercise I asked four pre-prepared questions using the chat interface:

- How important was it to be able to see another avatar/person in the scene?
- How do you think the design task would be easier or harder on your own?
- How did it feel to see objects moving around of their own accord?
- Why was any particular view point better than any other for constructing the spaces?

I then met with all the participants immediately following completion of the exercise. This enabled me to ask further questions to clarify points raised in the chat sessions. Sometimes this required yet further clarification. In such cases a subsequent meeting was organised either the same day or at least on the following day. Hence, feedback triangulation took place within the chat environment, straight after the exercise and in the following days. This took three forms: the student-student chat-recorded conversations, the student-teacher chat-recorded and interview conversations, and the student-teacher-student chat-recorded and interview conversations. The preliminary notes, responses to the online questions, issues raised at the meeting immediately following completion of the exercise, and clarifications from the meeting organised the next day, were all used as the basis for the analysis of the chat dialogues discussed in the Chat Dialogue Analysis section.

4.3.7.2 Summary of Exercise Setting

Participants were provided with a multi-user 3DVE which included shared objects with a believable motive necessary for engaging in the exercise. They were represented by avatars in a networked multiuser scene which included eight different types of shared construction elements (see Figure 15). All participants could see the elements move in real-time as actioned by any participant. Like the virtual Barcelona Pavilion case-study exercise, participants could urge each other to occupy their viewing position so that the other could see what they saw. Participants attempted to identify what, if any, differences there are between notions of privacy in a virtual environment and a physical environment. Participants had access to the same CosmoPlayer controls as in the previous two case studies. With gravity turned off, they could fly around, gaining an overall view of the model.

4.3.8 Participant's Experiences Recorded in the Chat Logs

As highlighted in the previous two case studies, the 2003 cohort was quite different in its attitude to the exercise – they did not take it as seriously as the 2002 cohort. For example, where the 2002 cohort raised an issue of common interest and pursued its possible trajectories until exhausted, the 2003 cohort tended to only spend a short time on any single issue and did not attempt to resolve it. One participant from the 2003 cohort commented they were bored, while others spent much time making jokes not related to the task at hand. It is possible that they felt under pressure to complete the task in one hour before the next group had their turn. If they felt it was not possible to complete the task in this time then they may have only approached it with a superficial interest.

Although, all groups in the 2003 cohort did, in fact, complete the task in one hour, the 2002 cohort did not have the spectre of another group coming in after one hour to take their place at the terminal. Nevertheless, they were able to complete the test in one hour and with more depth in their conversations and considered design exchanges. No time limit was placed on the 2002 cohort. The fact that they completed the task easily in one hour was what prompted me to adopt this time frame for the 2003 cohort. Perhaps it was the fact that there was a time frame at all that seemed to artificially constrain the 2003 cohort's engagement with the exercise.

Finally, although the 2002 cohort was smaller (only 2 participants), and comprised different students to those of the previous exercises in 2002, they were more critical and inquiring, hence I chose to focus my analyse on their chats here. Many similar issues *were* raised in the 2003 cohort and have been included where relevant, but, more, and with more detail, were raised in 2002. for example, where both the 2002 and 2003 cohort's adopted the view from above, the 2002 cohort discussed this at depth in relation to the notion of the importance of planning to the design process. The 2003 cohort, by comparison, simply remarked that the view from above made the task easier without going into detail why this was so. The 2002 cohort that completed this exercise did not do the first or second exercises detailed in the first and second case studies.

Most of the following chat log excerpts are derived from the 2002 group. The full 2002 chat logs are in appendix E as are the 2003 chat logs. Although both the 2002 and 2003 chat logs were analysed, the 2002 chat logs provided the richest source of experiential information. Much of the 2003 chats did not add but simply repeated much of what was raised in the 2002 chat logs. The extensive use of the 2002 chat log provides a continuous chronologically organised narrative that allows the reader to vicariously join the participants on their shared design journey.

What is of interest to this thesis here is how the design students reconciled their collaborative design task entirely within the 3DCVE using the shared props. Emerging from these chat logs is the dominant effect prior architectural training seems to have had on the way the participants approached the task.

4.3.8.1 Overview of the 2002 Cohort's Experience in the 3DCVE

After initially investigating the controls, Julie and Sally of the 2002 cohort started to navigate the 3D virtual construction space. Investigating the spaces between the 'construction elements' occupied the first twenty minutes. During this time there was lots of laughing. Laughter seemed to be triggered by the realisation that there was a presence other then their own, and objects appeared to move about in a seemingly unpredictable, 'ghostly' manner (my term). At approximately thirty minutes into the task they settled down to the serious work of designing the virtual pool house. After a short period of quiet contemplation they decided that one partner should 'construct' while the other comment on suitably aesthetic constructions. Interestingly, none of the groups from either the 2002 or the 2003 cohort thought of working out design issues on paper – all attention was on the visual space. This, and the head lolling – manoeuvring through space cranking the head as one goes around corners, talking to the screen only to realize others could not hear – was an indication of their level of immersion. Often a playful tug-of-war erupted between different participants wanting to manoeuvre the same virtual object. Suddenly Sally discovered the ability to view the overall scene from above. Julie quickly joined her. Henceforth, they used this 'in-plan', 'above view' or 'god-like' mode in Abbott's (1932) sense, exclusively (see Figure 31).

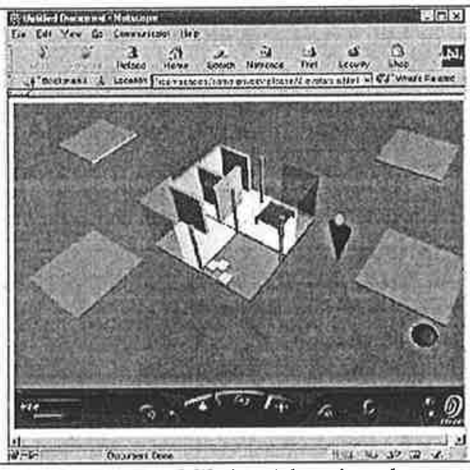
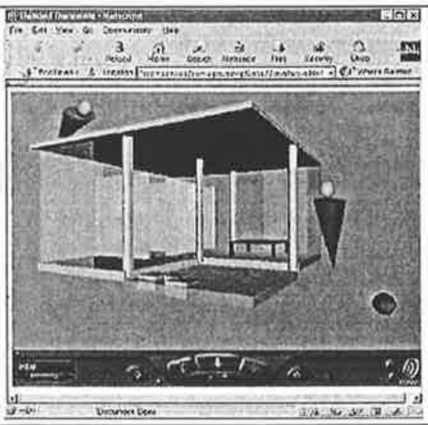


Figure 31. The view from an avatar in the 'god-like' or 'above' mode.

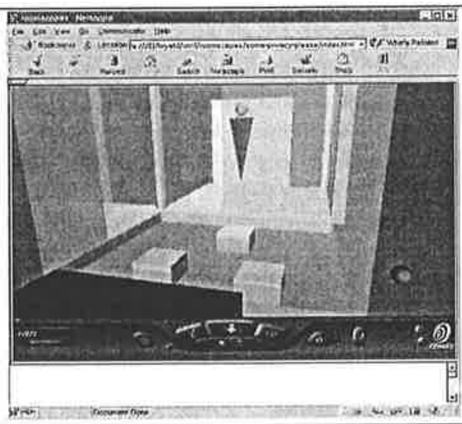
This plan, or 'god-like' view, seems to have been as much about their architect's learned practice as it was about control of the embedded 'plane sensor'. Approximately ninety minutes into the exercise, and after completing the Pool House, they finally began work on the creation of a private space. The roof elements were moved away to reveal the 'plan' and a vain attempt was made to satisfy the task requirements. The realisation was reached shortly after that whatever they tried, notions of physical-space privacy did not apply in a virtual world. One's presence was always identifiable by communication indicators, such as on the server display, without having to actually see the other avatar.

4.3.8.2 The Chat Dialogues

The initial phases of the task time was taken up by participants acquainting themselves with the tool and its functional features. During this time, there was little spatial experimentation at the 'floor level' of the design space (see figure 32 (a) & (b)).



(a)



(b)

Figure 32. Virtual construction elements for a virtual Pool House: (a) note the above or 'god-like' avatar at acute angle to the floor plane; and, (c) the view at floor level.

Instead, once it was 'discovered' that they could float above the space of the props, this became the preferred viewpoint. For example, in Chat Excerpt 3.1 Julie and Sally are explaining to me why this was good for designing the pool house.

Chat Excerpt 3.1

28 theodor: i noticed that you are both up in the air looking down
30 Julie: because it is good for des[igning]
31 Sally: we think it's better... [for getting] the composition [right]
32 theodor: Julie, why do you think it is better for design?
33 Julie: usually we design on plan first
35 Julie: also you can imagine the space you define
36 Sally: yes, kinda like [a] bubble, basic form and composition (DMM, 03/07/02, 13:01)

This 'working from above' mode was evident across both the 2002 and 2003 cohorts. For example, in one case in the 2003 cohort it was referred to as designing from the 'sky' (see Chat Excerpt 3.2).

Chat Excerpt 3.2

89 Trevor: ...u can 'see' the space [from] above
93 Trevor: [this is] pretty good
94 Trevor: for... design[ing] from the sky (DMM, 21/05/03, 11:21)

Chat Excerpt 3.3

43 Troy: i am on the top v1
44 Rod: just use 4 walls for the house
45 Troy: os i can see what is going on plan \
74 Troy: hi Rod i am at top
75 Rod: i try to go to the top... good idea
76 Troy: so i can see plan but i can't see section
104 Rod: i m on the elevation view
105 Rod: u go back to the top view (DMM, 16/05/03, 12:00-1300)

From the 'above' mode, both the 2002 and 2003 cohorts seemed to be using the props as cutout shapes moving them around as one does when erasing and making marks on a drawn plan. Chat Excerpt 3.4 shows that it was not just a preference for working in plan or above but that the tool was also more difficult to work with at floor level.

Chat Excerpt 3.4

41 theodor: earlier on [I noticed] neither of you knew about or used the plan view, instead you navigated at floor level
42 Julie: yes i know, [it is] just an option
44 Sally: we didn't know how to [at first]
46 theodor: do you think the experience of working at floor level was different to what you are doing now?
47 Julie: it is hard for you to control these elements [at floor level]
48 Sally: definitely, especially when you had to start with the basic form from looking at floor level (DMM, 03/07/02, 13:06).

Henceforth, the working or 'planning' from above mode was used extensively. In Chat Excerpt 3.5 both participants agree that this 'planning' is a critical part of designing.

Chat Excerpt 3.5

116 Sally: planning is critical in design, and planning is better when u can see face to face
118 theodor: Sally: do you think the planning you did with Julie was face to face in a virtual world?
120 Sally: it is proved here, we can do the planning / design in a matter of 10 mins [(on paper)] as compared to lengthy time [in the 3DVE]

123 theodor: Sally: does this mean it was easier to plan in a virtual world than say on paper?
124 Sally: absolutely no
127 theodor: Sally: so you think it is quicker to plan on paper?
128 Sally: yes
130 Sally: a lot of communication goes not [just] in writing, but in body language [too] (DMM, 03/07/02, 13:40).

This notion of planning from above was consistent across both the 2002 and 2003 cohorts. In the 2003 cohort other architectural drawing convention terminologies also entered the communications. For example, in Chat Excerpt 3.6 'plan' and 'section' appear; and, in Chat Excerpt 3.7 'elevation' and 'top view' are mentioned.

Chat Excerpt 3.6

43 Troy: i am on the top [view mode]
45 Troy: [from here] i can see what is going on [in] plan
75 Rod: i [will] try to go to the top [too]…. [Peter, this is a] good idea
76 Troy: …i can see [the] plan but i can't see [the] section (DMM, 16/05/03, 12:13).

Chat Excerpt 3.7

104 Rod: i m on the elevation view
105 Rod: u go back to the top view (DMM, 16/05/03, 12:29).

While Chat Excerpts 3.6 and 3.7 also demonstrate partners working in different modes – one above and one below – coordinating their design moves. However, this was quickly abandoned in favour of extensive use of the earlier above mode.

They used the presence of their partners in the virtual space to speculate on their design moves (see Chat Excerpt 3.8).

Chat Excerpt 3.8

49 theodor: what about knowing that someone else was in the scene with you?
50 Sally: that helps, but the system is difficult for the communication to go smooth[ly]
52 theodor: was it important to be able to "see" another avatar/person in the scene?
53 Sally: i think so
58 Sally: then, you will know what the person is up to, kinda speculate
60 Sally: or see what the person is actually doing, or 'looking' [at] (DMM, 03/07/02, 13:10).

This led to conversation debating the relative merits and validity of designing for privacy in physical and virtual environments (see Chat Excerpt 3.9).

Chat Excerpt 3.9

76 theodor: so what constitutes a private space?
77 Sally: [to] not be seen from side ways?, in this context?
78 theodor: do you agree with this Julie?
80 Julie: I agree [with] Sally
81 theodor: so, how do you know no-one can see you from the side in the virtual space?
82 Sally: yes
83 Julie: virtual and physical [spaces] are different
84 theodor: ok, how are they different?
85 Julie: in virtual space you… [would be able to] see each other even in [a so-called] 'private' space
86 Julie: but in physical space you can't see [because there are physical barriers obscuring the view]
87 Sally: different but similar i would say (DMM, 03/07/02, 13:24)

And a similar debate ensued in the 2003 cohort (see Chat Excerpt 3.10 and 3.11).

Chat Excerpt 3.10

48 Helen: we just [need to] cover the room [with a wall or screen in between]
49 Helen: so they can't see each other.
179 Helen: it is private because we can't see each other
183 Ann: I… think so… too! If we are both… in different rooms we can't see each other. There is no direct visual contact.
191 Ann: Alright we were designing the space keeping [the] physical world in mind but there exists nothing like PRIVACY in [a] virtual world.
192 Helen: yes
193 Helen: that's true
194 Helen: so what is privacy?
195 Helen: is there any privacy in the real world also?
208 Ann: We have some rules in [the] Physical world.... Those rules… [ensure our] PRIVACY [is preserved]
209 Helen: but someone can break your rules
220 Helen: so privacy is there, [but only] if we agree to [observe] the same rules [as in the physical world]
228 Ann: [but] you cannot take it for granted hence,… in cyberspace, there exists no word [or concept] like privacy (DMM, 16/05/03, 13:51).

Chat Excerpt 3.11

63 theodor: have you determined what privacy means in a virtual world?
65 John: privacy means you can't see them changing clothes?
75 Denis: a firewall is a useful wall in the virtual woirld… these are no good!
83 Denis: i can see you!!!nin cyberspace! (DMM, 14/05/03, 12:35-13:40) (continued in Chat Excerpt 3.13).

Having established the rules for designing a private space in the physical world they concluded that it simply did not apply to the virtual world. As most of the participants in this exercise were able to deduce the lack of privacy of the 3DVE, they did not feel compelled to use each other as prompts to check for privacy as they might have in a physical-world setting, such as in Chat Excerpt 3.12.

Chat Excerpt 3.12

88 theodor: so what does this mean about privacy in virtual space?
89 Sally: it is more transparent in [a] virtual world
90 theodor: can there be such a thing as a private space in virtual space?
91 Sally: i don't think so
93 theodor: Sally: why not?
94 Sally: anything linked to the computer/server, satellite is not private
92 Julie: [in this sense,] you can['t] use virtual tools to design space for physical goals.
97 theodor: [so] do you think it matters if you can see other people in the space or not?
98 Sally: it is good to test whether privacy is really necessary
104 theodor: Sally: you say it is good to test but you didn't coordinate the other person to prove it (DMM, 03/07/02, 13:35).

In fact, only one pair (from the 2003 cohort) used each other to check for privacy. But they quickly arrived at a similar conclusion – that privacy was not possible in this virtual environment (see Chat Excerpt 3.13)

Chat Excerpt 3.13

65 John: privacy means you can't see them changing clothes?
66 Denis: lol, doubt it's that easy to determine
67 Denis: digital voyeurs [(Denis moves roof element to one side)]
68 John: now you can see them changing clothes from the top
69 John: what happen to the roof?
70 John: why remove the roof?
71 Denis: just discussing

72 Denis: we don't need the roof
73 Denis: coz u can look in anyway
75 Denis: a firewall is a useful wall in the virtual world... [but] these [virtual] walls are no good!
76 Denis: i can see you!!! [(John had moved into the space to demonstrate)]
77 John: i can see you [too] [(John is looking up towards Denis who is above looking down)]
78 Denis: yeah well I'm not hiding [like you]
80 John: now i am in [a] private space [(John moves to the other 'private' space)]
81 John: can you see me?
82 Denis: ok ill look for u again
83 Denis: i can [always] see you... in cyberspace (DMM, 14/05/03, 13:16).

Being 'seen' in the virtual environment extended also to the ghost-like (my term adopted by the participants) movement of objects – design moves by the other partner could be seen in real-time, synchronised with their actions. For example, in Chat Excerpt 3.14 Sally could 'see' the spaces Julie created.

Chat Excerpt 3.14
139 theodor: Julie and Sally: how did you feel to see objects moving around on their own like ghosts?
141 Sally: interesting for me
142 Julie: yes interesting
146 Julie: you know actually the ghost [is] moved by somebody, and you can see the design idea of theirs instantly
147 Sally: yes Julie
148 theodor: Sally: are you talking about how you can move objects or how they seem to move on their own (that is, when Julie moves them)?
151 Sally: [it is] interesting to see [the] other's instant act
152 Julie: I... [felt I was] lost when I was moving these elements (DMM, 03/07/02, 13:44).

4.3.9 Chat Dialogue Analysis

4.3.9.1 The View from Above

From the chat dialogues it is clear there was little spatial experimentation at the 'floor level' of the design space. Once they 'discovered' they could float above the space of the props, this became their preferred operating mode. They claimed this 'working from above' mode was good for design; better for getting the composition 'right', and imagining the spaces defined as well composed. These are all phrases that can equally be applied to designing in plan on paper. They seemed to be using the props as cutout shapes moving them around as one does when erasing and making marks on a drawn plan. Chat Excerpt 3.3 shows that it was not just a preference for working in plan or above but that the tool was also more difficult to work with at floor level (discussed in more detail in the Discussion Chapter). Using the view from above dominated this case study.

Participants from both the 2002 and 2003 cohorts agreed 'planning' was critical to designing (see Chat Excerpts 3.4 and 3.5). Interestingly, other architectural drawing convention terminologies were included also in their spatial communications, such as 'plan', 'section', and 'elevation' (see Chat Excerpt 3.5 and 3.6). This hints at the influence of their prior architectural training, including planning on how they approach this task (discussed in more detail in the Discussion Chapter).

While the use of other architectural drawing convention terms in Chat Excerpts 3.5 and 3.6 demonstrates partners working in different modes, the more extensive use of the planning from above mode tends to support the case for 'thinking in plan' acting in 3D. This strong desire to work in 2D or plan mode limited their use of the perspectival tool in front of them. In turn, it also raised the question: what can this tell me about their perceptions of the tool? My assumption was that planning was adopted in this case study exercise because it is the way the participants were trained to view design space. As mentioned previously, it was also a function of the difficulty they encountered in using the tool to manipulate the props at floor level. At floor level in the 3DVE, if something is moved, consistent with perspectival geometry, it appears to get smaller. This makes it difficult to judge *where* it is in relation to other objects around it – it is simply in front of or behind another object. It is even more difficult to judge when one is viewing the object at an oblique angle.

The day following completion of the exercise, in one of the planned interviews with both partners present, I asked Julie, from the 2002 cohort, what she meant by her comment in Chat Excerpt 3.4 that, it was "hard… to control… [the] elements" at floor level? She replied that, "when I touch[ed] it [it] run [sic] away." This 'running away' is what happens when the angle between the plane sensor and its actioning plane (x-z) are the same or close, actions become exaggerated. In other words, the plane sensor works better at an angle to the plane. However, when I asked Julie's partner Sally the same question she said that "once I got it all arranged the way I wanted [it] it looked right [at floor level] but not in plan [from above]." This seems to confirm my first impression that it was both a function of the tool's sensitivity and their unfamiliarity with this type of view when using the 3DVE to visualise the spaces in a consistent manner at floor level.

Using the above view, it was clearly easier to gauge distances between objects because they could see them all in the same instance. This was further assisted by the other known fact, that they could only be moved in the x-z plane. Hence, it was also a product of a planar design space. Once the participants realised this (that objects could only be moved on one plane and that they could get an overview from above) they then made assumptions about what the spaces they created would look like after arranging the props below them before they went down into the space – to floor level – to check.

Using the view from above, they appeared to be working at the level of the plan *without having to visualise the spaces created.* They simply knew they would be 'right'. This confidence seems to have come from the certitudes of the tool itself and a pragmatic acceptance of its inherent accuracies. As a product of Perez-Gomez and Pelletier's (1997) 'epistemological perspectivism' (its presuppositions and foundations, and its extent and validity), the participants in this third case study exercise seemed to be accepting the ontology (the metaphysical nature) of the perspectival spaces they encountered as real and fixed, thus predictable. It should, and did appear to, support their imaginings of the spaces they mapped out with props which acted as surrogate plan markings[24]. I got this impression from Sally's 2002 chat comment, that she could use this 'planning' feature to get a 'better composition' (see Chat Excerpt 3.1). In the interview organised on the day after the exercise I asked Sally why she thought working from above helped produce a better composition. She said, "I could see it in there and it was like a real room so [I knew] it was right." In other words, with the roof elements removed, the layout of the floor plan was obvious. In fact, the slight convergence of lines receding towards the floor assisted the perception of a space with depth (see figure 33) – something a 2D plan alone does not do other than as a one-point sectional perspective. When I asked her partner Julie in the same interview why she thought it made it easier to 'imagine (necessary to visualise the spaces of a plan) the spaces she defined' (boundaries defined by conventional markings) from Chat Excerpt 3.1 she said, "the blocks [(props)] are in plan and when I move[d] them… [they made the] space I want[ed]." The spaces she was describing were actually *pre-imagined* 'correct' spaces. In other words, she didn't need to imagine the space because the tool was acting out her imagination for her. In fact, in a 2003 chat log this was made explicit (see Chat Excerpt 3.15).

Chat Excerpt 3.15

60 Trevor: I think we can visualise the space[s] without even be[ing] in them (DMM, 21/05/03, 11:59).

Here is a new spatial construct: the pre-imagined space as a product of the tool as a dynamic interactive perspective.

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[24] In this sense, the props could be seen to act as traditional plan signifiers (wall, window, column).

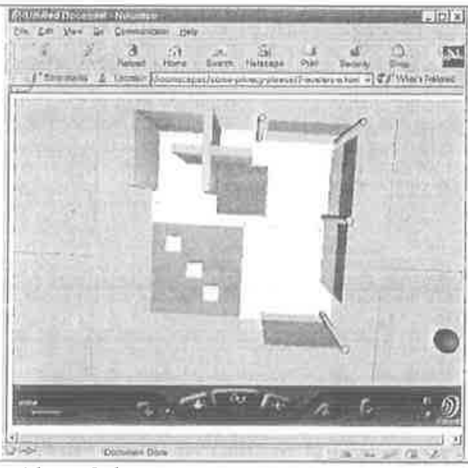


Figure 33. View from above with roof elements moved out of the way revealing a 'room' with perspectival cues.

However, these pre-imagined spaces were not always easily communicated to their partners. For example, in Sally's use of the term 'speculate' in Chat Excerpt 3.8, she did not seem convinced she was actually seeing what her partner was. Her allusion to speculation seems to suggest that simply being able to occupy the other's position in a 3DVE did not guarantee one will share their pre-imagined 'vision' as such. This is despite the ability to adopt the other's location being a key tenet of the power of perspective and central to the notion of a universal order, defined by rules and laws. Instead, it highlights the very personal nature of the mental constructs used to make sense of the spaces depicted.

4.3.9.2 Notions of Privacy and Transparency in the 3DCVE

The next major issue to be raised was the notion of privacy. Their notions of privacy and the relative merits of designing for privacy in physical and virtual environments was discussed at length by both the 2002 and 2003 cohorts (see Chat Excerpts 3.8, 3.9, 3.10, 3.11, 3.12, and 3.13). Having established the rules for designing a private space in the physical world most concluded that it simply did not apply to the virtual world. They ascertained that the 3DVE allowed for a non-private overview to be captured because the viewer is extant to the space, whereas in a physical architectural space it would be difficult to see past the walls to the overall space because they would be within the space. This exploration of the notion of privacy exposes their thinking through the virtual media revealing something about physical spaces they would not ordinarily have thought about. This is what Coyne (1995) refers to as how VR may reveal new ways of thinking about what 'reality' is.

The notion of an 'all-seen' transparent space was an artefact of the 3DCVE which facilitated a global view even when they were immersed in it. In other words, as revealed earlier, the 'above view' allowed them to look into the spaces much like in a plan, but it was also a view with some perspectival cues present. Added to this, the apparent certitudes of perspective meant they 'knew' what the spaces they mapped out from above would look like before they went down into them because they trusted the inherent certainties of the technology they were using to be consistent with their expectations. (An example of this is contained in Trevor's visualising the spaces without being in them (see Chat Excerpt 3.15)). Within this certitude they were also in total control. They could move any element to reveal the spaces contained – such as the roof. It follows therefore that they had an awareness of the spaces as 'mentally transparent spaces' – spaces containing objects without substance. The 3DVE manifested their pre-imagined view and dissolved any barriers in the way of it. This is quite unlike notions of privacy in both the view of a plan and its constructed physical corollary. Normal notions of privacy were not valid with the 3DVE version, the participants could simply move the roof elements to one side and 'see' in. This also meant there was literally nowhere to hide from the view of the other partner. Hence, Julie was quite right when, in Chat Excerpt 3.9, she said "in virtual space you… [would be able to] see each other even in [a so-called] 'private' space."

In a sense, this also announces yet another type of spatial construct peculiar to this case study: one where an overview is *always* present – the remembered layout view from above. Yet they did not need to be in the above view to know it was available. To make sense of this, one can draw on an analogous correlation between the way one of Piaget and Inhelder's (1956) pre-perspective infants depicts all the legs of a table and the all-inclusive nature of the 3DVE overview. Even though an infant may not ordinarily be able to see all the legs of a table at once, they will include them in their drawings because they 'know' they are there. Similarly, although Julie and Sally could not see everything in every view of a 3DVE they already 'knew' what it was that was obscured because they could shift their view to include them. In this sense, they were already mentally included.

In broader terms, where the perspectival image present in a 3DVE differs from its mature, traditionally static, depiction of, for example, a table in perspective, is the way it is extended. With the traditionally static perspective one cannot go behind the picture to see the missing or obscured legs, whereas with the 3DVE one can dynamically change the view to find them. Indeed, I would suggest that a conviction based on one's prior acculturation to the perspectival norms of a 3DVE is so strong that one does not even need to check if this is true. I saw this occurring in the way, despite being a logical method, most of the participants in this exercise deduced the lack of privacy of the 3DVE, hence did not feel compelled to use each other as prompts to check for privacy as they might have in a physical-world setting. Such as in Chat Excerpt 3.11.

When asked at the interview the next day why Sally did not check whether the private spaces they had created were actually private she replied, "I made some [private] rooms but I realised that it didn't matter so we gave up." In other words, no matter what they did their partner could always find a way to expose them. Privacy in their 3DCVE was a fundamentally flawed concept and not worth trying to prove. Thus, without conducting an exhaustive testing regime, the increased ability to verify this in a 3DVE seems to reconfirm this pair's subconscious acceptance of the perspectivist's epistemological ontology. In fact, only one pair (from the 2003 cohort) used each other to check for privacy. But they quickly arrived at a similar conclusion – that privacy was not possible in this virtual environment (see Chat Excerpt 3.13)

That they all arrived at a similar notion of the apparent transparency to privacy in the virtual environment tends to support the 'all-seen' spatial concept – the notion that all spaces can be known or computed hence do not need to be in-view to be 'seen', 'felt to be present', 'intuited', or '*real*-ised'. Being able to see (mentally visualise) all spaces at once, even from within them, tended to conflate the imagined spaces of their 'thinking in plan' with the actual 3DVE design spaces they created. This meant their normal concepts of privacy simply did not hold in a 3DVE. They resolved that the virtual environment was not good for designing physical private spaces by virtue of this 'transparency'. In fact, there was (almost) always someone else 'in there' with them and this someone else had the same access to the all-seen transparency of the 3DVE. Where this differs from their notions of privacy associated with a drawn plan is in the manner that a plan is more closely linked to its physical product and so contains (ontologically) opaque elements. The 3DVE, on the other hand, stood alone as its own *raison d'etre*. This transparent 'nonspace' of a 3DVE is what Wertheim (1999) refers to as a constructed cyberspace (see chapter 2).

4.3.9.3 Design Moves in the 3DCVE

Design moves in the 3DCVE were moments of shared visual orientation. In Chat Excerpt 3.14, where Julie says, when "you know… [the object was] moved by 'somebody'… [I could] see their idea instantly", I took this to mean design moves by their partner could be seen in real-time, synchronised with their actions. Similarly, Sally's claim that it is "interesting to [be able] to see [the] other's act" or design move, I interpreted to mean, unlike a drawn plan, Sally could see both Julie's 'marks' and the spaces she created with them. Here the construction elements or props acted as markings much like their corresponding signifier would be on a plan. But, the spaces created did not have to be imaginatively visualised. This is because, as discussed earlier, the 3DVE provided a pre-imagined visualisation of the resultant spatial arrangements. In other words, without having to imagine their design moves before acting them out they just transformed the given elements to see what arrangements were possible (this is similar to working with physical blocks).

Orienting themselves in the design space, I noticed their use of different views were akin to zooming. Much like, when one marks a plan one may mentally 'take a step back' to get an overview of their localised changes at a global scale, in the 3DVE these participants were using, they instantiated this 'stepping back' by zooming out. In one case this was confused with the 'zoom extents' function in the CAD programs they were more familiar with (see Chat Excerpt 3.16). Zoom extents was not a feature of the tool I developed.

Chat Excerpt 3.16

62 Ann: how to do zoom extent?
63 theodor: are you talking about the computer monitor or a screen element in the virtual world?
64 theodor: Ann you are thinking like CAD (DMM, 16/05/03, 13:10).

Despite not having access to a CAD-like zoom extents function, they did change their view to encompass different possibilities and the implications their localised changes made on the global – a kind of zooming. However, when someone else was making the changes they not only got a different view (to that of a traditional plan and from the other's) but as discussed earlier, without any agreed marking conventions they could not be sure they were interpreting the other's actions as consistently as they might do with a plan. The 'above' view afforded a better chance for a consistent interpretation, but this relied on the other actor also making their design moves from above too. Hence, two distinct types of design space emerged: the plan surrogate above view design space; and, the immersed floor-level design space. The first is closer to, and extends, the traditional plan view, while the latter confounds any consistent interpretation either from the same level or from the same location as its creator. Nevertheless, in the ostensibly orthogonal environment used in this third exercise the floor-level design moves could be consistently interpreted from the above view (assuming the props used were logical).

That the floor-level view confounds interpretation from anywhere but above suggests that the perspective image actually loses its unifying continuity when the objects in it are being transformed. It was in these moments that their vision was disrupted rather than enhanced by the other's actions. They seemed to focus on the moving object rather than the overall composition and then had to re-focus on the newly created 'picture'. This is present in Julie's final chat statement: "I… [felt I was] lost when I was moving these elements" (see Chat Excerpt 3.14). At the interview the next day I asked her why she felt lost when moving the objects. She replied, "I forget [sic] where I was.... I moved it and then [I] couldn't find Sally to see [where] it is.... I felt lost until Sally… [was] there." This is in contrast to her earlier statement in the same chat excerpt that, after an object has been "moved by somebody… you can see… [their] design… instantly." This suggests that the disruption was both visual and social; that Julie was relying on a connection to Sally's presence as part of a socially contextualised design move. From here I can perhaps confirm the overwhelming core reflection by all participants that it was as much a social exercise as it was a mechanical exploration; that they indeed felt a social connection to the resultant design outcomes because the whole exercise was a highly socialised affair.

4.3.10 Overall Outcomes

From the chat analyses three key issues emerge: the working in plan mode; the concept of an ontologically transparent spatial construct; and, the different approach to getting oriented in the space of the 3DCVE. The working in plan mode included:

- using props as cutout shapes in plan;
- the overview, view from above, and thinking in plan modes;
- this as a function of both their architect's training and the tool's inability to work well at floor level;
- unlike a plan, there was no need to imagine spaces in the 3DVE;
- assumptions about the certitudes of the tool and its incumbent perspective ontology;
- seeing props as surrogate markings;
- the 3DVE created pre-imagined spaces, but these were not easily communicated to others as a design 'vision';
- the deconstruction of perspective's hegemony; and
- due to their prior architectural training mapped onto the 3DVE spaces, the need for a new iconic language for describing design moves in a 3DVE.

The ontologically transparent spatial construct centred on the notion of an 'all-seen' view. Orientation issues were different to those identified in the two previous case studies. The combined predictable trajectories of the other's avatar and objects meant it appeared easier to get oriented in the space of the 3DCVE. From these, two main types of design space emerged:

the from above design space (easier to interpret because it was closer to the working in plan mode); and, the floor-level design space (which required refocusing, and confounded interpretation because it was difficult to follow the changes in spatial arrangements at floor level).

4.3.11 On Reflection

I set out to investigate how design students report their experiences of collaborating on a single design exercise in a shared-object multiuser virtual environment. I thought, by getting students to design and construct a virtual pool house with a private space, that they would have to devise a strategy for communicating their spatial interactions (the only form of communication between them being the chat channel). I did not know in advance what this would necessarily 'throw up' (in Guba and Lincoln's sense), other than: I had design students working in a medium for which they had had little or no prior experience with. The motive for having them physically separated and using online chat was the same as in the previous two case-study exercises. A primary assumption was that the shared virtual environment was a perspectival medium and that *how* the participants worked with this medium would reveal itself through the exercise. I did not know in advance just how this would occur or even what to look for. What happened of most significance in relation to the core topic of this thesis, how students interact with and navigate the perspective of a 3DVE, was the way they chose to adopt the plan view extensively, their discovery of a transparency ontology associated with the media, and an object-dependent orientation strategy.

The three different spatial realities that emerged included: the plan mode; the transparent ontology; and, the object-object-screen frame-viewer dependent orientation strategy. What this told me was that: firstly, the urge to design in plan was a dominant feature of their prior architectural training and, for the particular style and elements included in this exercise, it seemed quite appropriate to work in this mode; secondly, the very transparent nature of the media, as objects without substance, negated any conventional notions of privacy in such environments; and, thirdly, the shared-object design space with avatars facilitated a different kind of orientation strategy than that found in the two previous case-study exercises.

Combined, their spatial realities tend to demonstrate the ontological strength of perspectival media to inculcate a definitive veracity that promoted a certain confidence in their design decision making. I would not have been able to explore these notions without the process of going back and checking with the students what they meant by particular passages in a chat log, comments at one of the forums, or subsequent chance meetings. It was this triangulation that gave the study its depth.

4.3.12 In Summary

The pedagogical aim of this case-study exercise was to engage design students in a joint assembly project immersed in a 3DCVE; a virtual place for design exchanges to occur; a place where they could construct their own learning in a game-like risk-free fun environment. The motive of the game was to create a private space in a 3DCVE. To do this they explored various pool house designs. Conventions for expression in their collaborative designing invoked game-like rules, the rules ordered conduct and a cooperative assembly game emerged where each participant cooperated with their partner towards a common design goal (Dewey, 1957). They reached the conclusion that physical-world notions of privacy do not hold in a 3DCVE.

The research aim was to record and analyse how they communicated their experiences in the perspectival space of the 3DCVE. The chat logs I chose to analyse were those that I felt contained the most enquiring and richest content. Perhaps the strongest argument that comes out of their analysis and the subsequent clarifying interviews is the planning which occurred in a 3DVE. From this I noticed, unlike planning on paper, where the imagined spaces trigger its iconographical code, a 3DVE is a manifestly completely imagined representation of the same plans. However, there can be significant differences between the imagined environments triggered by the iconography contained in a plan and its fully realised (virtual) three-dimensional form. However, where there is little or no scope to change what is depicted in plan the 3DCVE contains a dynamically unfolding narrative which relies on the interactions of the viewer. Although both are open to reflective interpretation.

The 3DCVE puts the viewer in control. Through this control (and the overtness of privacy as a game motive) they were able to come to an agreement on the very nature of the medium itself. This insight into the ontological implications for a representational medium, ordinarily thought of as simulating a solid and real reality, was surprising. It means that the illusion of solidity of the scenes depicted could be dismantled and exposed as open to more interpretation than is ordinarily attributed by many authors to the media. One can choose to see the solidity or 'know' that this solidity is a semantic nonsense, or illusion. As Kubovy (1989) points out, once the illusion is unmasked it no-longer holds the same interest. Similarly, Brunelleschi's peep-hole was once an amusing trick which after being mastered, held little enduring interest as a legitimate art form.

4.4 Chapter Summary

This chapter reported on and analysed the case studies which form the raw data for this thesis. The pedagogical exercise that form the basis of the case studies moved in a sequential manner from simple physical-virtual object manipulation, through spatial identification on a plan and navigation of the spaces depicted in a 3DVE, to shared virtual-object manipulation towards a single design goal. The communications captured in their chat exchanges were analysed in detail. In the next chapter I tease out in yet more detail some of the key issues raised. in particular, those that relate specifically to the role of perspective in communicating spatiality.

5.0 Introduction

The case studies investigated in this thesis raised many issues with regard to the role of perspective in 3DVEs. Not all were envisioned in the original research question – many arose in process. This chapter begins with a review of the objectives, questions and premise as stated at the beginning of the study and my answers to these initial inquiries. In order to encompass a broader interpretation from the inquiry data uncovered, I next reframe the research question. This reframing reflects my experience of having undertaken the research.

5.0.1 The Shift in Aim

The original aim of the study was to investigate the role of perspective in real-time 3DVEs. This was embarked upon in the first instance as a critical review of the literature relating to the origins of perspective, the role of perspective in architectural visualisation and pedagogy, and (once an outline for developing a series of case study investigations had been established) a literature review of contemporary studies of how architecture students interact with real-time 3DVEs. The original aim has since shifted slightly to accommodate a richer, more meaningful understanding of the case studies that form the core of this thesis. In the following paragraphs I will revisit the original aim and describe how and why this shift was necessary.

5.0.2 Revisiting the Original Aim

In summary, the literature review tends to promote the argument that, based on the various scholarly studies of the parallel rise of perspective and the scientific method since the Italian Renaissance, perspective has had a pervasive influence on the manner in which the world is viewed in the West (see Chapter 2 for a more detailed overview). Viewed in perspective, the world is thought of in terms of a collection of objects in a 3-axes spatial coordinate system[25]. Where the combined perspective and its underlying scientific veracity find their greatest expression was in the nineteenth-century photograph. This has only recently been reconfirmed in the algorithmic constructions of perspective in 3D computer graphics programs. What is more pertinent to this thesis, however, is the way the day-to-day practice of the architect, and architecture pedagogy, is permeated by perspective, its geometric formulations, and incumbent ideologies. To understand how this came about, I included in the literature review a historical overview of the rise of perspective and its role in architecture, architecture pedagogy, and investigations into how architecture students interact with and navigate 3D

[25] While this Cartesian spatialisation scheme came after the mathematical refinement of perspective *per se*. Descartes' coordinate system built on this earlier work.

virtual environments. What the historical overview did was to establish the grounds for the objectifying ideology central to perspective. This suggests that perspective is not a value-free method for replicating or representing how we see the world. Instead, it imposes a particular order. Indeed, that the perspective ontology pervades our very existence. What almost all the authors reviewed agree on is the importance of the rise of perspective and the way it is used to shape the way the world around us can be articulated. Perspective and its recording techniques assist the documenting of architectural form and provides a consistent means for communicating spatial concepts which can be accurately interpreted by a variety of different people with similar results. The literature review concluded with an overview of other authors' investigations of architecture students' interaction with and navigation of 3DVEs (real-time perspective media). All the issues raised in the literature review relate to what perspective is. Hence, the initial research question seemed sound:

> *How do students of architecture interact with and navigate the perspective of a real-time 3DVE?*

As such the next section addresses this question as it relates to the case studies directly. Following this is my rationale for formulating a slightly altered research question which yields more, and more varied, results than is suggested by the initial research question.

5.1 Perspective Issues

5.1.1 Introduction

According to the main thrust of the literature review, perspectival technologies instil a particular ideology and framing of how spatial concepts can be conceptualised. As such, I sought to tease out the issues surrounding the effect and affect of perspective in the 3DVE component of the various case-study exercises. The following discusses the issues that emerged and their relevance and impact on communicating spatial concepts by the participants in my exercises.

5.1.2 Adopting the Other's View

A common, recurring, theme in the literature review was the notion that perspective allows one to see what the artist intended the viewer to see; that if only the viewer could adopt the artist's position they would see what the artist saw. This is particularly well articulated in Wertheim (1999) and Romanyshyn's (1992) notion of a locus of meaning associated with a perspective's centric point (dramatically demonstrated in de Vries' etching, see figure on page 3). However, what I found in my case study exercises was that participants had trouble 'seeing' what the other participant could see despite this being clearly possible using the technology available to them. They had even greater trouble trying to communicate these 'visions' using perspective cues.

5.1.2.1 The Fallacy of the Privileged Viewing Position

Perhaps the most significant finding in relation to the perspective ideology espoused by the literature was the assumption that perspective should allow one to see or experience the same vision that the creator intended at the time of its conception, by adopting their exact viewing position (such as standing on Pozzo's yellow dot under his 1690 ceiling fresco in the Church of St Ignazio, Italy) – literally standing in their place. This is exemplified in de Vries' etching (see figure on page 3) – one can see the artist has adopted the centric position in their work. By implication, standing in the same spot, the viewer should see not just what the artist created but their vision too – as the perspective is promoted as a realisation of that vision. Attempts by my participants to use this principle of perspective to communicate their design visions occurred in all three cases studies. In case study 01, it was the need to establish a succinct communication code so one partner could 'see' what the other saw. In case study 02, it was the ability to adopt the same position as the other by moving into it. In case study 03, it was the realisation of the pre-imagined spaces. However, in all case studies one partner was *not* able to visualise what the other did by simply adopting a common location. At least they were not able to arrive at consensus that they were all seeing the same thing. Instead, design visions – whether acted out using the physical or virtual blocks in case study 01, part of a spatial experience of a boundary condition in case study 02, or a shared design move in case study 03, such that each partner could manipulate their view to match the other's – tended to be highly personal, and neither easily captured by the other, nor communicated textually, by simply occupying the same viewing location.

5.1.2.2 A Personal Vision

In case study 03 Sally was clearly convinced she could not *share* her partner's vision by simply adopting the same location. For example, in chat excerpt 3.8, "…was it important to be able to "see" another avatar/person in the scene?" Sally replied, I "think so…. Then, you will know what the person is up to…. Kinda speculate…, or see what the person is actually doing, or 'looking' [at]". She merely 'speculated' on what her partner was seeing. This is despite the very feature of the 3DVE, its perspective view, and the ability to control the viewpoint, being a key tenet of the power of perspective and central to the notion of a universal order, defined by rules and laws. In other words, if the same rules are applied then the same solution should be arrived at. Instead, Sally's allusion to speculation highlights the very personal nature of the mental constructs – not the certainty of the perspective view – used to make sense of the spaces depicted. Even the raw, minimalist perspectival nature of the VRML scenes – simple orthogonal shapes sans shadows or any other realism cues other than perspectival geometry – was often interpreted in more than one way when a design vision was being communicated. For example, in chat excerpt 1.3 and 1.4b, "…did you do the H one?"; and, "So are you talking about the |-| model and about filling the gaps so it should be like |=|?" Instead of seeing the same thing when presented from the same location, they seemed to be interpreting the spaces, in a Gestalt-like sense – the mapping of their prior experiences and understandings of the shapes presented – and used this to form their impressions or judgements of what their partner could see or visualise. It was clearly difficult for the participants to communicate these impressions to each other using text, or within the 3DVE itself. This begs the question whether or not perspective is an efficient mode of communicating spatial concepts at all?

5.1.3 Is Perspective the Designer's Spatial *Lingua Franca*?

Once participants discovered the view from above they tended to use this mode extensively. It made it easier for them to communicate design actions. They seemed to be communicating in a mode that negated the benefits of the three-dimensional spaces below them. It was the most effective method for them to communicate their essentially two-dimensional moves.

5.1.3.1 The View from Above as Flattened Perspective

Unlike the supposed universality of perspective to communicate design visions, design visions tended instead to be a personal affair not easily communicated to others using perspective principles alone. Many methods of communicating their visions were used which did not include perspective cues. Most prominent were planar expressions such as in chat excerpt 1.5, "...now I'm going to use the square on the left and the rectangular [block] on the right to create an l-shape". These seemed to have been derived from their extensive use of the view from above.

The participants' use of planar expressions derived from the above view to communicate design decisions raises the question: was this because they put more faith into their training in established architectural drawing conventions to communicate visual or spatial meanings, or because perspective is not the *lingua franca*, touted by many authors on the subject, for communicating three-dimensional concepts? From my observations, I suggest it was a combination of both; that, for these design students, 2D, planar, iconic, symbolic, representations were just more effective than the real-time perspective of the 3DVE for communicating design moves. This meant they were constantly trying to enforce their pre-known spatial conventions (such as markings on a plan) onto the perspectival spaces they encountered, which limited them to acting in a particular way (viewing from above). Their mapping of pre-imagined spatial constructs (visualisations of a plan) onto the 3DVE were also manifestly contained within the forms of the 3DVE itself. In other words, from above, objects and spaces were simply *real*-ised objects and spaces 'in plan' – no less symbolic (for design purposes) than their equivalent markings on a 2D plan. What the perspective of the 3DVE did was to extend the traditional drawn plan by eliminating the imaginative visualisation step (identified in case study 02) that occurred between viewing a plan and interpreting its code as a three-dimensional space. However, the basic spatial concepts remain contiguous. Perspective, in this case, was largely redundant in both the visualisation and communication of the spaces and objects contained.

5.1.3.2 Communicating 3D Moves Using 2D 'Textual Pictures'.

The clearest manifestation of this apparent visualising in 3D yet acting in 2D was captured in case study 01. From the communications captured and analysed in case study 01, it appears little distinction can be made between the efficacy of performing the given task using the physical or virtual blocks. Although there was an expressed preference for the virtual, participants *were* able to assemble grammatical permutations of a typical Federation villa using either physical or virtual blocks with almost similar alacrity. This seems to have been due to the nature of their actions. Most actions were performed in two-dimensions only, and communicated by textually mediated 2D pictures (see chat excerpt 1.3, also discussed earlier). As such, this raises the question of the role of perspective in their actions.

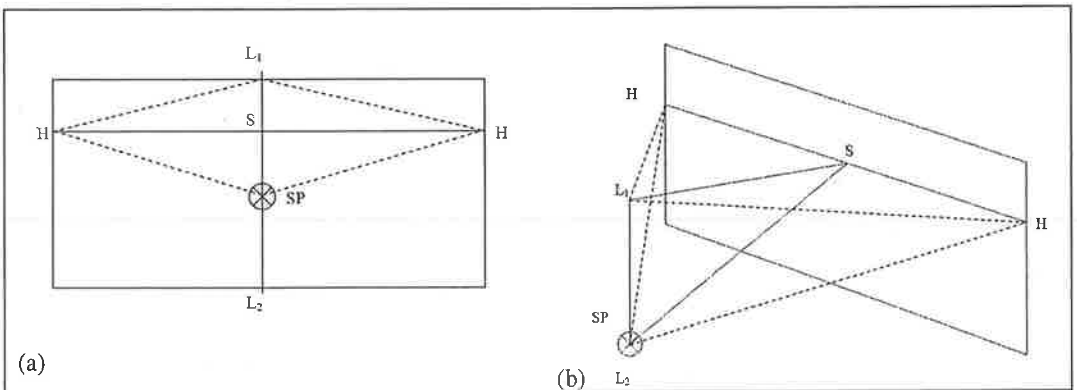
In other words, did their acculturation to perspectival technologies tend to conflate the virtual with the physical when engaged in tasks requiring similar outcomes using either type of object, or perhaps design students are so immersed in perspectival virtual (CAD) technologies that they mix real and virtual-world metaphors when communicating design moves? Either way, part of this apparent hybridisation of physical and virtual world descriptions may be attributed to the objectifying nature of the underlying perspectival technologies (espoused by Elkin's (1994) description of the fundamental object-to-object relationship of a perspective image). More particularly, the very nature of the virtual environments used in these exercises were object-oriented. In other words, perhaps it was the technology itself – 3D objects projected onto a screen, text projected onto the same screen, and their perceived need to describe the manipulations in a 2-axes plane – that guided the entire process.

As the 'space of design' tended to be flattened (the plane upon which most actions were performed), this suggests the third axis of the perspective image, on the screen or in the physical world, was largely redundant. The 3-axes system of the virtual blocks simply confounded attempts to communicate what was seen. The view from above seemed to alleviate some of this confusion. Most operations were performed in the picture plane and the plane of motion of objects. At least this is how moves were communicated for both the virtual and physical blocks. Although much communication was given over to aesthetic descriptions of three-dimensional forms, when focussed on the task-oriented descriptions their design moves were flattened. Hence, there occurred a visual switch between 'pleasing architectural form' in 3D, and 2D pragmatic manipulations of the actual architectonic elements. This does not imply that they did not 'see' depth in the images of their imaginations, but rather that the depth information was largely redundant, suppressed, or subconscious.

5.1.3.3 An Innate, Rather than Perspectival, Depth

The participants seemed to be using images embedded in the wording of the texts to describe the manipulations they wanted their partner to perform (see chat excerpt 1.5, also discussed earlier). These embedded 'textual images' tended to be planar rather than topological. Following the main thrust of the literature review findings one would expect to find depth features embedded in the wording of these textual images. However, I did not find anything that resembled a depth feature one would normally associate with perspectival notions of depth. To understand this, first I needed to revisit traditional perspective construction.

A traditional perspective is constructed with a horizon (*HH*) and a station line (L_1L_2) anywhere along which can be located a station point (*SP*). The picture plane can thus be divided into four quadrants as indicated in figure 34a. The relationship between the station line (L_1L_2) and the sight point (*S*) on the horizon could be thought of as, what I will call, a 'depth wedge'. It describes a wedge-shaped plane (L_1SL_2) as illustrated in figure 34b. This depth wedge marks out the depth relationship between the station line and the sight point.



S= sight point, *HH* = sight line, L_1L_2 = station line, SP = station point

Figure 34. Traditional perspective construction.

When one looks at the objects in a perspectively constructed picture they do not progressively get further away but simply smaller. The relationship is one of the *self in relation to* the picture as a whole. It is only when the self is removed and the space is entirely objectified, geometrised, or Euclidean (such as that produced by a computer algorithm, or the need to describe this phenomena such as in the oblique-view version of traditional perspective construction depicted in figure 34b), that an axis coming out of the picture plane towards the viewer (a z-axis) is required, *to conceptualise an abstract 3-dimensional space.* In other words, one is not *ordinarily* conscious of a third axis, only the interrelationships between the objects depicted, the picture plane, and a complete 'image' (see Kubovy's (1989) argument on this concept in chapter 2) – all contained within the 2D plane of the picture. Although depth may be detected or experienced in a perspective picture, it is only when we begin to *describe* the space depicted within the picture that a third axis is needed. As Lefebvre (1991) claims: "...it is only when we use *discourse* on space that we give it dimensions etc..." (see chapter 2 for a more detailed explanation). Hence, one must abstract the third axis from the information contained in the picture for it to be understood as a third axis, otherwise it is not cognised as such – ordinarily we see the picture as a whole. Following this thesis then, the participants in my exercises may have seen or visualised in 3D but they communicated their 3D visualisations as flattened 2D renderings within the picture plane in what they *said*. I describe these flattened 2D renderings as 2D 'textual pictures'. They are congruent with the plane of actions also. In other words, the plane where design moves occurs is also the abstracted picture plane they used to textually describe what they saw. This goes some way towards accounting for why I could not detect any perspectival depth features in their textual descriptions.

5.1.4 Effects and Affect of the Core Perspectival Technology used

Visualising in 3D, communicating in 2D, most pronounced in case study 01, was made explicit in case study 02. In case study 02, participants initially visualised real and implied boundaries from a plan. When they transferred this knowledge into the 3DVE interesting anomalies were thrown up. For example, elements ignored in plan were given different significance in the 3DVE: where columns were considered not to constitute a significant boundary of sorts, they appeared to do so in the 3DVE version of the plan; similarly, 'roof over', ignored in plan, was identified in the 3DVE as a significant boundary; and, stairs, treated as a whole in plan, were identified individually in the 3DVE, such as in chat excerpt 2.2, "...i could feel the jerk when i climb[ed] up or down the steps."

At first it seems the perspectival nature of the 3DVE revealed interrelationships not obvious in plan, such as the missing columns, roof over, or the stairs (treated as a whole) in plan, and re-evaluated as important in the 3DVE; that the apparent improved clarity of the perspectival imagery over the plan prompted a reassessment of what constituted a significant boundary condition. However, when the participants came to communicate some of these features they seemed to confuse the planar feature of the plan element with its corollary in depth in the perspectival scene. For example, in chat excerpt 2.6, "...for me the boundaries are the horizontal planes.... The roof and the floor." Perhaps, just as Alberti warned against trusting the (then) new perspective style in the sixteenth-century – that the artisan should instead put their faith in plans, elevations, and sections alone – here too, the illusion of perspective interfered with the participants' ability to make clear judgments about the actual significance of the objects depicted.

On the other hand, the perspectival nature of the 3DVE did seem to facilitate more, and different, imaginative visualisation modes than the plan could provide alone. For example, the ability to control the view (a central feature of perspective technology) facilitated notions of presence and the self in the 3DVE which were not present in the plan as such (other than in the imaginative spaces that the plan might invoke). For example, in chat excerpt 2.8 Bob claimed, "…if you come over to the corner where i am… you can see the column lines up with the end window…. Do you think the way they line up creates a corridor?" Moreover, the notion of the 'self in relation to' the space and objects in it reflected Panofsky's (1991) subject-object dichotomy discussed in Chapter 2 and reinforced the perspectivist epistemological argument about the commodification of space (as espoused by Lefebvre (1991) and Perez-Gomez and Pelletier (1997)) by recognising it as consisting of objects in a void – spaces contained; the reference to the privileged viewing position – the ability to stand where others stood – also reified the perspectivist epistemological position; and, the hide-and-seek game in case study 02 introduced yet another point-of-view within the 3DVE – where one did not want to be seen. To achieve this, one had to imagine the various ways they could be seen. In a sense, in all of these one was inside the picture, much like the semi-obscured figure in Brunelleschi's demonstrations. This is also something Damisch (1994) discusses in relation to the Urbino panels – the notion of the self within the perspective scene, and Piaget and Inhelder (1956) discuss as the infant emerging from a purely haptic topological landscape to experience themselves by imaging they can see themselves from other points of view – a precursor to experiencing space as projective, Euclidean, or three-dimensional.

All these experiences hinged on the perspectival technology which supported them. However, whether the participants had to be pre-acculturated to its norms is not clear. Although, as all the participants were design students, it is reasonable to assume they were already thoroughly accustomed to viewing representations of 3D perspectival spaces. What was revealed were the many different types of spatial visualisation modes or spatial realities they experienced. How they might be contingent on the perspective spaces encountered was only one form of spatial reality uncovered.

5.1.5 Enumerating the Participant's Various Spatial Realities

Many shifts in spatial realities were experienced by the participants in these case studies. Case study 02 gave the strongest examples. From case study 02 notes nine can be identified as:

1. working at the two-dimensional level of the plan;
2. experiencing the 'space' of the 3DVE;
3. a descriptive or experiential (or lived) space;
4. flip-flopping between two-dimensional and three-dimensional visualisation;
5. presence in the 3DVE;
6. a visionary space not easily communicated in the 3DVE;
7. the social dimension;
8. a contracted spatial reality when in hiding; and,
9. feelings of omniscience or anguish in the 3DVE.

5.1.5.1 Working at the Two-Dimensional Level of the Plan.

Participants visualised the spaces contained in the plan. This occurred in a Gestalt-like, internalised, mental reconstruction of the abstract markings as extruded three-dimensional spaces. These mentally visualised spaces did not always translate in a one-to-one isomorphic relationship to their correlating space in the 3DVE. This was despite most participants' obvious attempts to make them relate directly.

5.1.5.2 Experiencing the 'Space' of the 3DVE

Once participants had surrendered their visual sense of disbelief about the depictions of the Barcelona Pavilion in the 3DVE, they began to experience a new spatial reality – that of the 3DVE space itself. This was possible because, in James Gibson's (1979) terms, there were similar affordances to be found in the depiction of objects and their spatial relationships in the 3DVE and how the participants might expect to find them in the physical world. On occasion, this also included specific actions such as the bumping or jerking action associated with climbing the stairs.

5.1.5.3 A Descriptive or Experiential (or Lived) Space

Two clear types of space were explicitly communicated by the participants in the chat logs – descriptive and experiential (or lived in Lefebvre's (1991) terms). There were also a range of spaces in between these two extremes. At one end, the participants' spatial reality was still firmly in the physical world, where the frame of reference was the monitor's screen. In this descriptive space, individual objects were identified by type – walls, windows, columns, and so on. At the other extreme, the space was a more immersive, spatial, experience. Here, objects and spaces were referred to in terms of how they were experienced, evocative of physical-world experiential space – corridors, rooms, gaps, and so on

5.1.5.4 Flip-Flopping between Two-Dimensional and Three-Dimensional Visualisation

There were early attempts to map the schematic conventions of the 2D plans onto the 3D spaces of the 3DVE. This required the participant to mentally flip-flop between visualising the 2D spaces of the plan in three-dimensions and 'seeing' the 3D spaces of the 3DVE in terms of a flattened planar 2D version. This proved to be inefficient and was quickly abandoned in favour of 'giving over' to the 3D spaces of the 3DVE. This surrendering to the illusion of spatiality is what Kubovy (1989) describes as the power of the *trompe l'oeil*. In this case, it was an interactive, real-time, *trompe l'oeil* of the Barcelona Pavilion, albeit without the chiaroscuro cues.

5.1.5.5 Presence in the 3DVE

Slater et al (1996) and Knight and Brown (2003) describe presence in a 3DVE as a state of consciousness with behaviours consistent with what would occur in everyday reality in similar circumstances. While interaction with a 3DVE is hardly consistent with an everyday reality (yet) a sense of presence was triggered for these participants in this exercise. Their presence was further extended by their interactions with others in the scene. Their level of presence was indicated by their expressive positioning, recorded in the chat logs, between the descriptive and experiential spatial realities (discussed earlier).

5.1.5.6 A Visionary Space not easily Communicated in the 3DVE

Despite the ability to position oneself at the exact geometrical location of another in the 3DVE, it was still not possible to capture the other's 'vision'. This represents a very personal spatial reality, not easily communicated by the plan or the 3DVE (described earlier).

5.1.5.7 The Social Dimension

Socialisation was enhanced by the ability to communicate using an online chat application. The participants' communications via the chat channel in conjunction with their avatar in the 3DVE fostered this social dimension. Though not a spatial reality, it was a social reality. In turn, feelings of presence were supported and contingent upon this social reality

5.1.5.8 A Contracted Spatial Reality when in Hiding

The expansive spatiality experienced when navigating the 3DVE was contrasted by the contracted spatiality experienced whilst hiding in the game of hide-and-seek. This was similar to the contracted spatial reality associated with visualising the space of the plan or the critiquing of CAD drawings/models 'over the shoulder'.

5.1.5.9 Feelings of Omniscience or Anguish in the 3DVE

Whether feelings of omniscience or anguish can be defined as constituting a spatial reality is not clear. An 'out-of-body' experience clearly is. However, that an emotional reaction could be manifest in the participants' engagement with the spaces depicted in the 3DVE suggests a spatial reality of sorts. That these emotions were reported by the same cohort (2003) that reported an out-of-body experience suggest they may also be linked. If they experienced the omniscient reality of being in total control in the space, only to be jarred back into the physical-world reality (invoking anguish), then this indicates the sorts of metaphysical spatial experiences associated with an out-of-body experience.

5.1.5.10 Overview of Spatial Realities

From these descriptions, two key types of spatial realities emerged in case study 02: personal and socially mediated. The personal spatial realities were those that were experienced in the visualisation of plans and design visions. The socially-mediated spatial realties were those that involved communicating with others – either via the chat channel or visually (moving objects or the avatar in the scene). The perspectival technology used in this exercise provided an immersive environment for these spatial realities to emerge. However, in most instances it is not clear if the perspectiveness of the spaces was actually responsible for triggering a spatial reality. More seemed to hinge on planar interpretations than space-with-depth visualisations (a phenomenon described earlier). This tends to suggest their interactions with the media was not contingent on the perspectiveness of the technology in the evocation of the spatial realities necessary to complete the various tasks.

5.1.6 The Ontologically Transparent Construct

Where the pervasiveness of a perspective ideology did make itself apparent in these case studies was in the assumed ontological certainties that underpin its scientific veracity. This is also a strong point made in the literature review by the key protagonists for a perspective epistemological ontology (see Chapter 2). Interestingly, the pervasiveness of this perspective ideology did not arise in the case studies as an affirmation of the effectiveness of perspective to communicate spatial concepts, but rather to expose the failure of the 3DVE media to impose ordinary notions of in-depth obscuration. In other words, the *in*ability to hide one object behind another, confused the sense of depth – in the 3DVE, because of its interactivity, all spaces could be known. Hidden spaces could be exposed.

This was thrown up as a consequence of the motive for the case study 03 exercise – exploring notions of privacy in a 3DVE; the idea that physical-world notions of privacy are a nonsense in a 3DCVE. It highlighted the overall apparent transparency the environment invoked by the notion of an 'all-seen' ontology. While the 'above view' allowed participants to identify that it was also impossible to hide (in a digital sense) it also meant that all spaces were visible at once (even though one could not actually 'see' all the spaces at the same time); that all the spaces could be *known to be seen*. This is much like the child who draws in what they know can be seen, although not strictly in view from the same point.

This ontologically transparent spatial 'all-seen' construct relied on an overview knowledge and faith in the certitudes of the perspective medium. This was a mental construct that was more cognised than visualised as such. It is similar to the way one can locate objects in space after one has closed their eyes. One's spatial memory helps one locate objects in relation to one's self in space. One can mentally reconstruct the space around oneself by making logical spatial connections. One can predict the extent of objects they may be familiar with even though they may not have been in view when one's eyes were open, such as in the obscured table legs analogy used elsewhere. One ordinarily uses this ability to make sense of one's visual and topological haptic environments.

In this manner, from their overview position in the 3DCVE of case study 03, the participants could move construction elements around in the spaces below with the confidence that they understood the space as a whole and the implications of their moves. This is what makes an architectural plan so powerful and, in this instance, with the plan signifiers substituted by props, the 3DCVE so powerful as a planning tool for them (although it was not intended as a planning tool). Moreover, by having a more holistic knowledge of the spaces it also meant that all the space could be mentally re-constructed as 'seen at once' in a Gestalt-like manner (although this may not be what is actually on the screen at the time). In this sense, the 3DCVE acted as a substitute for the normally imagined spaces invoked by a plan. Both rely on a certain faith in the conventions used. In the case of a plan it is line weights and shading, in the 3DCVE's case it was the props with some perspective cues. While the first is well established for students of architecture, the second is less well established. However, the fact that the participants showed such facility in this medium suggests that they readily accepted the (in-perspective) planning mode as just as valid as its 2D paper-based counterpart. In fact, more so, as it was easier to confirm and validate by their ability to adopt multiple views (this was despite Sally's claims that to plan on paper was quicker, see chat excerpt 3.5). However, I suggest, contingent on their acceptance of the perspectival space as a valid method for their planning explorations, this required their wholesale acceptance of the certitudes of perspective's epistemological ontology. Moreover, that they were empowered to do so was due also to their thorough prior-acculturation to its norms.

5.1.7 Summary

In summary, when I look at how directly perspective related to my findings, five key features emerge:

- the fallacy of the privileged viewing position;
- the redundancy of the third axis;
- communicating 3D moves using 2D 'textual pictures';
- Many other spatial realities were thrown up too. These took the form of two distinct natures: descriptive and experiential; and,
- the notion that the medium itself appeared to be transparent.

What this tells me is that perspective was not as dominant as that espoused by the literature review. Rather, many other methods were used for describing the spaces the participants encountered, *despite* them interacting directly with a perspective media. What I thought, that the efficacy of the perspective as a dominant means of communication would reveal itself through the exercises, and in accordance with what the literature review says, and what I found were two different things. On the one hand, according to the literature, perspective has shaped our very understanding of space, how we represent it, describe it, move through it, and relate to it. On the other, the participants demonstrated that perspective was not so influential in the way they communicated, interacted with, or how they related to the 3DVE scenes they encountered. In fact, much of their interactions and communications were reframed as two-dimensional operations more closely aligned with the sorts of planning activities one would expect them to act out with pen and paper. This is discussed in more detail in the next section.

5.2 Reframing the Research Question

A number of clearly perspective-related issues were raised by the initial research question, as reported in the previous section. However, after analysing the case studies it became increasingly clear that other, perhaps more important, issues could be extracted from these analyses. The main theme that emerges is that the perspective influence, while present, was not as dominant as the literature review would suggest. This may have been due to a number of factors, such as: my decision to use pedagogical exercises as case studies, the type of pedagogical exercises used, communication methods, the highly socialised environments used, and the constructivist methodology employed to make sense of these. Indeed, in the final section of the literature review (completed after the case studies had begun), on investigations into the interaction with and navigation of 3DVEs by architecture students, I noted that neither the socialising affect of the environments within which the studies proceeded nor the core perspective technologies used were addressed directly. Commensurate with the constructivist methodology I chose to use, I felt this was the main gap identified in the literature which the case studies should now address.

Unlike the conclusions drawn from the literature review about the pervasive influence of perspective on spatial conceptualising, what the case studies show is a greater preference by my participants for manipulations and visualisations in two-dimensions which are not contingent on perspective. Nevertheless, the virtual environments used were explicitly three-dimensional, hence perspective was still influential, although not to the degree suggested by the literature review. On the other hand, many different types of spatial realities were uncovered. These alternate spatial realities are far more interesting than those mediated by perspective alone. Hence, the focus of this thesis shifted slightly to investigating perspective as only one spatial reality among others. This shift demanded a new research question:

> *How do students of architecture communicate spatial concepts whilst navigating in and interacting with the perspective of a real-time 3DVE?*

The new research question is more closely aligned with the method and outcomes of the case studies while still addressing the key issues raised in the literature review, albeit with a more open-minded approach. This is consistent with the constructivist method used which does not propose to answer hard-and-fast questions, but rather provide for judgements to be made based on the material available for analysis, to expand understandings in the field. Hence, the shift in research question at this stage enriched rather than constricted the possible outcomes and interpretations of this research. The following sections thus address this new direction. It includes four sections which tease out the emergence of alternative spatial realities derived directly from the participants' communications: Communication Modes, The Plan Mode, Socialisation, and Orientation. It concludes with a section on pedagogical outcomes and an overall summary of the chapter.

5.3 Communication Modes

5.3.1 Introduction

While the purpose of this study was the investigation of architecture students' interaction with the perspective of a 3DVE, my choice to use a restricted mode of communication exclusively – online chat – introduced its own effects on how and what data could be captured. Hence, communication became an issue in its own right. This was most pronounced in case study 01. The following describes typical communication modes encountered in case study 01 and what effect this had on the core research question.

5.3.2 Online chat as a Spatial-Concept Communicative Medium

The original reasoning to use online chat was to force participants to textualise their communications making it easier for me to capture them for later analysis; to avoid the risk of misinterpreting or just missing subtle but vital face-to-face tacit communications (subtle inflection, intonation, or accent in voice communication, or gesturing). Moreover, I wanted to, in Polanyi's (1967) terms, force participants to concretise their thoughts by writing them down (or, in this case, typing them). However, online chat turned out to be a particularly poor medium for communicating spatial concepts – especially for visually-oriented design students. Hence, what the online chat did was to filter the conversations such that much time was spent couching directions and responses instead of getting on with the design tasks as such. Although it could be argued this is part of Polanyi's concretising, it was not just about concretising spatial concepts, but more mundane task-organising issues such as what to do with the webcam or how to take a screen grab and so on. Nevertheless, the online chat did serve my primary purpose of capturing the communication data in a form which was easily organised, analysed, and could be referred to when meaning-making triangulation occurred with the participants.

5.3.3 The Acting Out of Instructions

Most participants came to the task with some prior experience of using online chat. Although, this was usually confined to socialising with friends remotely, not communicating spatial concepts *per se*. Hence, communicating spatial concepts using online chat was a novel concept for most. From an overview of all three case study analyses, clear 'design move' communication strategies emerged. The overall process appeared to be mediated by the textual communication, then visualised mentally, followed by action. Hence, the overall task-oriented exercise tended to follow the cyclic process of: fact-finding; resolution; reasoning; and solution, as illustrated in figure 35.

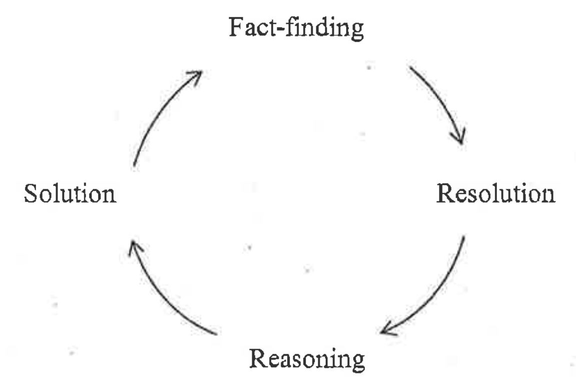


Figure 35. The typical design move communication cycle.

Often this meant considerable delays between segments of conversations due to partners taking time to frame their query or response to the other partner in using the chat interface. These delays were not always sequential. In other words, while one partner may have come to a resolution in their own mind, had communicated this to the other partner, and were ready to perform the next move, the other partner either did not appear to respond or took more time to respond than was comfortable to maintain a single thread of shared reasoning. This meant, often there would be more than one communication thread or conversation going on at the same time. In fact, many cyclic actions were performed simultaneously without apparent diminution in accuracy or instructiveness. Their ability to support multiply threaded conversations simultaneously is a legacy of the actions these participants engaged in when using chat for the more common task of friendly socialising. Indeed, when the participants were using the online chat interface, that I provided for these exercises, for socialising within the exercises, this strategy worked well. However, it was not used to communicate multiple moves (like in a game of chess – moves ahead). Instead, all design move communications were linear. In other words, a design move needed to be completed before a new one could start. The gaps in these linear design move communications were simply 'filled' with social banter, such as in the following, "…Lunch Time guys !!!!!!.... Where's lunch - in this world or the other one?.... In me BAG…. hahahaaha." (see the extended chat in appendix A.4 [265-270]). It was as if the pauses were intolerable. Much like in a face-to-face conversation where pauses are filled to create the impression that an active conversation is going on. This meant only a few design moves were actually tried out and a lot of conversation was given over to socialising. This was more pronounced in the 2003 cohort who seemed to dedicate more time to social chatting than design moves. This may be because, as a larger group they had more members to socialise with and chat about.

5.3.4 Communicating Design Moves

Delays in design move resolution was most pronounced in case study 01. From the overall outcomes of case study 01 I am able to identify some typical design move communication strategies. Participants' 'design move' processes typically involved the following sequence of events:

- A design is tried by the first partner.
- This is communicated to the second partner.
- Confusion may be experienced by the second partner – the textual description communicated does not match the picture generated in their mind.
- This confusion is communicated back to the first partner.
- The first partner then uses axes to drive a symbolic re-interpretation of their instructions.
- This is communicated to the second partner.
- The second partner interprets the symbolic communication successfully.
- The second partner communicates their agreement with the new instructions and completes the reconstruction of the first partner's instructions.
- The first partner communicates a new design move is to be tried, and the sequence is repeated.

This is highlighted in figure 36

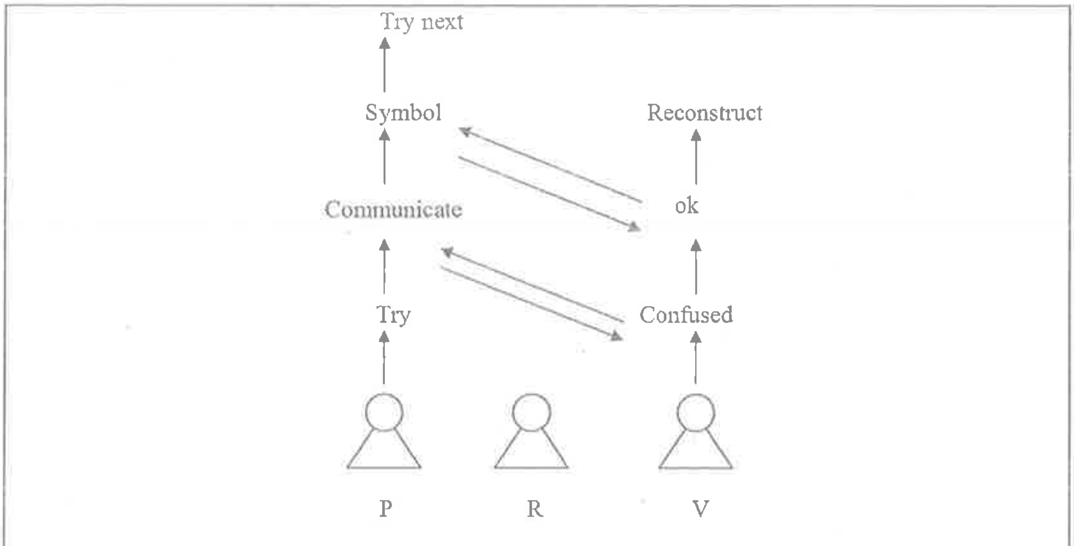


Figure 36. Typical instruction, construction, clarification and reconstruction cycle between participating partners. Researcher is largely a passive observer.

5.3.5 Aesthetic Considerations

When design moves were discussed (and despite the apparent pragmatism expressed in my design moves communication and the task resolution cycle diagrams), most were aesthetic moves (used to construct something recognisable) rather than purely pragmatic (trying out all mathematical permutations). This was borne out by the chats, forums, and interviews which often tended to be about living in a 'designed' environment. This was one of the unexpected layers of reality 'thrown up' by the exercises. Participants openly discussed what it would be like to live in their designs. In fact, aesthetic discussions often took up much of the remaining time between social conversations and design move instructions. For example, in case study 01 none of the participants arrived at the 'mathematically correct' solution. Yet, the fact that they were able to identify aesthetic permutations means they understood the 3D spaces well enough to overcome its limitations and focussed on aesthetic rather than mathematically 'correct' solutions.

As a mathematical problem its various elements can be arranged as in figure 37 Given that there can be only four rooms surrounding a central corridor and only two types of room (square or rectangular) and that the rectangular blocks can have at most two orientations then the solution can be expressed in the formulas that follow.

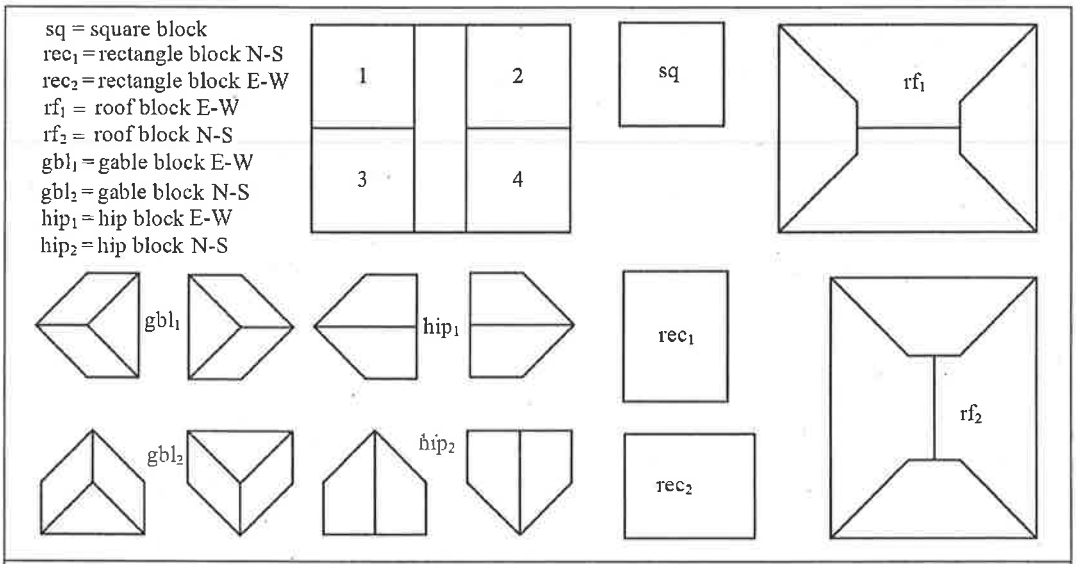


Figure 37. Mathematically organised elements of the Federation Villa exercise.

Mathematical solution:

$$(sq + rec_1 + rec_2) \text{ x } (sq + rec_1 + rec_2) \text{ x } (sq + rec_1 + rec_2) \text{ x } (sq + rec_1 + rec_2)$$

$= 81$ room permutations.

Where sq = square block, rec_1 = rectangular block in N-S orientation, and rec_2 = rectangular block in E-W orientation.

Now, there are two orientations for the roof, hence:

$(rf_1 + rf_2) \times 81$
= 162 room and roof permutations.
Where rf_1 = roof block in E-W orientation, and rf_2 = roof block in N-S orientation.

And, there are two types of roof extensions (hip and gable) with two orientations and no roof extension and combined hip and gable each in four possible locations, hence:

$((ext_0 + gbl_1 + gbl_2 + hip_1 + hip_2) \times (ext_0 + gbl_1 + gbl_2 + hip_1 + hip_2) \times (ext_0 + gbl_1 + gbl_2 + hip_1 + hip_2) \times (ext_0 + gbl_1 + gbl_2 + hip_1 + hip_2)) \times 162$
= 625 x 162
= 101250 room, roof, and roof extension permutations.
Where ext_0 = no roof extension block, gbl_1 = gable extension block in E-W orientation, gbl_2 = gable extension block in N-S orientation, hip_1 = hip extension block in E-W orientation, and hip_2 = hip extension block in N-S orientation.

The wording of the "verandahs…placed where appropriate" in the original task guide for this exercise means they are not a part of the calculations. They were not mandatory. As a mathematical problem, there are 101250 possible (although not all aesthetically desirable) permutations.

5.3.6 Summary

In summary, my choice to use an online chat facility to capture the communications between remote participants both provided me with a usable dataset and influenced the kind of data I had to analyse. Nevertheless, as this and the triangulation sessions were my only source of information to work with it proved fruitful enough. I was able to conclude what steps unfold in the process of communicating design moves and what effect they had on the various design moves possible. In the following sections of this chapter, how the textual communications are translated into revelations about alternate spatial realities is uncovered.

5.4 The Plan Mode

5.4.1 Introduction

Many of the design activities undertaken in these case study exercises were conducted from a view-from-above mode – perpendicular to the ground plane (except for case study 02). These activities were performed and communicated in a planar manner. This tended to reflect the participants' preference for working at the level of the plan. However, they did not always visualise in two-dimensions or choose a two-dimensional representation. The planar reflections and communications in case study 02 and 03 often tended to be re-visualised as legitimate spaces with depth while in case study 01 they were explicitly 2D.

5.4.2 The 'View from Above' Planning Mode

Extensive use of the 'view from above' mode in case studies 01 and 03 was part of the 'planning' seen as critical by the participants to designing. It was only used briefly in the 3DVE component of case study 02. This 'planning' mode tends also to support the case for the 'seeing in 3D working in 2D' identified in case study 01 (discussed earlier). It was the approach taken by both the virtual-blocks and the physical-blocks partners. This strong desire to work in 2D, or plan mode, limited their use of the perspectival tool in front of them[26]. In case study 02, the only time it was attempted it was quickly abandoned. (For example, when Bob tried to use the plan in conjunction with the 3DVE version). As it didn't work for Bob in case study 02, it seems what task is at hand determines which view is adopted. Some tasks require a floor level approach and others from above. In case study 02 it was clearly the view at floor level that worked best, whereas the 'thinking in plan', using the view from above, dominated the case studies 01 and 03. Apart from the difficulties some participants expressed about working at the floor level in the case study 03 3DCVE, the main reason planning seems to have been adopted in these case studies may be due to the participants prior-architectural training.

5.4.3 Differentiating Between Planning on Paper and in the 3DVE

Despite the 'view from above' or planning mode only being used briefly in the 3DVE component of case study 02, planning was an explicit part of the given exercise. It was confined to the plan drawing component alone. In the plan-drawing component of case study 02 the participants had to imagine they could see into the spaces of the Barcelona plan.

[26] That planning was such a strong featured use of the tool is counter to arguments promoted by much of the literature that a more simple tool is needed for understanding three-dimensional built environments (see Roberts (1999) in Chapter 02, 2.5.1).

However, while they may have imagined a view of the spaces encoded within the plan, they did not forget that it was a plan and not an actual space. How this is different from the physically or virtually constructed spaces is in what can be seen from above. Within the physical spaces of the actual Barcelona Pavilion it would be difficult to see the overall layout, for the building materials it contains largely prevents it. A bird's-eye-view could be gained from a crane, hot air balloon, hill top or other, but then the roof would still prevent one from seeing in. Indeed, the physicality of the roof is an insurmountable obstacle. Not so with the 3DVE version. However, the nature of the task meant participants were less inclined to adopt the view from above. Yet, while starting out from a plan, and having to imagine the spaces, participants were often surprised by what they found when they navigated the 3DVE version of the spaces (such as the roof and columns as boundaries not detected in the Barcelona *plan* but 're-discovered' as significant in the 3DVE, discussed earlier).

The core implications that arise from the second case-study exercise in relation to planning are that, while the students worked at the level of the plan when sketching and analysing it for boundary elements they were at the same time visualising the spaces coded within it as 'habitable' spaces. Consulting with them as a group revealed there was a base assumption that this cognition of the space as a real habitable space was automatic – it is a part of being an architect; that once one knows the code, one can 'read' the plans as habitable 3D spaces. But, looking at the analysis of the example chat logs given there seems to be little correlation between what was depicted in plan and how those boundaries were actually 'experienced' by the participants as habitable. In plan they were merely abstract geometrical constructs. In the 3DVE they were abstracted realities. There seemed to be a distinct difference between how the spaces of the plan were perceived and mentally visualised, and the same spaces actualised in the 3DVE. Despite this, the participants consistently tried to map their 2D understandings of the plan onto the 3D spaces they encountered in the 3DVE. This produced mixed results. In the end, most simply accepted the spaces depicted in the 3DVE as legitimate spaces and did not try to compare them to their planar corollary. Over the course of the exercise, this constituted a new spatial reality for them.

5.4.4 The Plan Mode Construct

In contrast to the 3DVE component of case study 02 exercise where it was difficult to gain a useful above view for planning, in case study 03 the participants could simply move the roof elements to one side to 'peer' in. Moreover, in case study 03, using the view from above seemed to empower them to work at the level of the plan *without having to visualise the* *spaces created.* They simply knew they would be 'right'. This confidence seems to have come from the certitudes of the tool itself and a pragmatic acceptance of its inherent veracity. This plan-mode mentally-constructed spatial reality involved mentally flattening the 3DVE so that operations could be performed at the planar level. Although it still contained perspective cues which helped, the screen *was* flat. Hence, it was essentially a plan view.

In case study 03, how the plan mode construct can be differentiated from the view of the drawn plan in case study 02 is in the way the 3DCVE of case study 03 provided substitute spaces or pre-imagined spaces. These were self-contained, realised spaces which actually existed in the 3DCVE and were verifiable. This is different to the imagined spaces invoked by a drawn plan's coded layout which are not verifiable other than by way of yet another coded metaphor. These pre-imagined substitute spaces and their verifiability rests on the ontological assumptions of the immutability of the perspective laws. However, paradoxically, while a perspective's ontology may hold as an abstract concept (in Euclid's terms) it was deconstructed in the 3DCVE. This occurred when its constituent elements (view, objects, orientation) were dynamically altered in real-time, such as when Julie commented that she was temporarily lost when moving objects in the scene. This encapsulated both the notion of immersion and the apparent deconstructability of the perspective which supported it. Unlike the immutable static perspective image which can be comprehended as a unified whole, consistent with the laws of perspective (despite Escher's impossible spaces), the dynamic perspective of the 3DCVE presented to the participants was not fixed. Unlike in case study 02's Barcelona Pavilion exercise, where all the objects were fixed, in case study 03's exercise not only did the avatars appear to move about but so did the objects. For Julie, this was disconcerting. Her sense of perspective spatial unity was momentarily interrupted. Whether this was because she was not familiar with navigating a shared object multi-user 3DVE or suffered a genuine sense of disorientation is not clear. Either way, as a mode for design exploration, the certitudes of perspective were dismantled in this act. It was replaced by the more familiar plan mode. This leads me to the conclusion that, in this instance, with this orthogonal space, and with these participants, the dynamic perspective of the 3DCVE was treated as a code, like a plan's. However, it lacked a comprehensive or consensual code to communicate design ideas as succinctly as the well-established plan does.

5.4.5 Summary

While the planning mode clearly dominated most of their actions and communications in the case studies the participants clearly re-visualised these actions as 3D spaces. In case study 02 they did not forget they were looking at a plan when they were describing the spaces indicated as habitable spaces. In case study 03 what they imagined in 3D seemed to be confirmed by what they found in the media. In other words, the perspective spaces were manifestations of their imaginations. However, this does not mean they were better able to communicate this directly to others (as discussed earlier, see section on perspective issues). Nevertheless, as a planning exercise the 3DCVE acted as a codified field for playing out their various planning moves not dissimilar to a drawn plan with its coded elements.

The exercises in the case studies were game-like. They relied as much on individual interpretation as they did on a shared design game of sorts. The social dimension these game-like exercises threw up is discussed in the next section.

5.5 Socialisation

5.5.1 Introduction

The case studies highlight the social dimension of interacting with multi-user 3DVE perspective media that is mostly ignored in the literature. The use of online chat and the participants' prior familiarity with the tool fostered a sense of social cohesion. My ability to investigate their actions and reactions also hinged on their willingness to use the online chat to socialise.

The chat environment had previously been used by the participants as a socialising tool. In case study 01 exercise this was exemplified by the casual language used. In case studies 02 and 03 it was not just the chattiness of the language used but also the combined notion of the collaborative virtual environments they found themselves in which fostered its own kind of social interaction. It was through their social interactions in the 3DVE exercises and their communications that I was able to derive the data analysed in my case studies.

5.5.2 Socialisation in the 3DCVE

The participants' social interaction within the virtual environments they encountered was most pronounced in case study 03. For the participants in this case study, the shared-object 3DCVE tool used as a pedagogical exercise, foregrounded shared design outcomes over its use. Their focus was on results. The three-dimensional shared virtual world, as a legitimate design medium, provided immediate results continuously. Once the tool was mastered, participants felt a connection with what they were doing and what they were seeing. They focused on the results rather than on the process, such as in chat excerpt 3.1, "...up in the air looking down... is good for des[igning].... Better... [for getting] the composition [right].... You can imagine the space you define." A cognitive shift occurred from awareness of the tool's interface to the results of their interactions with it and each other.

After having navigated the virtual Barcelona Pavilion exercise some weeks prior in case study 02, in case study 03 it was quite apparent that at first they were thrilled to 'see' another 'person' accompany them in a virtual world. This was followed by the expectation that others *would* reveal themselves. In case study 03 the apparent random movements of their partner's avatar and their own interaction with objects in a virtual design space could be likened to inviting someone to 'participate in one's dream'. Both are identified by Heim's (1998) 'felt quotient of immersion' due to the presence of others and the ability to share objects in real-time. Where case study 03's exercise differed in its operation from case study 02's exercise was in its motive for sharing objects in a construction game. As a design exercise, rather than a simple navigation exercise, this led to participants adopting a common viewing protocol, similar to that used in case study 01 – the god-like view from above (discussed earlier, see section on above view). In so doing, they agreed to see the spaces in a particular way.

After positioning objects from above (in plan) participants often then moved down into the scene to experience the spaces created. They either invited their collaborator to descend with them or an 'unspoken' recognition of the cues caused them to descend in tandem. Communicating textually, and with the corresponding movement of virtual objects, their design ideas were both realised and experienced. Participants agreed they were sharing a 'lived design experience', and that this level of immersion was distinct from experiencing design objects or spaces in isolation, such as with traditional forms of CAD collaboration, such as that expressed in chat excerpt 2.15, "...I think that showing someone through your space virtually is different from just having them look at the screen over your shoulder." Bob's reference to the 'screen over the shoulder' was about the CAD arrangements he was more accustomed to using for discussing computer-mediated design issues.

From the case study 03 chat logs two key social concepts arose:

- the notion that it would make a difference if collaborators did not personally know their collaborators; and,
- that a 3DCVE is essentially transparent, meaning that notions of visual privacy do not hold in the strict sense.

It is not clear whether personal knowledge of collaborators assisted or detracted from the ability to reach consensus on design moves, hence, this remains problematic. The transparency of the 3DVE and the ability to 'see all', or at least be able to detect the presence of others by external indicators (such as 'ID's' logged on the server, or chat panel), suggested the prevailing acceptance of a reduced autonomy associated with society's dependence on electronic media obtains also in this 3DCVE. In other words, both their prior knowledge of their collaborator and the fact that they were not able to hide from them contributed to a social openness and willingness to engage in the exercises as a fun social activity. This goes some way towards authenticating my interpretations of their actions as natural and not contrived, as in the more typical laboratory settings used in the reported outcomes of similar exercises uncovered in the literature review.

5.5.3 The 3DVE as a Responsive Environment

In some instances the 3DVE responded in a predictable manner (such as in case study 02 where Mary referred to climbing the stairs as bumpy (see chat excerpt 2.1)). A certain confidence was derived from the apparent predictability of the virtual environments they encountered. This was predicated on the spaces they encountered and an expectation about how the spaces should respond to their interactions with it. So much so that Trevor expressed his feelings that the spaces could be visualised without having to be in them – an expression of total control (see chat excerpt 3.15). The tool's apparent predictability was the subject of some conversations (see chat excerpt 2.2, discussed earlier). Tacit agreement on these points fed into the overall social atmosphere of the exercises, further supporting the relaxed and natural settings fostered by the participants' prior knowledge of each other.

5.5.4 Summary

Both the 2002 and the 2003 cohort claim to have enjoyed working with case study 03's exercise. Indeed, they claimed they felt a social connection with their designs that they would not ordinarily have experienced with traditional CAD. This tended to be as much about the fact they were collaborating on a design exercise as it did about the ability to work in a real-time interactive virtual environment. This was a type of social designing they had not previously experienced.

Socialising using the online chat interface and shared interactions in the various 3DVEs used in the case studies was crucial to establishing the natural, relaxed, friendly environment necessary for this constructivist study. Its effects largely ignored in the literature[27], the social dimension provided a richness to the study not possible using quantitative methods alone. It was within the participants' social banter that critical insights were captured; those embarrassing moments such as getting stuck in one spot and calling for help; the use of emoticons and abbreviations to express delight at seeing the other in a scene; or, making comparisons with the traditional CAD 'over the shoulder studio critique'. Socialising also assisted getting oriented in the spaces. This is discussed in more detail in the next section.

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[27] Although, it is worth noting that early design collaboration studies focussed on socialisation over visualisation *per ser* (see Chapter 2, 2.5.2).

5.6 Orientation

5.6.1 Introduction

Getting oriented – knowing where one is, letting others know where one is – in the 3DVEs was critical for the succinct communication of design moves. The various orientation strategies adopted ranged from the explicit in case study 01, adopting the other's view in case study 02, to socially connecting movements with the other's avatar in case study 03.

5.6.2 Communicating with Text and Objects in the 3DCVE

In case study 03 there were two examples of the exercise in case study 01 being taken to its logical extension (see chat excerpt 3.12). Case study 01 was about communicating design moves based on a set of rules using either a physical or virtual kit of parts. This was logically extended in case study 03 by sharing the construction elements or props in a multiuser navigable design space.

The first example where case study 01's exercise was logically extended in case study 03 occurs where Julie says, when "you know… [the object was] moved by 'somebody'… [I could] see their idea instantly". I took this to mean, unlike in case study 01's exercise, where the participants could only communicate their design moves using text, in case study 03's exercise, design moves by the other partner could be seen in real-time, synchronised with their actions. Hence, the various negotiated design move iterations involved a similar process to case study 01's exercise. However, in case study 03, orientation seemed to be facilitated by being able to see the other's avatar and their orientation in relation to the objects they were moving rather than negotiating an explicit orientation strategy based on Cartesian coordinates (as was the case in case study 01). Where this also differs from and extends case study 01's exercise, and to a lesser degree case study 02's exercise, was in the manner where one's partner had to imagine the view from the other partner's position. Unlike in case study 01, where this was difficult to judge based on textual communication alone, in case study 03 the cues (avatar, object, screen, up, down) were sufficient to negate the need to actually adopt the other's position because the secondary trajectory reference was the moving object itself. In other words, with multiple sources of orientation information one partner was able to follow the other's design instructions without having to establish either an explicit orientation strategy (as in case study 01) or to adopt their position (as in case study 02).

5.6.3 The Orientation Construct

The need to get oriented in the various spaces occupied much of the available time for the exercises and communicating of moves in the chats. This was most pronounced in case studies 01 and 03. This is not surprising, as case studies 01 and 03 involved design moves which required the establishment of a strategy for communicating coordinated moves. In case study 02 this was less critical, as there were no movable elements. In case study 02 the focus of the exercise was on navigation alone and, when a known avatar was in view, orientation invariably involved adopting the other's viewing position only (discussed earlier). In case studies 01 and 03, on the other hand, the need to orient oneself in relation to the scenes depicted was critical for the clear communication of design moves. In case study 01 this was entirely textually mediated, as they could not see each other's actual blocks. In case study 03, movement of both an avatar and the design elements was visible for both partners at the same time. In this sense, design moves in the case study 03 3DCVE were moments of shared visual orientation – design moves by one partner could be seen in real-time by the other partner. These moves were synchronised with their, and their avatar's, actions. One partner could use the given design elements to 'mark-out' the design space and the other partner could see their moves in real-time and associate them with their partner's actions and their partner's avatar's presence in the scene. For example, in chat excerpt 3.14 Julie claimed, "...[when]... you... see objects moving around on their own like ghosts... you know actually the ghost [is] moved by somebody, and you can see the... other's instant act." The presence of the other's avatar in the scene was crucial to 'understanding' the moves. This understanding was a social understanding: the moves were being made by her partner, and her prior knowledge of her partner included a social agreement. Hence, the moves were socially mediated. This can be further translated into a socially mediated orientation construct (the mentally constructed notion of using the other's avatar as a social signifier of their presence and location in the scene). Thus, one was able to orient themselves in relation to the other both as a socially and visually mediated point of reference.

5.6.4 Framing the Orientation Construct

In case study 03, the socially mediated orientation construct was not only founded on use of the other's avatar. It included transformed object trajectories (an object moved from one location to another in a particular direction), and the screen's frame, to establish a unified coordinate system. To understand the topological relationships of this orientation strategy

Piaget and Inhelder's (1956) discussion on the shift from haptic topological to projectional relationships helps (discussed in more detail in subsequent work published by this author).

According to Piaget and Inhelder (1956), a non-egocentric view is necessary to identify objects in Euclidean space. On the other hand, the pre-perspective condition is where all objects are viewed in relation to the self, as highlighted in figure 38.

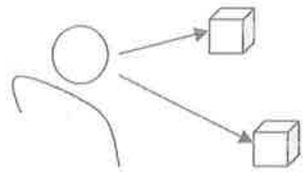

Figure 38. Egocentric topological relationships between self and objects in space.

Hence, for participants to be able to orient themselves in relation to the objects in the scene required the empirical knowledge of the image on the screen, and their interpreted mental re-construction of the image depicted on the screen. This is similar to their interpretation of the physical-world topological relationships of proximity and separation. However, in the projective Euclidean space of the screen image, objects were located in relation to each other and their positions relative to an overall coordinate system. Hence, the perspectively constructed object on the screen was not viewed in isolation but was considered from a 'point of view.' The projective interrelationships between the objects presumed the inter-coordination of the objects separated in space. Within this system, the self was viewed in relation to the objects depicted as a group of which the viewer was merely yet another object within the same group (the non-egocentric condition). Thus, when they mentally adopted the view of their partner then the object viewed also had a point of view relative to other objects around them including themselves. This meant they could 'see' the other's view without having to adopt their position (discussed earlier, see section on perspective issues).

To relate objects spatially, using a system of projective viewpoints or coordinates, required a cognitive shift in the conception of space in general, from topological to projectional. It required the coordination of the various viewpoints into projective relations. To become consciously aware of the relativity of other viewpoints was the opposite of an egocentric view point. In other words, they were subconsciously aware of themselves from the point of view of the objects in the scene, as illustrated in figure 39.

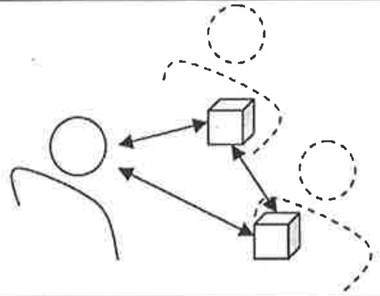

Figure 39. Non-egocentric topological relationships between self and objects, between objects, and between objects and self in space.

Developing a coordinate system for identifying their own position and orientation in space in relation to the screen required an empirical knowledge of the screen and mentally re-placing themselves with their partner to see what their partner saw. To do this they had to construct a physical frame of reference. This was essential to understand the Euclidean spatial concepts contained. Only then could the interrelationships between themselves and the objects in relation to themselves parallel the general coordination of a non-egocentric mental viewpoint construct, the salient feature of projective space (Piaget and Inhelder, 1956).

For example, in figure 40 there is no requirement for a topological spatial awareness other than that of the screen. In this scenario, for Julie to understand what Sally could see she had to imagine herself in the position of Sally (B) (Julie (A')). Julie (A) could then go 'there' to check. When Sally (B) made a design move, an object moved, and Julie (A) associated the movement with Sally's avatar (B), otherwise the movement had no apparent cause or origin. Thus, the object moved in relation to objects close by, its shape changed in relation to the screen's frame, and it appeared to be actioned by Sally's avatar (B), because Julie (A) 'knew' it to be so. This relied on an ontological understanding which was also supported by their socialisation and textual communications. Nevertheless, as Julie reported earlier, affordances were disrupted during movement because the focus was on the object not the mover – as Julie explained, when no avatar was present it did not make sense. Without Sally's avatar present, Julie could not connect the action with a person. When Sally was present, Julie saw the object move, assumed Sally (or Sally's avatar) was responsible, and knew the object's position was relative to the avatar and the other objects in the scene. As the purpose of the movement was design, Julie mentally visualised what the new design was as seen from Sally's perspective *without having to 'go there'*. In this sense, and when Julie reported feeling lost when Sally's avatar was not present, the social connection the partners felt when interacting and communicating with each other assisted their orientation beyond simply the topological conditions. They genuinely felt each other's moves as a single action.

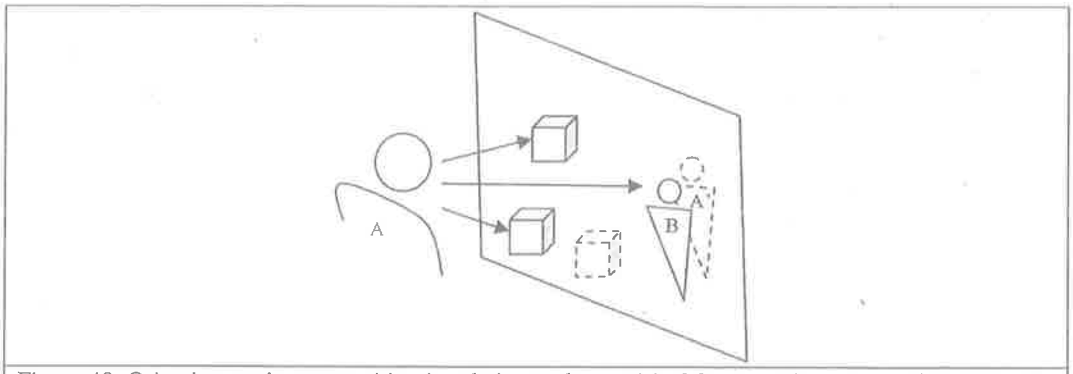

Figure 40. Orienting one's own position in relation to the empirical frame of the image and the objects within it, and then orienting themselves within it to see what the other sees.

This was different to how they perceived actions and reactions in the physical world of the wooden blocks in case study 01's exercise. Working with the physical blocks, they had a different spatial awareness of their environment and objects in relation to the self. When an action occurred, objects were seen to move because their arm came into view and moved it – simple cause and effect. If their partner was present they would have seen their partner's arm move the object (see figure 41). When the virtual blocks were projected onto the screen, they needed to infer their movement actioned by the mouse from empirical knowledge, social understanding, and an inherent faith in the veracity of the system as a whole.

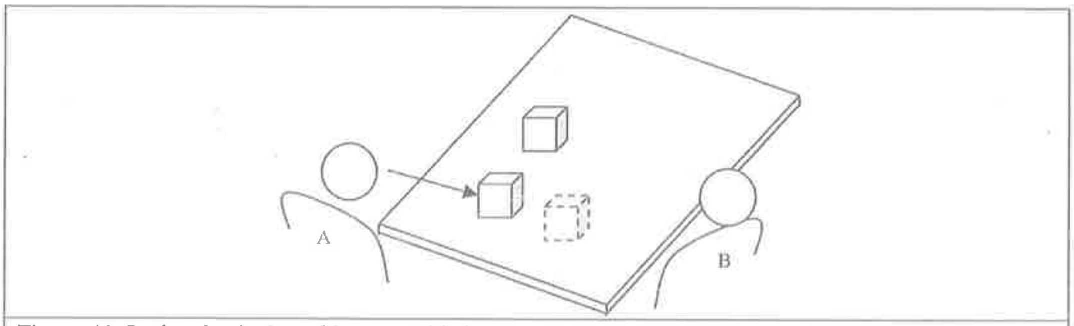

Figure 41. In the physical world one establishes topological relationships between themselves and objects in space. When a move is actioned by another the other's hand gives them away.

5.6.5 Summary

The progression from an explicit orientation strategy in case study 01, through semi-social 'standing in for the other' in case study 02, to a socially-mediated orientation construct in case study 03, demonstrates the increasing importance of socialisation in these exercises. The connection the participants felt with each other through the exercises cannot be understated. The media was essentially transparent to these social interactions. In this sense, it was neither affective nor did it act as a lens. Although, it could be argued that the coarseness of the media filtered out much of the tacit meaning that could be conveyed. Nevertheless, the messages did get across. In this sense, perspective as a lens for filtering and ordering their social interactions was not present.

5.7 Pedagogical Issues

5.7.1 Introduction

From the triangulation process – discussions with the participants, clarifying and re-clarifying apparent meanings (described in more detail in the Methodology Chapter) – I got a glimpse of when the participants' understanding of the media, and of their own interaction with it, was transformed by the case study exercises. Their transformations occurred while reflecting on the process – not a paradigm shift in Kuhn's (1996) terms but a transformation of how the media could be conceptualised. There were both pedagogical and conceptual transformations: pedagogical when the transformation helped them identify the potential for the media to be used in other pedagogical settings; and, conceptual when the participants came to independent enriched understandings of the fundamental nature of the media and its potential to alter or generate alternate subconscious spatial realities. In other words, they became more aware of their own spatial realities. This occurred through the process of reflecting on their concretised thoughts typed into the chat logs and later reflecting on these thoughts in the various organised and informal forums. The following are exemplar transformative outcomes from all three case studies.

5.7.2 Transformative Outcomes from Case Study 01

A pedagogical transformation occurred in Mary's self revelation of her desire to better understand virtual technologies, and a conceptual transformation occurred in thinking through this process. Similarly, on reflection, Bob formed a richer understanding of the fundaments of the media.

When Mary reflected on her chat about preferring to "work with [the] virtual model sometime" (even though she had not seen it) she was surprised that her desires were so clear and irrational, although apparently justifiable. She justified this 'irrational' desire by claiming that:

a) she was actively pursuing a better understanding of virtual technologies; and,
b) she thought it would be easier to complete the task with the 'virtual model' because it appeared to be easier to communicate moves based on "what Bob said [or typed]" (because he was using the virtual blocks); that Bob's descriptions helped frame the 'picture' she had created in her mind of how the task could proceed.

Until being involved in this exercise, Mary claimed she had never made any *conscious* distinction between how what was depicted as virtual could be described in different terms to what it might represent in the physical world.

Similarly, for Bob, transformative outcomes came after reflecting on the chats in the organised forum the day after the exercise had been completed. For example, he was surprised that Mary had so much trouble understanding his orientation strategy. For him it was quite clear, "all 3D modelling tools [have the same] axis language", so surely others would see the same as he did. He did not distinguish between what he could see on his screen and what he thought Mary should see in her arrangements of blocks – that for all intents and purposes "they ...[were] the same." That they might not be the same is where Bob's 'click' of recognition (Lather, 1991), and a more sophisticated understanding of the media, was formed.

5.7.3 Transformative Outcomes from Case Study 02

Bob had a pedagogical transformation when he compared CAD with the exercise at hand, and a conceptual transformation occurred for most of the participants, including Bob, in relation to the difference between the apparent fixed nature of a plan and its 3D extruded corollary in a 3DVE which proved to be quite different.

When Bob reflected on his chat about using the plans next to him when navigating the 3DVE, it was with some small embarrassment that he confessed that he felt he was "cheating" at the time. I pointed out to him that what was important was not that he had cheated but that he had actually chosen, of his own volition, not to continue using the plans because they only served to confuse matters. He expressed surprise that he had not thought of that. This revelation, and his reflections also on how case study 02's exercise compared to CAD, had "opened his eyes" to how powerful this medium could be and how it might be used in other design settings.

Most participants in case study 02's exercise expressed varying levels of astonishment that their notions of what constituted a real and implied boundary could be so different between the way they had identified the different types – depicted in plan, and finding new ones in the 3DVE. Initially, they had felt very sure that their plans were "correct"; that they would find exactly the same relationships in the 3DVE. In fact, even after witnessing the differences emerge, some were still not sure whether the 3DVE or the plan was "right". After all, the plan was "fixed" and objective. The 3DVE, on the other hand, was an "illusion". This in itself is interesting and demonstrates a reluctance by these students to transform their prior understandings to accommodate the newly gained knowledge.

5.7.4 Transformative Outcomes from Case Study 03

A pedagogical transformation occurred when Sally wanted to use it in another exercise, and when Julie wanted to learn how to use the tool more efficiently. A conceptual transformation occurred when Sally realised the fallacy of visual privacy in a 3DCVE, and was surprised at the level of suspension of disbelief invoked by the task.

When I explained to Julie how the plane sensor worked, she gained a deeper understanding of the tool's functionality prompting her to further enquire how to adjust this feature so it would work better at floor level. After discussing this and the plan-mode activities with Julie and her partner, Sally, Julie began to change her attitude towards the tool, from being a clumsy planning tool that took a "lengthy time… compared [to its paper-based counterpart]", to a tool that offered spatial planning benefits over the "square [room-shapes of a plan]"[28]. This was followed by discussions with both of them about the notion of privacy in a virtual world, and their reluctance to test this by trying to hide each other. Although the objective of the exercise was to hide each other, they did not actually act out this scenario. Through this discussion their vague notions about why they behaved this way were transformed into concrete ones. By reflecting on why they chose not to perform the check, they realised the 3DCVE was simply transparent to such a concept. Indeed, this fostered a deeper understanding of the nature of virtual environments in general – not something either of them had contemplated or debated at length before this exercise. Finally, at the point in the exercise where Julie waited for Sally to appear in her view before making another move she expressed with some embarrassment that, on reflection, she felt "silly" waiting for an "imaginary" person (avatar). She surprised herself that she "believed" Sally was "in the world". Again, she was surprised at the level of suspension of disbelief invoked by the task and the media.

5.7.5 Transformative Outcomes of the Researcher and Participants Alike.

Perhaps the greatest transformation for the participants and researcher alike was the apparent conceptual transparency of the objects and spaces depicted in the 3DCVE of case study 03. This was contingent on both the ability to control individual objects in a scene and the ability for others to control the same objects. Unlike a single-user 3DVE where the user has complete control of the objects in a scene, in the multiuser 3DCVE of case study 03's exercise these controls could be overridden by their partner, thus negating any especially private or inaccessible space. Prior to case study 03's exercise I assumed that most participants involved in these exercises saw the objects and spaces in the 3DVEs as solid (real) objects and concepts. That an overview could be formed which meant one could 'see through' the solidity of the spaces based on its deconstructable abstractness[29] was revealed in case study 03's privacy game.

Part of my motive for using privacy as a concept to be tested in a 3DCVE in case study 03 was that I wanted to see if the participants would be fooled into hiding behind the props just so I could expose their folly. It did not occur to me that they would see through this ploy so quickly. They did not need to check for privacy because they came to the conclusion that the whole space was essentially transparent. The view from above also supported this – they did not always feel the need to go down and check their design spaces for similar reasons. They 'knew' beforehand what their design spaces from above would look like from below. Their faith in the technology was implicit and was being acted out explicitly. However, their's was not an *a priori* factual knowledge it was a *post facto* interpretation of the spaces they were presented with. They thought they could predict the form of the spaces they created before they created them. Instead, what they appeared to be doing was manipulating the elements and then mentally interpreted what they saw below them as fully formed spaces. However, these mentally interpreted spaces were actually present and fully formed by their actions. Hence, they were not mentally interpreted at all – they were actually formed *at the same time* by their interaction with the tool itself. In other words, the 3DVE was manifesting their pre-imagined spaces. As a planning exercise (the extensively used mode of action), these were the ordinarily imagined spaces of a plan that did not need to be imagined because *there it was in front of them.*

To help understand this phenomenon, the analogy of a movie version of a book comes to mind. When one reads a book one has to rely on one's imagination to form the spaces described in it from one's memory. In the movie version, on the other hand, one's imagination is formed for one in the images on the screen. In fact, one is often surprised and dismayed or

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[28] In fact, Sally approached me in the days following to ask if she could use the tool for another project in another part of her course which involved working with a remote partner in India (unfortunately for a number of unrelated reasons this did not happen).

[29] The ability to readily understand the parameters of the environment as interactive perspectival media with clear and predictable rules.

delighted at how different or similar a movie portrayal may be when compared to one's imaginations triggered by the reading of the book version. Nevertheless, after having read the book and then watched the movie version, the scenes depicted appear to be predictable because one has already formed a mental image of what the scenes might look like. However, the predictability of these scenes comes after actually witnessing the movie, therefore they only appear predictable on reflection or *post facto*. Similarly, in the 3DCVE the spaces formed by the participants tended to match and even substitute those they would otherwise have had to imagine.

5.7.6 Summary

Transformation occurs when one's understanding is enriched such that one may no longer hold a prior notion or concept. A new conceptualisation occurs that means one understands a particular phenomenon in a new light. This may occur as a 'click' of recognition or as a more subtle but equally transformative process over time, such as unlearning that the square root of negative one is not undefined after all. While many of the transformations discussed in this section were not what Kuhn (1996) would describe as paradigm shifts, many were profound nevertheless.

5.8 Chapter Summary

This chapter brought together the analyses from the chat logs and organised them, where possible, into themes rather than by case study alone. This helped consolidate discussion around important issues raised in the chat log analyses. It did this while addressing a slightly different research question to better capture the richer meanings possible by widening the original research question.

Applying the initial research question first, the discussion centred on issues of perspective. While the pervasiveness of a perspective ideology, promoted by the literature review, was found, it was not as influential as the literature review would suggest it should have been. Indeed, it took the form not of framing the communication modes, but rather exposing the transparency of the media. The significance of the other tenets of perspective – the privileged viewing position, perspective as the designer's *lingua franca* for spatial communication, and communicating using perspectival depth features – were similarly dismantled in this discussion.

As a consequence a new research question was broached. This addressed a broader investigation exploring the myriad spatial realities thrown-up by the participants in these case studies. Although still addressing communication of spatial concepts while interacting with a perspective technology, the discussions now centred on the various communication modes present – perspective being only one possibility. Of these, those that stood out were the textual communication mode itself, the predominant planning mode, socialisation, and orientation.

As these case studies were circumstantially framed by a pedagogical setting a section was dedicated to discussing their pedagogical outcomes. It was noted that the methodology employed for this investigation in this setting provided the opportunity to witness transformative outcomes of both a pedagogical and conceptual nature.

In the next chapter I will address the issues raised in this discussion chapter and try to draw some conclusions about their significance to what was raised in the literature review, how the research question needed to be reframed, and what this has captured in the analysis and subsequent discussions.

6.0 Introduction

In this study I set out to explore how students of design navigate and interact with the perspective of a 3DVE. I did this by reviewing the relevant literature on perspective and the use of 3DVE in practice and pedagogical settings, and conducting a series of exercises with design students engaged in the use of 3DVE perspectival media. It shows not only that perspective is implicated in the way design students represent the world but also how they perceive it. The literature promotes the idea that perspective is an all-pervasive and profoundly influential ideological method for representing, seeing, and 'knowing' the world. The exercises, on the other hand, tend to show that perspective is less influential in communicating spatial concepts when designing with 3DVEs. In the genre of Schon's (1983) 'reflective practitioner,' and the constructivist methodology adopted, this research makes its conclusions based on the researcher and participants' reflections. As such, the following conclusions aim to enlighten and thus contribute to the field in broad terms within a very narrow praxis. My conclusions are based on my participation with, and observation of, design students engaging in collaborative design exercises in a natural setting.

6.1 From the Literature Review

The literature review sets out the case that perspective is an all-pervasive mode of thinking that affects the way we see and interact with the world – perspective pictures are reflections of reality or a window on reality[30]. With the parallel rise of empiricist objectivism and perspective came a shift from a concept of space for which humanity was an integral part to an externalised space where humanity became spectator looking on. This transition to the externalisation of space can be seen in Brunelleschi's explication of the self in the picture in his peep-hole mirror experiment (the eye reflected in the mirror through the peep hole).

As Lefebvre (1991) discussed in the second chapter of this thesis, two types of space emerged from the paradigmatic shift to perspectivism: space as represented in perspective and the lived space of perspective. The first embeds a perspectivist ideology in the image and the second reflects how this ideology affects our understanding of how we live space. In lived space, the self gives the world scale. A picture, on the other hand, does not have to, and cannot, conform to a lived space scale. We judge our environments in relation to ourselves – how far things are from us, how much of our hand covers the pebble, where the horizon is, and so on. When we describe notions about our environments we rely on real-world relationships – how many hands a horse is tall, how many paces between the house and the fence, how many days and nights are needed to travel from Adelaide to Brisbane by car. The spatial system in a perspective, on the other hand, is given. There are 3-axes and a centre of projection. Time can be added to generate an animation or movie, or real-time 3DVE. We use terms like up and down, left and right, in lived space, but we rarely think of these as conforming to any strict axial relationship. They are arbitrary orientations which are made to fit many different situations. Unlike lived space, perspective circumstantially nominates its own coordinates and spatial system which is divorced from the real world. Many of the authors reviewed in the literature review argue that perspective is a natural law – a law that was waiting to be discovered. Such a law for perspective could be formulated as: field-of-vision is a function of the distance of the station point from the picture plane. Such spatial formulations make it easier to communicate everyday spatial experiences, especially if they are applied as illustrations. Illustrations are the coda for perspective notions of space. Simply asking a group of design students to verbally or textually describe a box with at least three sides showing generates an enormous array of articulations and much confusion. Yet, if asked to illustrate the same box, many different styles and configurations are generated but they are most often more legible than their textual descriptions (see subsequent work published by this author). The same students would similarly have little trouble in accepting the notion that the box is separated from them by space. In this sense, perspective guides their notions of how space can be organised (and indeed how it appears to be so, by virtue of the way they are able to illustrate it as such).

This separation of the self from objects in a spatial void is a key feature of the perspective paradigm. It also underpins the detached observations of the objectivist's scientific empirical investigations. The latest iteration in a long history of perspective technologies is the real-time 3DVE. In the 3DVE the self is represented by an avatar. As an abstract representation of the self in a 3DVE, the avatar explicates the notion of the externalisation of space begun in the Renaissance – the avatar as metaphor for the self in the void of space.

The paradigmatic shift from the Gothic to the Renaissance, from the thinking of the internalised self to the externalised self, to the projecting of ourselves and our thoughts into the world, instead of looking inside, looking out, is what perspective does. Its projection radiates from the person to the world. In a Freudian sense this existentialism is not that different from Sartre's notions of existentialism, or Descartes' *cogito ergo sum* – the embodiment of the externalisation of the world contingent on an internalised thought. In this

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[30] But a picture is not a window on the world. Where one can focus on different parts of one's natural view, in a

manner, the avatar can be seen as the reification of the human condition after the paradigmatic shift from the Gothic to the Renaissance, from the body-soul dimorphism or duality to just the body. As such, one would expect to find any study of navigation of and interaction with the perspective of a 3DVE dominated by spatial metaphors reminiscent of the heightened realisms of *trompe l'oeil*-like illusions and discussion about immersion and presence in the indistinguishability of virtual environments from their physical-world corollaries. Indeed, as discussed in the last section of the literature review chapter of this thesis, this is how many authors report their findings.

6.2 In Anticipation of a Dominant Perspective

As this study investigates how design students navigate and interact with the perspective of a 3DVE, it follows that perspective should play a significant role in my reportable research outcomes. According to the literature, the reason it is such a strong feature of Western visual culture is based on the premise that perspective replicates how we see. As such, it should also be a dominant method for communicating spatial concepts. In communications about perspective images I should expect my participants to describe 'objects in depth', using phrases such as "from my view I can see some objects are hidden by others", "things seem to get smaller as they get further away", and so on. According to Edgerton (1991), perspective is a universal constant – accessible regardless of race, gender or culture. Therefore, design students should be able to read a perspective. They would generally be either fully immersed in perspectival visual media or actively seeking new visual understandings. Hence, they would also most likely hold the common view that perspective is the way they actually, or physiologically, 'see' the world. Concurring with Kubovy's (1989) investigations, for the same students, the robustness of perspective relies on its ubiquitous use and their exposure to it, as well as the ability for one's disembodied eye to adopt the location of the centre of projection in a perspective. Without this, perspective would not be as robust and hence not play such a powerful role in the way the world can be represented. Through a lifelong acculturation to perspectival imagery, these students of design should be so accustomed to understanding or reading a perspective that it becomes, as Lefebvre (1991) and Romanyshyn (1992) contend, simply 'second nature'.

Hence, assuming that design students are able to 'read' a perspective, as still and moving images, it follows then that this is also how they are able to navigate and interact with the perspective of a 3DVE. This would require a level of immersion in the perspective, and its

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picture everything is in focus at once.

ability to unify a scene by creating geometric referents to objects in a void. According to Edgerton (1991), this abstract notion of virtual objects in a void should also affect their perception of real objects, further supporting his other assertion regarding virtual objects as simply substitutes for their physical counterparts (although Edgerton was referring to illustrations and photographs rather than 3DVE objects *per se*). Thus, in exercises involving virtual and physical media, I expected my students to demonstrate a common ease in their ability to manipulate either media. This would show a reliance on *perspective-as-second-nature* in the navigation of a 3DVE. This conflation in perception of the physical and the virtual would be due to the way perspective tends to objectify not only their experience of a 3DVE but also of the physical world, thus leading to similar conceptualisations and approaches to a task requiring manipulation of either media. In other words, this should translate to the manipulation of virtual objects in 3DVE-only tasks treated as if they were real physical objects.

Moreover, if we accept that perspective and its robustness relies on one's ability to view it from any angle, and that it tends to objectify one's view of space, then we can begin to understand how these design students should be able to navigate and interact in a 3DVE. They would find what they expect to find because the prevailing perspectivist paradigm tends to fulfill their expectations of a *reconstructed* reality. Panofsky's (1991) 'window on reality' would prevail such that, at times, they should become so engrossed in the task that they temporarily forget they are in front of a computer monitor in a studio (due also to the contradictory external stimuli described by Kubovy (1989)). In essence, as a natural law replicating a physiological fact, I should expect their transition to a virtual reality to be largely seamless. Indeed, this is how it is described in the literature.

6.3 Instead, Plural Spatialities

My pedagogical case studies were set up to investigate the role of perspective in navigation of and interaction with a 3DVE by design students. Following the emphasis in the literature review, the role of perspective in this investigation should have been most pronounced in my case study findings.

A number of clear, direct, perspectively-mediated issues were uncovered. Most of these related to the ontological certainty of perspective as a method which not only has its roots in projective geometry (based on provable mathematical formulae) but also appears to emulate the physiological condition of seeing depth. Both of these are central to the arguments of an ontological certainty associated with perspective espoused in the literature review. However, despite this being revealed in the case studies it was not the only schema participants used for making sense of the spaces they interacted with. Many schemas were used. These alternative schemas were captured in their communications. Indeed, it became increasingly clear, as the case study analyses progressed, that issues relating to the effect or affects of perspective on how my participants communicated spatial concepts became of less importance to the final analysis in this thesis than I had anticipated or the literature review would suggest should be the case.

Instead of using common perspective terms like viewpoint, converging vista, ground and sky, and so on, they did visualise in 3D but communicated what amounted to two-dimensionalisations of their visualisations. They could 'see' the forms on their screens and interpreted the images in terms of its perspectival nature – just as one would 'read' another type of picture – but when they communicated what they saw to their partner they fragmented the picture into 'things' or elements. They then described these elements and how they relate to each other rather than the image as a whole. Proportions, scales, and form are what were important to them, not volumes as such. It was the visual impression that mattered, and this was at the surface. They did not communicate its three-dimensionality. They visualised and described parts in isolation – there was no way to describe it all at once. This raises questions about the apparent unifying nature of a traditional perspective image one would expect to detect in these discussions.

At times they did attempt to establish an orientation strategy using a Cartesian coordinate system within the virtual spaces and on the screen, but individual screen orientations were arbitrary thus largely negating the effectiveness of this approach. Rather than composing 'scenes' I could describe as perspectival vistas, they chose instead to construct complete assemblages. When describing these assemblages they moved the obscuring parts out of the way (when they could) and talked about what types of elements or blocks they had placed around a central feature (the corridor in case study 01, and some other defining element in case study 03). They often assumed the other person could see what they did, a key tenet in the power of a perspective to communicate a common view. However, they were confused and frustrated when others *could not see* what they did. They thus had to find alternative strategies for communicating their design visions. The perspectiveness of the 3DVEs did not seem to support a common view after all.

What emerged was the way the activities in all three case studies tended to require a two-dimensional convention of sorts for action to be established before design moves could proceed. This involved the communication of visualised fragments, only coming together as a perspective on the surface of the screen. They then saw the perspective form at the surface of the screen as a convincing caricature of their imaginations. They could see their imaginative visualisations of virtual objects as real objects *in the picture*, and they felt, sensed, and experienced the virtual blocks in the same way they did the physical. This was not framed as the construction of a picture, but a model.

When trying to communicate these visions, they fragmented the screen pictures. They then described their experiences of being in the presence of a fragment in the picture. This is different to interpreting the whole picture as unified. They interpreted experiences of fragments of the picture rather than the whole picture. Imaginative visualisations were replaced by their actions and the picture formed on the screen as the fragmented interplay of individual elements.

As the much vaunted unifying nature of a traditional perspective did not hold up in practice, the expected use of perspective terminology to communicate design visions was minimal. This presented me with a dilemma. Simply pursuing the initial research question would not yield as much, or be as interesting, as analysing the data that related to their communications of alternative spatial concepts might. Hence, in order to formalise a new approach, I chose to recast the research question to reflect the greater richness of the information available:

> *How do students of architecture communicate spatial concepts whilst navigating in and interacting with the perspective of a real-time 3DVE?*

Now I was investigating how design students communicated *many different types* of spatial concepts rather than those generated by perspective alone, although all were still circumstantially framed by the perspectival technology at the core of the case study exercises. Once this was established, it was possible to identify five main themes emerging from the analyses beyond those related to perspective alone: plural communication modes and extensive use of a planning mode of action; socialisation within the media contributing to communication modes and orientation; orientation strategies; and, pedagogical issues. The following outlines my conclusions on the observable outcomes related to each.

6.3.1 Following the Revised Research Question

6.3.1.1 Plural Communication Modes

Rather than finding recognisable perspectively-mediated communications, there were multiple communication modes. My choice to use an online chat facility captured the communications between the various participants yielding a variety of strategies for communicating spatial information in text. It also formed a spatial reality of sorts in its own right. That the participants were more familiar with online chat as a socialising medium meant it was being used out of its normal context for them. However, this also meant they were well versed and quite relaxed in its use facilitating the natural setting I sought in my case study design. More importantly, they concretised their thoughts by committing them to text revealing patterns of the types of spatialisation they tried to communicate. Ostensibly, these were discussions about fragmented operations at the surface of a two-dimensional plane. In action, instead of perspectively-generated modes of communication dominating the participants' actions, what emerged was a planning mode more aligned with a two-dimensional design ethos. This can be attributed to a number of the features of the various exercises themselves: most actions were only possible in a 2D plane; the ability to 'view all' from above; and, not least, much architectural design is planning by nature. However, with the almost infinitely variable views possible in the real-time perspective media available to the participants, and the fact that it was only after they had 'discovered' the view from above that they then used this viewing and acting mode extensively, it was surprising that so much of their exploration focussed on this plan mode. On the other hand, as they were all architecture students, planning was also the activity they freely admitted they were most comfortable with. This questions the efficacy of perspective in the environments engaged in these exercises to help fulfil the required tasks compared with conventional two dimensional views.

6.3.1.2 Socialisation

Contingent upon both actions and their communication, was the prevalence of socialisation in the case study environments. The fact that I used an online chat facility – ostensibly a socialising tool – to capture the participants' communications meant that the sorts of information gathered was always going to be of a socialising nature. Although I had not intended this initially, it proved to be valuable in creating the relaxed atmosphere necessary to capture the casual conversations within which were embedded the spatial constructs I sought. Moreover, it is this social dimension that underpins much of my analysis and is largely ignored by the literature. Where the literature tends to follow empiricist methods, discounting the value of socialisation – seeing socialisation as potentially contaminating the data rather than contextualising and supporting multiple understandings – in my study, discoveries were situated within the network of social interactions captured and recorded in the chat logs. Indeed, not only did the participants socialise in the online chat but the delight they expressed in 'seeing' each other and each other's actions played out in the real-time 3DVEs supported its own socialisation. This is the basis of most networked computer games and was not lost on this cohort. That they were able to socialise at all suggests the tool was largely transparent to their socialising interactions. Whether this was due to the net effect that perspective is intuitive (as suggested by the literature review) remains problematic. However, what I can comment on is that my research suggests the socialisation took place in an imaginary space somewhere between the screen and the viewer, somewhat like day-dreaming (this is also the space that Lefebvre (1991) refers to in his analogy of theatrical space as the lived space of the narrative, somewhere between the stage and the audience). From their conversations, I caught glimpses of this third space. This suggests there is still much to be learned from these kinds of case studies.

6.3.1.3 Orientation

This middle or socialising space also assisted participants in getting spatially oriented. This was most pronounced in case study 03 where partners oriented themselves in relation to their counterparts. Indeed, that on some occasions their ability to stay oriented hinged on the presence of their partner tends to support the notion of a socially-mediated orientation. There were, of course, other orientation strategies too. For example, the various orientation strategies ranged from explicit x y z axes discussions in case study 01, 'come over here and see what I can see', ordinarily associated with perspectival norms of orientation, to the socially-mediated strategy described in case study 03. This last orientation strategy, contingent on socialisation, demonstrates an alternative spatiality which does not rely on perspective.

6.3.1.4 Pedagogy

These case studies were circumstantially framed by their inclusion as pedagogical exercises within an existing curriculum. This also added authenticity to the notion that this study was conducted in a natural setting. As such, pedagogical issues arising from this process are crucial to a holistic understanding of the study undertaken.

As is the goal with most pedagogical exercises the teacher hopes to transform their students' understanding about a particular topic. In this case I was charged with providing an educational outcome for my students as part of a teaching program and this formed the case study arena for my investigations into how the group of students approached the various pedagogical tasks. While the pedagogical transformations were embedded in the case study outcomes, the triangulation process used also created the opportunity for the participants to transform their understandings of their own involvement with the research, the role they played in it, and what transpired as a consequence of having participated in the exercises as part of a research investigation. I identified two types of transformations: pedagogical and conceptual – pedagogical as learning outcomes, and conceptual where it triggered recognition of alternative spatial realities. These transformations were important to the participants, as they were to me. My understanding of the media, its pedagogical application, and perspective efficacies, was equally transformed by this research. In short, students and researcher/teacher alike transformed prior notions of both the role of perspective in navigating and interacting with 3DVEs and how such environments can be used to generate collaborative design outcomes.

6.3.1.5 Summary

While my views are still divided as to whether perspective is as influential on critical thought related to spatial concepts as that espoused by the literature, through these case studies I have come to an appreciation of the multifarious spatial realities possible and necessary to make sense of what is otherwise a very straightforward medium – the real-time perspective of a 3DVE. This tends to confirm the necessity to accept plural rather than singular explanations for spatial organising. My conclusions on this dilemma are discussed in more detail in the next, and concluding, section.

6.4 In Conclusion

The deeply embedded conventional reliance on perspective in the representation of the world, that can be traced back to Giotto's early explorations in the Italian Renaissance, has been extended into contemporary physical and digital media and, more recently, 3DVEs. The shift to a perspectival view in the time of Giotto (which witnessed the transition from a medieval spiritualism to Renaissance materialism in the physical representation of perspective) was profound. But the shift to digital perspectival media (in the form of static images and their controlled animation in movies etc.), was perhaps equally profound, as was the more recent shift to the *real-time* perspectival media of 3DVEs. The significance of this shift to the real-time perspectival media of the 3DVE is the emergent notion of virtual space as something that can be inhabited and explored. It is this latest iteration that this thesis used to address the notion of perspective as a spatial medium communicated by design students using online chat. What arose from this study was a multitude of spatial realties, not all reliant on perspective as a hinge to their understanding (in Perez-Gomez and Pelletier's terms). Yet, as perspectival representation of space has become so ubiquitous it has tended to cloud debate on these alternative spatial realities.

The abstract impressionists and expressionists of the late nineteenth and early to mid-twentieth centuries understood the need to explore alternative spatial realities beyond perspective. They railed against the formulaic perspective realisms following the advent of the nineteenth-century photograph. They understood that, whereas a realistic perspectival representation tends to provide as much information as possible, thus obscuring, or at least providing multiple meanings beyond that intended, abstract representations could instead purvey a single or minimal message in a succinct manner, often with greater clarity. It should be remembered, however, that even abstract expressionism relies on an acculturation to its viewing conventions to understand this message. Where abstract expressionism 'fits in' to the realm of 3DVEs is not clear. What is clear, however, is that the realm of 3DVEs seems to suffer from a *raison d'etre* beyond the simulation and replication of physical environments. While this is sufficient in computer games, medical research, architectural/urban visualisation and so on, it also limits alternative paths of exploration in its simple quest for greater and greater realism at the expense of meaning. This was highlighted in those exercises (in case study 02 and 03) which indicated that immersion tended to be as (or in some cases more) reliant on human-human and human-object interaction than it did on the realism of the scenes depicted. Indeed, the levels of interaction in these environments provided a dimensional distraction which allowed participants to 'make-do' with a higher level of abstraction in the representation of the spaces depicted due to what appears to be the competing realities of perspectival immersion, chat immersion, and their associated social interactions requiring processing in a cooperative 'mental space'. In other words, it was more the unfolding narratives of their chats and actions that they were immersed in than the perspectival environments *per se*.

Clearly they saw in 3D – the projective geometry of the 3DVEs provided a convenient method for visualising spatiality because it implies an axial space with dimensional markings and so on. The known rules for these perspectival spaces also helped them make sense of space. But they also needed to communicate what they could see. It was in their transcriptions that these spaces were metaphorically and practically flattened. From this I can speculate that the perspective was encountered as a physiological visualisation, but communicated as a convention.

On the other hand, the literature review tells me two types of space should have emerged in their communications, variously described as: represented and lived, pictorial and sensed, passive and active, external and internal, imagined and experienced. They should have used terms associated with these two types of space to communicate their perspectival visions. But this was not the case. Seeing the spaces represented in perspective means they should have seen the environments as a series of pictures much like Lynch (1960) – the author most often referred to as providing an analogy for how 3DVEs are encountered as real spaces –describes how we recognise urban environments. But they did not see the pictures of the spaces they encountered. Instead, they experienced the spaces as fragments of a whole. They saw real objects, known things, familiar things – if they were not familiar then they just saw the shapes. Similarly, they experienced the spaces as imaginative mentally internalised reconstructions (in a Gestalt sense) rather than the fully immersive experiences reported in the literature.

What role did perspective play then? Referring to Gibson (1979), they re-cognise things according to their familiar affordances. In this sense, they did not see in perspective, they saw things, and when they tried to communicate what they saw they did not describe a perspective view but the 'things' they found in it. This is a subtle but distinct difference. Perspective merely facilitated an illusion for them. As an experienced, lived space, like in a reflection, they saw themselves in the spaces. Their experiences were thus also highly contextualised as encounters within a socialised environment.

Hence, I can conclude that the perspective environments they encountered were experienced physiologically but only at a very personal, localised, level. Communicating spatiality was far more difficult. While most of the participants could, if asked, illustrate spatial concepts with some facility, this was not an option in these case-study exercises. Instead, they had to textualise their spatial visualisations. By doing so they revealed a more common planar mode of communicating spatial relationships. This suggests the rigidity of operating at the level of a plane offered more shared control over possible orientations than the infinitely flexible, yet explicit, rules of the 3DVE perspective. Describing plans, maps, or diagrams textually just seemed more natural to these participants than trying to interpret or extrapolate the apparent complexities of those plans in a third dimension. As sketching plans was not a part of the active 3DVE interaction and navigation, this preference for communicating two-dimensionalisation of three-dimensional spaces cannot be due to the ease of drawing plans but rather because it was the most *effective* method to conceptualise and communicate the spaces encountered. Even though they could be 'there', in amongst the 3D forms, they still chose to abstract a two-dimensional view (in plan) and communicate three-dimensions as if it was two-dimensional. This interplay of 2D and 3D framings, or the stepping in and out of real, virtual, and imaginative environments was mediated by the physicality of the monitor's screen. In this manner, the projecting of a three-dimensional geometry onto a two-dimensional surface was also consistent with the two-dimensional images they chose to communicate.

Moreover, they did not engage with the perspective as much as the literature review suggests they should have. The central empowering feature of the perspective, the ability to see what others see by occupying the same location, was not afforded by the perspective of the 3DVEs used in these case studies. Nor did the other perspective cues – depth, occlusion, shading, and so on – seem to help them communicate what they could see, what they wanted the others to see, or their visions (mental view). Instead, they had to devise a communication code of sorts which was largely divorced from direct perspective cues.

The fact that chat is an inherently socialising medium meant that the sorts of communications were imbued with a social subtext. What this meant was that they had to textualise a mental interpretation of what they could see on their screen, how they thought their partner would interpret their words as images, and the imagined spatial images themselves, all in a medium that they were used to using as a socialising tool. This unintended socialising of their communications, provided for rich and verbose recordings. Within these relaxed social exchanges were captured the meaningful spatialisations at the core of this study. Planning was the strongest form of spatialisation to emerge.

Planning emerged not only as a core medium for spatialising and communicating design visions, but it appeared to support and in turn was supported by the sorts of socialisation that occurred in the textual chatting. Moreover, according to this study, planning was clearly an integral part of the design process that could not be supplanted by the apparently greater flexibility and expressiveness of the 3D visualisation media, except for capturing particular views – and even these did not reveal as much about the spatial characteristics as one's imaginings of plans did. Whether this was due to the participants' prior architectural training or an innate sense of planning is not clear, and a subject for further study. What this study does show is that while planning and diagrammatic sketching may appear to be primitive forms of spatial representation they tend to be more intuitive than the perspective. This may also explain why it took so long to formulate the rules for perspective construction we know from the Renaissance.

6.5 Future directions

This thesis demonstrates the need to address the social issues that contextualises a study of collaborative design practices using 3DVEs. The processes and outcomes of this study revolved around social interaction. It yielded its richest insights from the recording of casual conversations. To this end, the constructivist methodology employed contributed to a greater understanding of remote collaboration communication about spatial issues in design practice. Although not the core purpose, the outcomes of this thesis do provide fertile ground for further study in the efficacies of communication modes used by various existing remote design collaborative practices. With this in mind, the sorts of issues raised in this thesis that warrant further investigation include, among others:

- trying different settings with participants from different backgrounds;
- exploring non-perspectival spatial representation mediums;
- comparing different approaches to the same media;
- exploring the role the avatar plays in creating a spatial and social frame of reference; and,
- investigating what spatial switches occur when one moves through architectural space in the physical world.

6.5.1 Different Settings

Trying different settings with participants from different backgrounds, would help validate the work done here. It would expose the nature of perspective as an all-pervasive media understood by those not actively exploring visual media, unlike the participants in this study.

6.5.2 Non-Perspectival Spatial Representation

Exploring non-perspectival spatial representation mediums, such as abstract expressionism and alternative non-Western cultural variations, may throw up its own communication modes which in turn might prove to be more efficient than the modes uncovered in this thesis.

6.5.3 Different Approaches to the Same Media

Comparing different approaches to the same media, such as those in case study 01, could take the form of comparisons where both partners use the same media: physical-physical or virtual-virtual. To this we could add comparison of the hand drawing and communicating of plans of the Federation Villa blocks. This would also go some way towards addressing the notion of planning as a learned or innate skill, by explicitly exploring the role of planning by conducting comparative studies of the drawing and communicating of hand-drawn plans representative of three-dimensional forms.

6.5.4 The Socialising Role of the Avatar

What role the avatar plays in creating a spatial and social frame of reference could be explored by seeing how one's avatar in first or third person affects the frame of reference of a collaborative design exercise.

6.5.5 Spatial Switches in Physical-World Environments

A number of spatial switches were identified in this thesis occurring within, between, and outside the frame of the 3DVE, its physical apparatus, the virtual worlds it depicts, and its physical-world corollary. It would be interesting to explore what spatial switches occur when one moves through and analyses architectural space in the physical world.

6.6 Epilogue

Conducting this research raised a number of interesting issues related to teaching and research alike. The role of research in my teaching described in this thesis was critical to establishing a natural setting. I could not have done this without the generous support of staff in the school, and the students themselves. The students responded to the dual demands of research embedded in a teaching program with a genuine interest in their outcomes. They were involved in the research and pedagogical processes at every stage. This alone suggests this type of combined research and teaching practice may have a place in the curriculum – with benefits both to pure research and more engaging, relevant, and improved teaching.

Following on from my earlier research into the use of images to communicate spatial relationships in planning (see Masters Thesis, 1999), the literature convinced me that 3D computer-generated perspective should be an efficient method for communicating spatial concepts. However, after thoroughly analysing the data from my case studies I found that when text was relied upon to communicate spatiality, using words to describe what could be seen, it reduced perspective to a two-dimensional plane. My remote design collaboration exercises comprising the case studies relied on textual descriptions for the composition, construction, and reporting of three-dimensional objects and spaces. The reduction of the three-dimensional spatiality of the scenes encountered to two-dimensions and back again in the textual transfers suggests two-dimensional planning was a more natural medium for my participants in describing spatial concepts than perspective. This was captured in the highly socialised chat logs which formed the core of data analysed – ordinarily discarded by empiricist research. Hence, this thesis also demonstrated the value in interpreting meaning from the social interactions of participants. The discoveries described in this thesis are set against a literature background on the history, application, and ideology of perspective practice.

Finally, while in this thesis I have perhaps raised more questions than answers – as should a constructivist study – it does go some way towards broadening our understanding about the plurality of spatialisation that occurred in the remote design collaboration exercises described. Moreover, it provides fertile ground for further research in this topical field. An important question that is raised for further research is, "what are the implications of the emphasis on planning revealed here on ongoing remote design collaboration using 3DCVEs in professional practice?"

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Appendix A: Chat Logs

A.1 (2002)

DMM, 07/05/02, 11:20-13:10

1 BOB: just entered this channel
2 MARY: just entered this channel
3 THEODOR: just entered this channel
4 MARY: we have to decide how many permutations are possible with the rules
5 BOB: yes
6 BOB: we know
7 BOB: have you tried with the four of the large rooms Mary?
8 BOB: it is like a letter H
9 MARY: how did u put the block[s together]?
10 BOB: big roof and 4 of the hips roofs in every corner
11 BOB: along the x axis
12 MARY: and [where] do you want to put verandah?
13 MARY: but this model seems to[o] massive?
14 THEODOR: hey Bob is your H like =|= or |-| ?
15 THEODOR: and why do you want to make an H anyway?
16 BOB: [mine is] like the second one
17 MARY: ok then i built a wrong model
18 BOB: and put the varandah covering the holes
19 BOB: could be an interesting place
20 MARY: i tried again...and this ones much better
21 THEODOR: any estimates on how many permutations are possible yet?
22 MARY: more than 75 models
23 THEODOR: how did you arrive at this figure Mary? And does Bob agree?
24 BOB: where did you get that number from Mary?
25 MARY: just try every block combin[ation] with the other block and it could produce many permutation[s]
26 MARY: what do u think Bob?
27 BOB: did you do the H one?
28 MARY: yup
29 MARY: but i don't like this model
30 BOB: did you cover the holes with varandahs?
31 BOB: why?
32 MARY: u didn't say i have to cover the hole[s] with verandah
33 BOB: yes I did
34 MARY: all of the hole[s]?
35 BOB: let's try this one
36 MARY: ok i cover one hole with verandah
37 BOB: put the large ones, on y axis, underneath x axis
38 MARY: underneath x axis?
39 THEODOR: so you are talking about the |-| model and about filling the gaps so it should be like |=|?
40 BOB: ok, upper right corner large one y axis
41 BOB: theodor, the gaps do not fill completly
42 BOB: the hips roofs are a bit larger
43 MARY: i think it doesn't matter
44 MARY: u only one verandah in one corner?
45 MARY: how about the other corner?
46 BOB: underneath, I mean right down hand x axis
47 BOB: let's try this
48 MARY: the x axis is looking at you?
49 MARY: at your computer monitor?
50 BOB: let me explain [it to] you
51 BOB: up right corner y axis with the large one
52 BOB: down right corner x axis with the large one
53 THEODOR: Bob, you said that the verandah does not completely fill the gap in the H construction. Does it matter?

54 BOB: left down corner -y axis with the large one
55 BOB: yes otherwise it is not an H
56 BOB: the verandah is not big enough to fill the hole
57 THEODOR: is this what you mean Bob? |-_
58 BOB: and left upper corner -x axis with the large one
59 THEODOR: -|_ ?
60 THEODOR: ~|_?
61 BOB: how do you get the symbols so close
62 MARY: i am confused
63 THEODOR: don't put a space between them
64 BOB: do an H along the Y axis
65 BOB: with the large rooms
66 BOB: and put the big roof
67 MARY: ok
68 MARY: then
69 THEODOR: oh ok so its like an I ?
70 BOB: over the holes that conform [to] the H put verandahs
71 THEODOR: or rather =|=
72 BOB: and use the hip roofs to extend the roof, they are quite large
73 BOB: and you will see that the verandah is not big enough [for] the hips roofs
74 THEODOR: but does it matter?
75 MARY: Bob ...[does] y axis mean along the corridor ?
76 BOB: yes along the corridor
77 BOB: so the rooms are going to be out of the floor a little bit?
78 THEODOR: so should it really be ||| with the middle pipe being shorter to represent the corridor?
79 BOB: yes it is like this theodor but the verandah is not big enough to fill the holes completely
80 THEODOR: yeah that's right Bob. it is just a pretend house afterall
81 BOB: pretend?
82 MARY: then...how about the verandah?
83 THEODOR: really i don't think it matters about the verandah
84 BOB: the rules say that we need [a] verandah
85 THEODOR: Bob are you trying to put verandahs in front of the rooms which extend out past the floor. The rooms with the hip roofs over?
86 MARY: if u want
87 MARY: it doesn't [say] exactly u have to put [a] verandah
88 MARY: only if necessary
89 THEODOR: i don't think you need to put verandahs out past the rooms with hip gable roofs over
90 BOB: I mean because the verandah could be a quite nice cover place without walls so u can read
91 BOB: have air with out feel[ing] the sun burn
92 MARY: but if we put verandah [there]…it means the entrance will [be] cover[ed] up
93 THEODOR: that is a nice thought Bob. Tell me more
94 BOB: dont you guys think so?
95 THEODOR: hey Marydid you take a photo yet?
96 MARY: yes...but will it look nice if u put [a] verandah in this model?
97 BOB: are you guys ready for another one?
98 THEODOR: talk to Maryand see if she agrees about the verandah
99 BOB: Maryare you agree about the verandah?
100 THEODOR: Maryi don't think it matters much about how the model looks, what is important is how you came up with the idea etc
101 BOB: the varandah does not need to be solid could be like glass!!!!
102 THEODOR: that's an interesting idea
103 THEODOR: have you guys decided on exactly how many permutations there are yet?
104 BOB: not yet there are as many as we want I guess
105 THEODOR: do you agree with this statement Mary?
106 MARY: do u want to try with two different size of blocks?
107 BOB: ok
108 BOB: just tell me
109 MARY: ok
110 MARY: how about if we put 3 small block with one large block?
111 BOB: how

112 BOB: which axis [is] the large one?
113 MARY: put the big one up [on the] left side y axis
114 BOB: x or y?
115 MARY: y axis
116 BOB: ok done
117 BOB: which roof?
118 MARY: put the big roof and [the] gable roof
119 BOB: and the verandah on the right side?
120 MARY: yes!!!
121 MARY: what do you think?
122 MARY: but i want the small verandah with triangle roof for the corner
123 BOB: what do you think with the corner verandah finishing it [off]
124 MARY: i think it will look like the house [has a] private verandah
125 MARY: what do u think?
126 MARY: Bob....what do u think
127 BOB: what do you mean private?
128 MARY: because if we use the other one, it feels [like] we can add more verandahs as long as we want
129 BOB: and it is a problem?
130 MARY: yes for me
131 MARY: if i'm the owner of the house :-)
132 BOB: but if we finish [off] with the corner verandah it will be better if you want like a finishing detail
133 MARY: yes
134 BOB: ok shift [it]
135 BOB: i sorry!!!
136 THEODOR: ok guys its now 11:18 and you haven't agreed on how many permutations there are. I think you should decide this before moving on
137 BOB: how are we going to decide that?
138 BOB: there are a lot of permutations!!
139 MARY: the rules are clear
140 BOB: so 16 combinations?
141 THEODOR: do you agree with this Mary?
142 BOB: 4*4*4
143 BOB: I guess?
144 MARY: more than 16
145 MARY: how about if u find the combination us[ing] 2 square and two rectangular [blocks]
146 BOB: should we try another one?
147 BOB: ok lets do it
148 MARY: and I['ll] find the combination between 1 square and three rectangular [rooms]
149 BOB: let's go for the 2 squares and 2 rectangles
150 BOB: ready?
151 MARY: ok
152 BOB: put the rectangles in the up[per] right corner x axis and the other one left down corner -x axis
153 BOB: and the squares in the remaining space
154 MARY: the position of the rectangular [room], along the x or y axis
155 BOB: x axis
156 MARY: ok
157 MARY: how about the roof?
158 BOB: [use the] big one
159 MARY: then [what]?
160 BOB: and then cover the rectangles
161 MARY: with [a] hip or gabble [roof?]
162 MARY: gable?
163 BOB: and put the verandahs in the short sides
164 MARY: Bob?
165 BOB: no the hip
166 MARY: ok
167 MARY: [for] both of [the] short sides?
168 BOB: yes
169 MARY: ok
170 MARY: finished?

171 BOB: yes
172 BOB: take the picture
173 MARY: wait…i [will] take a pic of the model first
174 BOB: ok?
175 MARY: finished!
176 THEODOR: so did you work out how many permutations?
177 MARY: i think about 256
178 MARY: do u want try another model?
179 THEODOR: why do you think it is 256 Mary?
180 THEODOR: you need to both agree on an exact number!
181 MARY: Bob?
182 BOB: let me see
183 MARY: Bob...how many permutations?
184 BOB: should we meet now? or?
185 MARY: no…we [haven't] finished with the permutations [yet]
186 MARY: not yet Bob
187 MARY: Bob...how about the permutations?
188 MARY: how many permutations do u think?
189 BOB: same as you
190 MARY: ok…how did you find that number?
191 MARY: i think becoz we have 4 block[s], 4 position[s] and 4 possible place[s] for each block and two different size[s] of block[s]
192 BOB: it's like the colours of the computer
193 MARY: it means every block could [be] put in four different place[s] with four different model[s] and four position[s]
194 MARY: and we have four block[s]
195 MARY: what do you mean with the colours in the computer?
196 MARY: Bob
197 BOB: I am not sure there are too much more
198 MARY: so...what do u think?
199 MARY: becoz we can't finish this session if we can't agree [with] each other
200 BOB: 256 because 16 *4 is 64 and that *4 is 256
201 BOB: [+]3 is equal [to] 259
202 BOB: is it 259? what do you think?
203 BOB: because you have to add the blocks in the form as they are now without combination with each other
204 BOB: 256 plus 3
205 MARY: how about this
206 MARY: we have four place[s]
207 MARY: with one rectangular [block] which can [be] put in two different position[s], along [an] x azis or [a] y azis
208 MARY: it means the mathematical method is 1x4x2
209 BOB: there are infinite possibilities
210 MARY: then if we have 2 blocks [we] just count 2x4x2
211 BOB: I do not know the formula [for how] to do it, but I know it is without ending
212 BOB: we have 4 squares and 2 possibilities for each square
213 BOB: sorry rectangle
214 BOB: so it is 2*4
215 MARY: ok
216 BOB: 2*2*4
217 BOB: 2*2*2*4
218 BOB: 2*2*2*2*4
219 BOB: plus 1
220 BOB: and sum all
221 MARY: yup
222 MARY: so it becomes 121
223 THEODOR: do you [both] agree to a number?
224 BOB: it is 113
225 THEODOR: i think Bob is having trouble adding up?!!!
226 BOB: sorry
227 MARY: 121
228 BOB: 122
229 THEODOR: now that you have agreed to a number can you answer the next question please?

230 BOB: yes
231 MARY: which model Bob?
232 THEODOR: Bob i want you to describe your experience of working with the virtual model and how this might compare to that of mary's work with the physical model
233 THEODOR: and Mary i want you to describe your experience of working with the physical model and how this might compare to Bob's work with the virtual model.
234 BOB: [I can be both] interactive with the computer and with Mary
235 BOB: so it is simultaneous [interaction]
236 BOB: but it [would be] better to have a code first to communicate [our ideas such as] the axis [we are working on]
237 MARY: it is really nice working with the physical model, but [the] first time was difficult for me to understand Bob's command with the axis
238 MARY: i agree with Bob, [it would have been better if] we had [the] same perception about [an] axis code [before starting]
239 THEODOR: so you both think there needs to be some common convention on how to communicate the orientation of the models?
240 MARY: yes
241 BOB: [however,] the predefined grammar makes the communication and the combinations easy
242 THEODOR: Bob started to use the term axis in relation to xyz etc but this got confusing
243 BOB: it is not confusing!
244 MARY: yes [it is Bob] becoz you didn't mention it the first time, about the y axis
245 MARY: is it along the corridor or not
246 THEODOR: the axis system was not confusing for Bob. was it confusing for you Mary?
247 MARY: yes! BOB: you can see the axes in the vrml screen
248 THEODOR: what axis can you see in the vrml screen Bob
249 MARY: but you have to imagine i didn't work with vrml screen!
250 THEODOR: well put Mary
251 BOB: it is clear that this is a 3d modelling tool [and] all 3d modelling tools work under [the same] axis language
252 BOB: and moreover i like it because it was a real time animation or modelling
253 MARY: but if we work in form z (a different, non-real-time, modelling package), it has different axes
254 BOB: [no] they are the same
255 BOB: but to make [it] easier we should be able to send some pics or images
256 BOB: to each other
257 BOB: so we can develop [a] better [understanding of what each other sees]
258 THEODOR: Bob how do you think you would have seen things differently if you were working with the physical model instead of the virtual model?
259 BOB: or be clear with the language that we are going to use
260 BOB: but this is more personal i guess
261 THEODOR: and Mary do you think you would have seen different things if you worked with the virtual model instead of the physical model?
262 THEODOR: i think your ideas for sending each other images is a good one!
263 BOB: I think so because I can see in my screen all the elements so this make [it] easier to 'picture' what I want
264 BOB: and how I want it
265 MARY: ok
266 BOB: Yes and if sketches could be sent too
267 THEODOR: Bob did you navigate down into your model to 'see' it from on the ground?
268 THEODOR: Mary did you get down and look at the model to see what it looks like up close?
269 BOB: that is right I have more views with out moving myself
270 BOB: I saw the model from many views
271 MARY: yes
272 THEODOR: can you elaborate please Mary
273 BOB: K
274 BOB: ok
275 MARY: how?
276 THEODOR: tell me how you 'experienced' the physical model
277 MARY: it is nice and easily to understand but can i try work[ing] with virtual model sometime?
278 BOB: ok I have to go now
279 THEODOR: ok Bob thank you for all your work today!

280 THEODOR: i will now go down and see Bob before coming up to my office to see you P
281 MARY: ok
282 BOB: just logged off.
283 MARY: just logged off.
284 THEODOR: just logged off.

A.2 (2003)

DMM, 16/05/03, 11:30 - 13:50

1 SDFG just entered this channel
2 SDFG: sdfg
3 SDFG: ef
4 SDFG just logged off
5 Trevor just entered this channel
6 Helen just entered this channel
7 Helen: halo
8 Helen: halo
9 Helen: Trevor????
10 Trevor: hi
11 Helen: testing
12 Trevor: ok u getting this?
13 Helen: yup
14 Trevor: one configuration take pic!
15 Helen: do i have to take the pic?
16 Helen: how to do it?
17 Trevor: use vrml print screen???
18 Helen: ooo ok
19 Trevor: two
20 Helen: weird
21 Trevor:
22 theodor just entered this channel
23 theodor: hello Trevor and Helen
24 Helen: theo, do i have to take the pic??
25 Helen: through print screen?
26 theodor: yes Helen that would be good
27 theodor: simply press the printscreen button
28 Helen: and then save it???
29 theodor: save the images to the desktop
30 Helen: where to put it?
31 Helen: oh oke
32 theodor: call them Helen01, Helen02 ect
33 Helen: oke
34 theodor: etc
35 Trevor: three
36 theodor: are you able to determine the maximum permutations?
37 Helen: hmmm
38 theodor: what do you mean 3 Trevor?
39 Helen: how do i suppose to do after press print screen??? :D
40 Trevor: third config, thoe
41 Trevor: theo
42 theodor: hi Helen: if you open the paint program from the start bar then accessories
43 Helen: i got it
44 theodor: once the 'paint' program is open go edit paste
45 theodor: then save as to the desktop with your name and a number etc
46 Trevor: fourth
47 theodor: does it make sense Helen?
48 theodor: what do you mean fourth Trevor?
49 Helen: i got one :p
50 theodor: great Helen
51 theodor: are you saying you have determined four permutations so far Trevor?
52 Trevor: fifth
53 theodor: can you tell us how you are working out your permutations Trevor?
54 Trevor: this is endless
55 theodor: and can you let Helen know so you can see if you are both doing the same thing?
56 theodor: what about you Helen? what is your startegy for determining the permutations?
57 Trevor: ok Helen are u following?
58 Helen: theo

Helen: yes???
Helen: sori trouble some here
Trevor: I'm getting 'username & password required' prompt on my screen
Trevor: Helen shall I come down to take over your place?
Helen: no it's okay
Helen: the proxy one, just press cancel
Helen: i got it too
Trevor: can u do this 'design'?
Helen: which design?????
Helen: i cant see yours
Trevor: can u c?
Helen: cant
Helen: there's no webcam here
Trevor: yu theodor joking???
Trevor: then why do I need to use webcam for?
Trevor: it's faster/better to use digital camera
Helen: take the pictureeeee
Helen: :P
Helen: i just print screen it
theodor: how are you communicating your ideas to each other?
theodor: clearly you cannot send images to each other so you have to find another way
physical?
theodor: what are the differences between working with the virtual model and the
Helen: for me, it's alot
theodor: and also state how you arrived at this figure!?
theodor: alot is not a number!
Trevor: same here buit can't be sure if we have the same ones
Helen: but it's difficult to move it
theodor: why would they be different Trevor?
theodor: why are they difficult to move Helen?
Helen: dont know
Helen: sometimes i lost them
Helen: so i have to find it
Helen: or make another one
Trevor: bcos we can't see what the other is doing???
theodor: Helen i noticied you are loking at the model from above
Helen: yes
theodor: does this make it difficult to move the pieces?
Helen: it's easier for me
Helen: really? but i can see all of them
theodor: why do you need to see each other's models Trevor?
theodor: how would seeing each other's models help?
Helen: really?
Helen: i got 5
Helen: in the desktop
Trevor: I have 7
theodor: Trevor can you communicate to Helen what your 7 are
Trevor: I can send the pics for her to view check your email, Helen in a minute
theodor: the idea of the exercise is to use the chat channel only
theodor: what is the purpose of sending images?
Trevor: why?
theodor: the images are only for my records of what you have done
Trevor: why sld we restrict ourselves to chat channel only?
theodor: at this stage you need to both agree on the total number of permutations!
Helen: ha???
Helen: i got 6
Helen: but i dont know it's the same with Trevor or not
Trevor: ok, Helen I'll wait for u to complete another sop we'll be equal
Helen: 7
Helen: i think it can be more
Helen: than 7
Helen: it depends on the due time
Trevor: I know but I'm not sure if we are suppose to co-ordinate to have the same

permutations
122 Helen just logged off
123 Trevor just logged off
124 troy just entered this channel
125 rod just entered this channel
126 rod just entered this channel
127 rod: hi troy
128 rod: hi
129 rod: theodor u there
130 rod: hel?
131 troy: ok i am here
132 rod: ok lets start
133 troy: hi theodor u there ??
134 theodor: do you both understand what you are required to do?
135 troy: i am not suer??!!!!
136 rod: ooh?
137 rod: e of us here
138 theodor: the idea is to communicate to each other how many possible permutations there are given the pieces you have each
139 rod: ok i try 4 permutations
140 rod: hmm
141 theodor: if you have time can you take a webcam pic of the models rod
142 rod: arrange the blocks in a few trials
143 theodor: and troy if you can take screen garbs when you have time too
144 theodor: both of you need to save these images on the desktop
145 rod: see if he accepts it or not
146 theodor: don't try to email them to each other you won't have time!
147 rod: then we finalise on the best permutations
148 rod: ok
149 rod: good idea
150 theodor: rod how will you communicate your arrangement?
151 rod: ok
152 rod: send snapshots to troy
153 rod: can he see me?
154 rod: troy can u see me?
155 troy: no i can't see u !!
156 theodor: you can't send snapshots to each other!
157 theodor: troy does not have a webcam!
158 rod: o ic
159 theodor: the purpose of the exercise is to communicate only via the chat channel
160 rod: we hav to establish some rules then
161 troy: i see !
162 theodor: great idae rod!!
163 rod: rule one - roof must fit
164 troy: ok i ag!
165 rod: rule no 2 veranda can go on sides only
166 rod: rule no 3 rooms must stick together
167 troy: room stick to where i mean rooom to room
168 rod: rule 4 jack roof must not hang over veranda
169 troy: can i paly this game base on our' rules now kant!!!??
170 rod: i tink wat theodore wants is for us to work on the same rules n comopre the results
171 rod: compare
172 troy: ok i see so can be not to be the same sampe of house ?
173 rod: same rules but work on differnt medium across cyberspace
174 theodor: ok guys how is it going?
175 theodor: have you determined the maximum number of permutations yet?
176 troy baisc
177 troy just entered this channel
178 troy: zdfg
179 troy: hey kant theodor u there !!
180 rod: gdfgh
181 rod: yeah
182 troy: how u's going there

183 theodor: can you agree on a total number of permutations please
184 rod: i have 5 permutations
185 rod: how aboput u troy?
186 rod: ok
187 troy: i have 5
188 rod: tats good
189 rod: so wat next?
190 rod: anyone there?
191 troy: actarlly i don't know what's going on there
192 rod: hahaha
193 rod: was it difficult with vrml?
194 rod just logged off
195 Jack just entered this channel
196 troy just logged off
197 John just entered this channel
198 John: hello
199 Jack: hallo John
200 John: Jack
201 Jack: yes
202 John: what are we going to do?
203 theodor: ok so have you looked at the rules?
204 Jack: i will arrange the blocks
205 John: yes
206 John: ok
207 Jack: can you see
208 John: where?
209 Jack: on the camera
210 John: I can't see your camera
211 theodor: you cannnot see each other from the camera!
212 theodor: you can only communicate with each other via the chat channel
213 theodor: only if you have time should you take some pictures
214 theodor: save them to the desktop using your name and a number
215 John: ok
216 theodor: John John you will need to use print screen and the windows paint program to do this ok
217 Jack: so how am i going to save my permutations
218 theodor: now you need to communicate with each other how you are going to determine what the permutaitons are
219 theodor: you don't need to save your permutations merely add up how many ther are
220 Jack: o k
221 Jack: so i will be doing and John will be saving
222 John: ok
223 Jack: yes
224 Jack: so what's up?
225 John: I am checking what the other guys talking
226 John: maybe we should setup some rules first
227 Jack: yes
228 John: can you see the rules of rod and troy?
229 John: tell me what you are doing, Jack?
230 Jack: i have done five permutations
231 Jack: enjoying doing
232 John: yep
233 theodor: what difference do you thing there is between working with the virtual model and the physical model?
234 Jack: in physical model you can feel the change
235 John: yep
236 John: it is a little confusing
237 John: maybe 5
238 Jack: yes
239 Jack: how many can we do?
240 John: maybe theodor what us to create a language to describe what to model
241 John: like vocabulary and rules
242 Jack: o k

243 Jack: did he tell you?
244 John: nope
245 John: I think this is about how to build a relation through limit media
246 John: Jack
247 John: is it 5?
248 Jack: i have done 7 options
249 John: ok
250 John: 7
251 Jack: what have you done?
252 Jack: are you working on the vertual thing?
253 John: yep
254 Jack: are you through?
255 Jack: finished?
256 John: yes
257 John: and you?
258 Jack: so what did you find?
259 John: 7 I think
260 Jack: o k
261 John: this is a game about how to transfer info through different media
262 Jack: o k
263 John: we should change the visual info into human language, like text
264 Jack: yes,but how do we that?
265 John: it would be better if it is in chinese
266 Jack: oh yes
267 Jack: i understand
268 Peter just entered this channel
269 Peter: hey guys im in
270 Peter: brb
271 John: I have reloaded the scene
272 Jack: what are you doing here?
273 John: you mean Peter?
274 John: I think helen will like this game because she chat a lot
275 Jack: yes
276 Jack: sorry
277 John: hehe
278 John: sorry what?
279 Jack just logged off
280 Ann just entered this channel
281 Peter: yeah John how was it?
282 John just logged off
283 Peter: yup lets see whats in store for us
284 Denis just entered this channel
285 Denis: hello there
286 Denis: hello there
287 Denis: we're being recorded!!
288 Peter: hey Ann
289 Denis: is anyone there??
290 theodor: ok guys do you understand what you are meant to do?
291 Peter: ??
292 Peter: ??
293 Peter: ??
294 Denis: kind of
295 Peter: hi Denis
296 Ann: hi
297 Peter: okay
298 Denis: so we're being recorded, huh??
299 Peter: theoor can you brief us for what has to be done?
300 Ann: hello there
301 theodor: you cannot use the webcam to send images to each other
302 Peter:
303 Peter:
304 Peter:
305 Peter:

306 Peter:
307 theodor: but if you have time it would be good to record some images which i will collect at the end
308 Peter: hi
309 Peter: ok
310 Peter:
311 Ann: I think I have to arrange blocks to come up with some kind of design
312 Peter:
313 Denis: ok now what??
314 Peter:
315 theodor: ok now the idea is to communicate to each other how you are going to reach an agreement on what are the maximum number of possible permutations
316 Peter: ok
317 Peter:
318 Peter:
319 Denis: hello????
320 theodor: whats the idea Peter with all the no-message messages?
321 Peter: i am geting all these messages very late
322 Ann: what is my role?
323 Denis: lol what shud i do??
324 theodor: Ann and the rest of you need to agree on how to go about the task
325 Peter: fine so we have to come up with permutations !!!
326 theodor: you all have the same rules
327 Peter: hey Denis
328 theodor: you have to agree somehow with each other thats all
329 Peter: sorry i was just trying to type nuthing since the messages scroll up only when i type sumthing
330 Ann: I am starting to arrange blocks, guide me the way you guys want it
331 theodor: how many permutations can you find Ann?
332 Peter: ok
333 theodor: c'mon guys how are you going to do it?
334 theodor: Peter and Denis how many permutations can you find?
335 theodor: how do you know if what you are finding is the same as each other?
336 Denis: loads
337 Peter: okay Ann what has to be done
338 Denis: im using the squares with the bigger roof form
339 Peter: what should i do ?
340 Denis: i can make loads of permutations here
341 Ann: I just found two and I have taken picture of it
342 Denis: am i missing something?
343 Peter: hey guys what do i have to do ?
344 Denis: 2?
345 Peter: i am missing everythig
346 Denis: why are these two columns there?
347 Denis: HELP!
348 Peter: HELPPPPP
349 Peter: i cant control this thing
350 Denis: theodor??
351 Denis: Ann??
352 Ann: You have virtual model with you just let me know which model you are placing at which position
353 Peter: theo is coming to help us
354 theodor: ok whats up?
355 Peter: yes Ann i have a virtual model here
356 Denis: whats the point of that?
357 theodor: you rnot making sense Denis
358 theodor: i think anina means each piece of the model
359 Denis: ok
360 Peter: theodor i cant delete these things
361 Ann: yup!!
362 Denis: i have one block on the riht front and one on the left back
363 Denis: and im usig the hip-roof
364 Denis: acroos the bottom of your screen

365 theodor: ok Peter to delete the objects either click on the corresponding object in the row
366 theodor: this turns them on and off
367 Denis: Ann?
368 theodor: alternatively you can simple move them out of the way by clicking on them once hold the left mouse button down and move yoyr mouse
369 Ann: start with the rectangular blocks first
370 Denis: square bock
371 Denis: now im going to use the square on the left and the rectangular on the right to create an l-shape
372 Ann: yup!! done
373 Denis: hello?
374 Ann: I have placed gallery
375 Ann: next step
376 Denis: ok now one of the smaller roos goes on the left
377 Ann: have you used one big roof
378 Denis: hmm its tough makin it a pure l-shape
379 Denis: wait one sec
380 Denis: yeah now im getting this
381 Ann: On the right i have joined rectangles back to back
382 Denis: theo why are the two columns there in the iddle?
383 Denis: l shape not possible
384 Denis: yeah but the roof wont it
385 Denis: fir
386 Denis: t
387 Denis: fit
388 Denis: theres no roof to support the l
389 Denis: is anyone there?
390 Denis: we can use the rectangulare bases with the two hip roofs
391 theodor: Ann whats up?
392 Ann: I have one big roof and from that hip can be attached
393 Denis: i dont have a one sided hip
394 theodor: the two columns are actually chimneys!
395 Ann: Can Peter tyake my place I have to pick up my son before 1 PM
396 Denis: the square bases are smaller theyll fit ith the other smaller roofs
397 theodor: Denis you have all possible orientations for hip roofs
398 Denis: is taht a question?
399 Ann: I dont have chimneys
400 theodor: Peter can you go to my office and log on?
401 Denis: the big hip roof can actually cover more than one small base
402 Ann: I am coming down
403 Peter: ok
404 Peter: im on my way to yur office
405 theodor: Ann please don't leave my office until Peter gets there!
406 Denis: permutations can also be made from orienting the roofs differently
407 Denis: just that in itself will give 4 options for each pair of bases
408 Denis: front-front
409 Denis: back-back
410 Denis: front-side
411 Helen just entered this channel
412 Peter just logged off
413 Denis: theres very little communication hre
414 Helen: can i join you?
415 Denis: yeah i guess so
416 Ann just logged off
417 Peter just entered this channel
418 Peter just entered this channel
419 Peter: Denis
420 Peter: i am here in place of Ann
421 Denis: yeah ok
422 Denis: plac the square blocks
423 Peter: i shall be making some models here and yu have to transform it into the cvirtual thing
424 Denis: one on left one on right
425 Peter: wait

426 Denis: ok then u tell me instead of teh other wy round
427 Peter: tell me how much have yu done so that i can oplace my models accordingly
428 Peter: or shiould bwe start afresh
429 Peter: Denis yu there?
430 Denis: yeah
431 Denis: ok lets start now
432 Peter: fine
433 Peter: start by placing the corridor
434 Denis: u place 4 rooms in combinations and tell me and then ill recreate the here
435 Peter: place it in the middle of the floor plate
436 Denis: done
437 Denis: done
438 Peter: no place two square on either side of it
439 Denis: then?
440 Denis: we're supposed ti have 4 rooms not 2
441 Peter: done?
442 Peter: ok i shall add another two
443 Denis: fine so 4 squares on all 4 corners
444 Peter: take two rectangular shapes and add them to either side of the corridoor
445 Peter: yup four squares
446 Peter: two on either side of the corridoor
447 Denis: yeh done
448 Peter: cool
449 Denis: 4 squares are ready
450 Peter: now lets put a roof oer these
451 Denis: now which roof theodor u using
452 Peter: lets put the big roof
453 Denis: ok
454 Denis: done
455 Peter: so now is this one possibility ? shall we get on with another one?
456 Jack just entered this channel
457 Peter: who is supposed to talke the photograph?
458 Jack: hi guys
459 Denis: yeah lets try another now
460 theodor: how are we going?
461 Peter: Jack did u send the mail?
462 Denis: theres another big roof have u tried that one??
463 Denis: not bad
464 Peter: we have one outcome theodor am i supposed to click a pic?
465 Denis: pretty easy now that tere more communication
466 Denis: ive taken a pic
467 Peter: cool
468 Peter: shall i take too ?
469 theodor: have you wrked out whats going on Peter?
470 Denis: ive put on the second roof Peter
471 Peter: yes theodor
472 Peter: cool
473 theodor: thats great guys remember you can't send images to each other
474 Denis: its the second big one with the different orientation
475 Peter: ok
476 theodor: but good if you can take some images and save them to the desktop!
477 Denis: have u done that? now lets take pics
478 Peter: i just have one big roof here Denis
479 theodor: so what is the verdict on how many permutations there are?
480 theodor: Peter you rroof should be able to be rotated
481 Denis: i think its the same oe in two different orientations
482 theodor: however you will notice that it is not quite square
483 Denis: so rotate that place it and take a pic
484 Peter: ok
485 Denis: that way we wont flunk
486 theodor: yeah Denis koool
487 Denis: lets try something else now
488 Peter: ok now put three rectangles and one square on either side of the corridoor

489 Denis: theodor how do i remove these things from theor resent spots without sending them wandering?
490 troy just entered this channel
491 Denis: which side has 3 rectangles and which side has one square?
492 Denis: do we have a roof for that?
493 Denis: hi troy
494 theodor: Denis the little row of shapes acroos the bottom of your screen are switches
495 Jack: yes i have made one aesthetically pronouncing design
496 theodor: you can simply turn the objects on and off
497 theodor: Jack can you take a screen grab
498 Denis: yeah got that
499 theodor: do you know how to do this?
500 Denis: Peter??
501 Peter: yaa Denis
502 Denis: gosh thisplace is crowded
503 Peter: i havbe got another one lets make it\
504 Denis: tell me
505 theodor: ok guys how many permutations have you all got?
506 Denis: 2 so far
507 Peter: take two rectangular rooms and place them close to eeach other along the longer side
508 Peter: got it?
509 Denis: ouch i dint knwo it was time based
510 theodor: what do you mean the longer side?
511 Denis: ok done
512 Peter: now along the smaller sides of the two rectangles add a corridoor
513 Denis: longer side ive taken in front
514 Denis: as in frnt to back
515 Denis: we'll do both
516 Peter: now on the vacant side of the corridoor add a rectangle and a square
517 Peter: add the new rectangle such that the shorter length touches the corruidoor
518 Denis: we can only do 4 rooms at one time
519 Peter: yeah so we have four here
520 Denis: so lets stick to the regular 4 combinations
521 Peter: 3 rectangluar and one sqaure
522 Denis: squares, rectangles sideways and rectangles fro t to back
523 Denis: dont try it u wont find a roof for it
524 Peter: umm i was thinking of adding a few skylights they look giood here
525 Peter: anyways lets start from scratch
526 Denis: er ok if its possible lets do it
527 Denis: u tell
528 Denis: ill folow
529 Peter: ok
530 Peter: now i have two squares on one side of the corridoor
531 Denis: quick!!!
532 Denis: ok
533 Peter: and then two rectangular blocks on the other side of the corridooor
534 Peter: the rectangular blocks shud stick to the corridoor along the shorter length
535 Denis: ok done
536 Peter: done?
537 Peter: cool;
538 Peter: now add the big roof
539 Peter: u will see that a portion of the rectangular rooms is still out
540 Denis: not fitting on the rectangles
541 Peter: not covered by the roof
542 Denis: exactly
543 Denis: see theodor we're doing good here
544 troy just entered this channel
545 Peter: yeah so yu have to pick skylights two of them
546 Denis: which ones are the skylights??
547 Peter: pick skylights and place them opn top of the rectangular portionns that arent covered by the biug roof
548 Peter: umm see the blocks that are sloping and are pointed
549 Peter: pointed on one side and flat on another

550 Denis: not fitting
551 Peter: no probs lets try again
552 Denis: lets stick to teh regular shapes for a while
553 Peter: put one rectangle and a square each on either side of the corridoor
554 Denis: dude can we do all rectangle first??
555 Peter: i have only three rectangular blocks here with me
556 Denis: simpler
557 Denis: i have 4
558 Denis: ok ok
559 Denis: then we cant
560 Peter: oh i guess we need to tell that to theo
561 Denis: k then ure the boss
562 Denis: yeah do u hink hes listening??
563 Peter: we DONT have four rectanglulars here lol
564 Peter: i dont think he is reading all this
565 Peter: :P
566 Denis: anyways start
567 Peter: ohh actaully the rest of the rectangular bloacks and the square ones are supporting the cam
568 troy: hey!
569 Denis: DUDE
570 Denis: get the rectangular blocks
571 troy: can i jont it
572 Denis: jaldi karte hain yaar bore ho gaya
573 Peter: hey Denis
574 theodor: hi jeremey can you help these guys?
575 Denis: i'd say 7
576 Peter: ok lets start with the rectangulars
577 theodor: so Denis says 7 what about the rest of you?
578 Denis: seven's my bet
579 Denis: but Peter lets preceed pls
580 Denis: PETER????
581 Peter: yeah
582 Denis: i wana change that
583 Denis: its more
584 Denis: i just got more
585 Denis: wait ill give au a number quickly
586 Peter: ok
587 Peter: tell me
588 Peter: il place them here
589 Denis: ok take rectangles
590 Denis: front on
591 Denis: place little roof on them
592 Peter: ok
593 Denis: 6 will fot in a lot of different combonations
594 Denis: start quick
595 Peter: done
596 Denis: k so alculate the o of ways in which u can lace the small roofs which fir 6 at a time when u put them on the rectancles
597 Denis: calculate QUICK!!!
598 Peter: i think we can do that 7-8 times
599 Denis: get a specific number itll be more
600 Denis: theo is there a rule for how the roofs sit next to each other?????
601 Peter: 7
602 Denis: shit i got this game really late wuldve nai;led it by now
603 Peter: yeah
604 Denis: ok now try one rectanle and one square each side
605 Peter: Trevor had put two squares and a rectangle to make the tower to support the cam
606 Peter: ok
607 Denis: what the hell
608 Peter: fine done
609 Denis: ok anyways
610 Denis: now lets o what we can

611 Peter: ok place the rectangulars vertically opposite
612 Denis: put one sq and one rectanglt each side and see how many ways it can be done
613 Peter: done?
614 Denis: yes gt me a number quick
615 Peter: 2
616 Denis: u keep trying it ure the one with physical blocks itll be quicker
617 Denis: ok so we have 7 7 2
618 Denis: 16
619 Denis: theo???
620 Peter: theo ???
621 Denis: theo???/
622 Peter:
623 Peter: theoooooooo
624 Denis: is it only permutations or also combinatios????
625 Denis: listen Peter take 4-5 snps
626 Peter: i have taken snaps
627 Denis: theo?????????????????????
628 Denis: chaen??
629 Denis: chalen??
630 Peter: chal
631 theodor: ok guys I am coming upstairs now do not logoff yet!!
632 Peter: ok
633 Peter: hang on Denis
634 Denis: yeah ok
635 Denis: is thoe upstairs yet??
636 Denis: tell him about the blocks for camera tower
637 Peter: he is coming
638 Denis: lol
639 Denis: anyways
640 Denis: i think we got it
641 Peter: so how many permutations we have?\16?\
642 Denis: yeah
643 Denis: as long as the rectangles bit was right
644 Peter: think so lol
645 Peter: hope so rather
646 Denis just logged off
647 Peter just logged off

A.3 (2002)

DMM, 14/05/02, 11:30-13:15

1 Mary: hi
2 Mary: i'm s5taring at u
3 Mary: let's start
4 Mary: Bob i think the stair is the first boundaries
5 Bob just entered this channel
6 Mary: hi
7 Bob: hi Mary i'm at the bottom of the stairs
8 Mary: u tried to pass me
9 Mary: Bob i think the stair is the first boundaries
10 Bob: yes
11 Bob: all the edges of the stairs are boundaries
12 Mary: ok
13 Bob: and the edge that goes down to the wall
14 Mary: i walk along the pool
15 Mary: is it a boundarie
16 Mary: ?
17 Bob: go there
18 Bob: yes otherwise you can fall off
19 Mary: ui 7ugly
20 Mary: where theodor u?
21 Bob: so mark the stairs and the edge that goes down to the wall
22 Bob: the pool one
23 Bob: and all the edges of the pool are boundaries as well
24 Bob: what do you think?
25 Mary: yup
26 Mary: i agree with u
27 Bob: so come up tp me
28 Bob: and give me a virtual kiss
29 Mary: ha
30 Mary: where do u want to move now
31 Bob: so come and lets see to the spaces under the roof
32 Bob: where are you now?
33 Mary: i'm inside the roof
34 Bob: but can u see me?
35 Bob: because i can not see you
36 Mary: yup
37 Mary: i'm inside now
38 Bob: so the roof obviously make a boundarie
39 Mary: in the end of the building
40 Bob: am i right?
41 theodor just entered this channel
42 Bob: theodor I can not see Mary why is that?
43 Bob: I see you
44 theodor: hi guys!
45 theodor: don't forget to take screen shots of interesting stuff
46 Bob: it is very funny
47 Bob: for me the boundaries are the horizontal planes
48 theodor: you remember how you to use the print screen button and then in photoshop paste etc??!
49 Bob: the space flous through the walls
50 theodor: Bob Mary is going to logoff and then log back on ok just wait until she returns!
51 Bob: ok
52 Mary: ok
53 Bob: ouch i tried to go through the wall!
54 theodor: ok so rissma is back after some re-connecting!
55 Bob: so as I say before the horizontal planes are the principal boudaries
56 Bob: what do you think?
57 theodor: sorry Bob i was just showing rissma how to take screen shots

58 theodor: you haven't moved for a long time Bob
59 Mary: yes but not only horizontal
60 Bob: the roof and the floor
61 Mary: yes
62 Bob: should we marked them
63 Mary: of course
64 Bob: hey guys if you come over where i am you can see a column in the middle of a room
65 Bob: please come and see!
66 Mary: ok
67 theodor: hello
68 Mary: hi nice to meet u
69 theodor: Bob bumped into a window!!!!!!!!
70 Mary: hei move
71 Bob: in yer face!!!!!!
72 Mary: what theodor u doing
73 Bob: now if you come over to the corner where i am
74 Bob: and the purple wall yes?!
75 Bob: you can see the column lines up with the end window
76 Bob: you have to be looking the same way i am
77 Bob: do you think the way they line up creates a corridor?
78 Bob: the column is an implied boundary
79 Mary: yes
80 Bob: Mary your back is not beautiful and you hair smell bad
81 Bob: let me see
82 Bob: pl;ease
83 theodor: charming!
84 Bob: thank you
85 Mary: but you are in theodore's back
86 Bob: there are boundaries everywhere
87 theodor: hey Bob move over i can't escape when you are in my space!
88 Bob: the windows, the columms, etc the interesting think is how they connect to each other
89 theodor: are you taking screen shots Bob?
90 theodor: what is the connection you are talking about Bob?
91 Bob: is a boundarie but at the same time is related to the other space
92 Bob: the walls yes
93 theodor: how is it related?
94 theodor: can you show me an example?
95 Bob: yes about the screen shots
96 theodor: ok good about the screen shots
97 theodor: you are still blocking me in Bob
98 Bob: the walls project the space making it flow into the other
99 theodor: what example have you got?
100 Bob: there is a boundarie everywhere but the boundaries interlap with each other
101 Mary: can u move the the other side Bob?
102 Bob: the corner in we were
103 Bob: with the space in the front
104 Bob: orange wall window and purple wall
105 theodor: i would like to see that but you are in the way!!!!!
106 theodor: ya!!!!!!!!!!! i'm free!!!!!!!!!!!
107 Bob: with your back to the two glass walls you can see the orange wall and the window beyond
108 Bob: nice dress
109 Mary: i bthink Bob falls in luv with u theo
110 Bob: yes
111 theodor: do you mean (Bob) that the orange wall seems to be extended beyond its obvious ends to the other walls
112 theodor: and that this creates a new space?
113 theodor: you guys are all the same!
114 Bob: and from the orange space the one you are now and the other beyound the window there is boundaries but all of them conected
115 Bob: and the one in the back
116 Bob: and the little space between the columns and the blue-purple wall near the stairs?
117 theodor: can you indicate them on your plan?

118 Bob: i am next to you at the moment
119 theodor: let me get out of the way
120 Bob: come on
121 Bob: where are you going?
122 Mary: yes the wall but not the column
123 Mary: it wasn't show up at plan
124 Bob: you need to get really closs the gap
125 theodor: ok from here
126 theodor: i am up the other end you do the same at your end
127 theodor: ok let me move back now you are at my end
128 Mary: sorry i'll block u
129 theodor: ok Mary you are looking in the right direction now
130 theodor: where are you going?
131 theodor: no don't worry about blocking me i want you to see the gap!
132 Bob: the space i am now
133 Bob: the other of the pool
134 theodor: please use a red pen to mark your plans
135 theodor: ok so you have seen the same thing on the other side
136 theodor: do you want us to come to where you are Bob?
137 Bob: yes
138 theodor: ok we are looking now what?
139 Mary: inside the buildingh
140 Mary: we can see many boundaries
141 theodor: why do you need to?
142 Bob: ill came back
143 Mary: U bump me
144 Mary: Bob ucan't enter that room
145 Bob: yes
146 Bob: this is very interesting you feel inside
147 Bob: this is really a virtual world
148 Bob: the extension of our consiousness
149 theodor: it is interseting to note i am in the same room with Mary but we don't talk at all!
150 Bob: I am on the water at the moment and nothing happen
151 Mary: i just tried to look surrounding the model
152 theodor: hey Mary stay still i want to take a foto
153 theodor: can you face me?
154 Bob: ok
155 theodor: just wait
156 theodor: snap
157 theodor: thank you
158 Mary: Bob, why u still standing above the pool
159 Mary: don't u want to walk around the model?
160 Mary: i'm here now
161 Bob: i'm hiding!!!!
162 Bob: see if you can find me!!!
163 theodor: come back
164 Mary: i show u
165 Mary: i saw u
166 Bob: not now!
167 Mary: gotcha
168 Mary: gotcha
169 Bob: sprung1
170 Bob: yeah yeah!!!
171 Bob: ok your turn
172 Bob: i saw you go past the window
173 Bob: can you come back to the window so i can take a foto?
174 theodor: what is going on with you guys?
175 Bob: join in theodor!
176 theodor: i wish i could look over the walls!
177 Mary: c'mon theodor
178 Mary: it's fun
179 Bob: i bet you can't find me now!!!!!!!!!!!!
180 Bob: i am totally hiden!!!

181 Bob: do you give up?
182 Mary: not yet
183 Bob: when you find me i am going to take a foto
184 Bob: theodor is lost!
185 Bob: nuh nuh nuh you can't find me!!!
186 theodor: no i am hiding as well
187 Bob: so close
188 Mary: i saw u
189 Mary: i'm win
190 Bob: cool hiding place huh?
191 Mary: theodor yu didn't hide
192 Mary: icould see u
193 theodor: hello!!!!!!!!!!!
194 Mary: very easy
195 theodor: come on down
196 theodor: are you angry Bob?
197 Mary: theodor u angry Bob
198 Mary: u even didn't say hello
199 Mary: just pass me
200 theodor: ok guys thats about it for today
201 theodor: what did you think of your expereinces?
202 Mary: it's fun
203 Mary: like in a real space
204 theodor: i need you to answer soem questions please
205 Mary: i could imagine the space
206 Mary: very well
207 theodor: question 1) what is an avatar?
208 Mary: i think it is represent us in the virtual space
209 Bob: avatar?
210 theodor: but what does it mean to be represented in virtual space?
211 theodor: does it matter what you are represented by?
212 Bob: so avatar is owr person inside
213 Bob: the computer?
214 Mary: no
215 theodor: the avatar for Mary is the head and for me it is the angel
216 Mary: it is a thing which represents us in the space?
217 Bob: and for me?
218 theodor: for you Bob it is a half moon
219 theodor: you can't see your self
220 Mary: avatar is important becoz it can show us to others in the virtual space
221 Bob: how?
222 theodor: we can t see you though
223 theodor: the half moon is what you were logged on as
224 Mary: for example u can see me in the virtual space
225 Mary: u can see me as a physically not only word like in chat room
226 Mary: u can identify where i'm moving and where i'm standing
227 Bob: did i fall
228 Bob: if i want to go to Mary i have to go and get the stairs it is right?
229 Mary: can i use the avatar for another project ? like last week
230 Bob: did you activate the option to sink?
231 theodor: question 2) do you think your expereince in the virtual space changes the way you see architecture?
232 theodor: that is a very interesting question Mary
233 Mary: yes
234 Bob: of course we can disign and at the same time live the space that we are creating
235 Bob: I think that showing someone through your space virtually is different from just having them look at the screen over your shoulder
236 theodor: that will be interesting
237 theodor: Bob that is a great idea!
238 theodor: do you think if you could build the space with someone else this would be interasting too?
239 Bob: with some one else?
240 Mary: yes, becoz we can combine the idea

241 Bob: e g with you?
242 theodor: you know those example vrml files i showed you last week the model where you can move things around
243 theodor: if you could enter the world with someone else and moved stuff around you could construct a new architecture yes?
244 Mary: yes
245 Bob: yes i know but which project and who with?
246 Mary: theo pretends, if u create a model with someone without physically connected
247 Bob: yes I understand
248 Mary: could u capture his or her idea and get the same idea?
249 Mary: i think it will world
250 Mary: i think it will work
251 Mary: if we use this kind of software
252 Mary: Bob do u want to see yazib and tony presentation
253 Bob: can we make the model in another software an imported in
254 Bob: ?
255 theodor: Bob we can talk about this but yes you can make your model in formz and import it into this programme ok
256 Bob: ok
257 Bob: so it is very flexible
258 theodor: see you later
259 Mary: i will leave now
260 theodor just logged off
261 Bob: ok
262 Bob just logged off
263 Mary: bye
264 Mary just logged off

A.4 (2003)

DMM, 07/05/03, 11:30-13:10

1 theodor: hi all!
2 PETER: heyy Helen
3 Helen: !@#!!@#!#$!@$
4 PETER: ??
5 PETER: hi theo
6 Jack: hey John where are you going??
7 John: follow me
8 theodor: Jack are you drowning?
9 Jack: blurb blurb
10 theodor: now c'mon guys we have got some serious stuff to do here too!!!
11 Jack: hey theo u look like frosty the snowman
12 theodor: har har
13 theodor: can you all start identifying the boundaries?
14 Jack: how do i look like?
15 theodor: what sort of boundaries do you encounter?
16 Jack: oh thank-you
17 Jack: hey John why are you standing on water
18 Helen whispers:
19 Helen: hi
20 Jack: Helen you look like an angel
21 Jack: hi
22 Helen: i am an angel
23 Jack: hey Peter why are u following Helen
24 PETER: ci is after me
25 PETER: hey guys talk
26 Jack: helo
27 Jack:
28 PETER: we are supposed to chat ehre HELEN what keeps yu from the keyboard ;)
29 PETER: type type
30 Jack: we theodor supposed to tok aby boundaries
31 Jack: there theodor no boundaries here
32 Jack: we theodor like phantoms
33 [Dean has connected]
34 Jack: we cannot cross throgh walls
35 Dean: Hi all!
36 Dean: Answer your tasks!!!
37 Jack: wewe can walk on water n not feel anything
38 Jack: we cannot even walk thru the glazings
39 Dean: Who has completed the task first?
40 theodor: ok guys have you identified the boundaries?
41 Jack: thhere is no perception of levels
42 theodor: Jack had a major revelation just now - he was able to see herself!!!
43 theodor: what do you mean by levels Jack?
44 Jack: tat is bot possible in the real world
45 theodor: Jack what is not possible in the real world?
46 Jack: to see ourself
47 Helen: hi
48 theodor: oh i see Jack
49 theodor: hi Helen
50 theodor: Jack what does it mean to see yourself?
51 Helen: dean is dancing
52 theodor: how did you feel when you could see yourself?
53 Jack: cahange of levels cannot be felt
54 Helen: theo how about introducing reflections
55 theodor: where is dean?
56 Helen: dancing
57 theodor: Helen that is an interesting idea

58 theodor: after this session i will show you some work i am doing regarding mirrors and avatars
59 Helen: coz if u introduce reflections then the whole idea of the avatar takes a new meaning
60 Helen: i kinda get the conversation yesterday better now
61 theodor: are you stuck in the roof dean?
62 Dean: anyone for a dip in pool?
63 theodor: koool
64 theodor: are you coming in dean?
65 theodor: i thought the cow was meant to jump over the moon not the moon jump over the angel!
66 theodor: people need to communicate with each other using the chat
67 Helen: yup
68 theodor: you all need to agree what types of boundaries are present in this world!!!
69 theodor: you need to communicate with each other your ideas about boundaries
70 theodor: rod made an interesting suggestion that the boundaries in this world are different to the real world
71 PETER: we can't see the text clearly on the big screen
72 theodor: can you elaborate on this please rod?
73 PETER: or maybe I need glasses
74 theodor: have you moved your screen Peter?
75 Helen: hehehe
76 theodor: what is funny Helen?
77 Helen: i smile to hou
78 PETER: move screen?
79 theodor: it looks a lot to me like you are just fumbling around in the space
80 theodor: most of the timeis taken to accustom yourselves to the virtual world
81 PETER: Game over we are trapped in the pool
82 theodor: learning the controls and so on
83 theodor: whats up Peter?
84 PETER: Tell us please theo
85 theodor: tell you what?
86 Helen: wherre am i???
87 PETER: We need to get out of the pool
88 Dean: Where is the treasure and the secret rainbow?
89 theodor: ok hang on i will go over and have a lok
90 PETER: We are in the smaller pool on the staircase end of the building, theo
91 theodor: oh i see you are in the other pool!
92 Helen: dean is swimminggggggggggg
93 theodor: ok now to get out of the pool you need to look at your controls
94 PETER: John! come into the pool and play
95 theodor: see the lever on the left of the panel push it down
96 theodor: oops sorry push it up
97 theodor: now you can use the four way pointer to pan your way up or out
98 PETER: ok that's cheating, but ok
99 theodor: when the lever is up this overrides the gravity and collision detection
100 Dean: Where is the digital home theatre set?
101 theodor: cool it dean
102 Dean: Helen talk to me?!
103 PETER: Dean u haven't found the cellar yet?
104 theodor: you can video stream images into these worlds
105 Jack: dean do u want to swim with me?
106 Dean: No thanx I out of here!
107 theodor: Jack you are so provocative
108 Helen: what are you doing Jack??
109 Helen: waooo
110 Jack: thanx
111 PETER: The snowman has some imagination
112 theodor: who wants to play hide and seek?
113 Helen: :)
114 theodor: hello Peter
115 PETER: water is too cold gotta get out of here
116 Helen: Peter, you swim???
117 Dean: Where is the attic?
118 theodor: you will have to ask mies that one dean
119 Helen: where are you??
120 [PETER has disconnected

121 [Mies has connected
122 Helen: Peter??
123 theodor: ok now you can ask Mies your question dean!!!
124 Mies: God's in the detail, dean
125 Dean: the details is in the God!
126 Jack: theo i cannot go out from here
127 Mies: Thank you, but I can't take all the credits And stop worshipping me
128 Mies: Helen
129 Mies: use your ring to save Dean from drowning
130 John: who can get into thr water ?
131 Dean: Helen has been swallowed by Ho
132 Helen: Mies??
133 Helen: we got it
134 theodor: dean has a bogus avatar
135 Dean: theo i found u
136 theodor: oh John you came really close!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!1
137 Dean whispers:
138 theodor: where did you find me?
139 Jack: please help me i got stuck//
140 theodor: what is the problem Jack?
141 Dean: ah now ure mving to the back room
142 Helen: where are you??
143 Jack: i cannt come out in the air around,,
144 theodor: did you see the message i sent to Peter about how to get out of the pool?
145 Helen: Jack, can i help you???
146 theodor: basically Jack push the lever next to your controls up
147 Mies: The angel is a saviour Helen help Jack to get out of the pool
148 theodor: or if you click on one of the pre-programmed viewpoints this shoudl get you out of trouble
149 Jack: i am still stuck in the pool
150 John: saurar how did u get in there?
151 John: sausra ?!!!!??!!?!!!?!?!
152 Jack: i was just exploring
153 Jack: please help me theo
154 Mies: Jack
155 Mies: HI all
156 Helen: Jack, look behind you
157 Mies: I am God
158 Jack: why cannt we walk thru the walls,,
159 Mies: I can see all of you from up here
160 Jack: yes,,, you are god
161 Helen: where is everybody???
162 Helen: just Jack and hou??
163 Dean: who is invisible?
164 Dean: Ho?
165 Jack: why cant we cannot even walk thru glazings do you all agree??
166 Jack: we cannot even walk thru glazings do u all agree?
167 Dean: I am inside Helen's head - nothing there!
168 Helen: I think that is my reflection, dean
169 Jack: hahahahahahahaah
170 Helen: i am around the pool
171 Mies: Helen you have nor reflection either
172 Jack: try Peter's ngead maybe more
173 Mies: can u see me?
174 [Tony has connected]
175 Helen: who are you asking to?
176 Mies: Helen
177 Helen: hahaaha
178 Helen: you are up there???
179 Jack: dean is omni-present
180 Helen: nope
181 Helen: it's weird
182 theodor: ha ha
183 Mies: the snowman is in the pool

184 lusi: hahahaha
185 Tony: hi, I'm tin man 2 - not the hiding one
186 Helen: hi tony
187 theodor: hi tinman too
188 John: yes
189 John: yes
190 Tony: I'm practising walking on water
191 lusi: nope just kidding
192 Jack: come tony
193 theodor: hi dean
194 Helen: hahaha
195 Mies: ya
196 theodor: hey dean do you think there is scope to do prototype gaming in this environment?
197 [Mies has disconnected]
198 Tony: where are you, Jack?
199 [Peter has connected]
200 theodor: John what are you up too?
201 Tony: he's surrounded by tin men
202 theodor: tony do you think the boudaries, implied and 'real' are the same for this scene as the physical world?
203 [Dean has disconnected]
204 Jack: boo
205 Jack: boo
206 Tony: Yes, near enough If I follow tyou could you show me around, please?
207 theodor: boo hoo?
208 theodor: ok follow me
209 Jack: gotcha
210 theodor: i will go back to the stairs
211 Jack: ok
212 Helen: where are you???
213 Tony: Lost you again, Theodor
214 Tony: OK can see yopu now
215 theodor: tinman leading the tinman :)
216 Tony: I'll follow
217 theodor: the first thing to notice is the space between the columns and the wall in front of us
218 Jack: ok
219 theodor: Peter i'm just in the middle of a tour right now
220 Helen: i cant move
221 Tony: it's hard to know whio's speaking to who
222 Peter: Let's join the tour
223 Helen: i am in front of you Jack
224 Jack: chta server is not good
225 theodor: tony it is customary to put the name of the person you are speaking to at the front of your message
226 Helen: but i cant move
227 Jack: frozen angel
228 Tony: OK Theodor Can you rescue Helen?
229 theodor: i find that because the angle of view is 25 degrees it is hard to distinguish boundaries - i will see Helen now
230 Helen: whaaaaaaa *crying*
231 theodor: whats wrong Helen?
232 Helen: yeeeeeeeeee
233 Helen: i can move now
234 Jack: Helen wats wrong?
235 Helen: that's weird
236 Jack: ok
237 Helen: i am behind you tony
238 Tony: Peter it's really odd seeing your head bouncing around
239 Helen: how come there is the two of me??????
240 Peter: helen am right behind ya
241 Jack: double identity
242 theodor: tony if you push the lever up you can roll the world around - the lever to the left of the control panel
243 Helen: i can see my self here
244 Tony: I'm going off down the other end of the building I've lost my tour guide again
245 Jack: i m wating for the tour

246 theodor: perhaps if everyone would like a tour they can meet at the top of the stairs??????????/
247 theodor: the tour starts at the top of the stairs!!!!!!!!!!!11
248 theodor: ok lets go!!!!!!!!!
249 Tony: OK, I/m waiting
250 Peter: ok
251 theodor: we need to look at boundaries
252 theodor: the first i want to discuss is the gap between the row of columns and the mauve wall
253 theodor: can everone see what i am talking about?
254 Tony: Ok
255 Peter: ok
256 Peter: yes
257 Helen: yes
258 theodor: how does the combination of the row of columns, how the wall terminates and the glass screen dived the sapce?
259 Tony: I'm surprised how much of a sense of inhabiting a space that we are getting here
260 theodor: moving from the virtual 3-D space and the chat dialogue is disorienting
261 theodor: why didn't Mies just put the columns in the wall?
262 Tony: Need to be a touch typist - otherwise people disappear while you're talking to them
263 Tony: I'm following theodor
264 theodor: thats true - it comes with practice
265 Peter: Lunch Time guys !!!!!!
266 Jack: well the wall is just a screen not structural
267 Tony: Where's lunch - in this world or the other one?
268 Jack: n i think there is a mistake in ur model
269 Peter: in me BAG
270 Helen: hahahaaha
271 theodor: if we move down into the space between the column/muave-wall and glass screen space what type of space do we 'feel'?
272 Jack: the wall does not touch the roof
273 theodor: the glass wall announces a transition from the outsied to an interior space
274 theodor: the row of columns is almost a ghostly hint of the muave wall yet independent as well
275 Tony: i was trying to sqeeze between the columns and the wall but I must be too big
276 theodor: the gap is not big enough to fit through
277 theodor: this scene is to scale and the avatars are too!
278 [Jack has disconnected]
279 Peter: Jack yur skirt is torn
280 Peter: bye Jack
281 Peter:
282 [Jack has connected]
283 Tony: A 'good' series of space in the 'real' world also seems to be good in this world - interesting to explore
284 John: yes
285 John: yeah
286 John: yes
287 theodor: i think tht Mies' spatial intentions can be felt in this virtual space
288 John: yes
289 John: h
290 theodor: though i am less certain about what is missing until i go to the original physical space
291 John: hi
292 theodor: welcome back Jack
293 [John has disconnected]
294 Peter: Tony is having a swim
295 Jack: sorry i cliced a wrong key
296 Tony: it was getting hot
297 theodor: tony are you stuck in the pool ?
298 Peter: yeah im just hungry at the moment !
299 Tony: maybe - its hard to getout
300 theodor: if people have had enough we can start winding up???
301 Peter: Everyone for Tony's rescue !!!!!!
302 theodor: push the lever up and then rotate
303 Jack: i also got stuck
304 Jack: again
305 Helen: hahahaa
306 Helen: can you see me tony???

307 [John has connected]
308 Tony: I'm out now scary to get stuck
309 John: i'm back
310 Helen: hahaha
311 Peter: helen
312 Helen: yes?
313 Peter: lunch time
314 Helen: yes
315 Peter: ;)
316 Helen: i get headache here :(
317 Peter: i got no head left
318 John: me too
319 Helen: where are you John???
320 John: walking around
321 John: trying to draw the detail
322 Helen: is there any toilet here? i need it
323 Helen: *giggling*
324 Helen: :O
325 Helen: what are you doing here?
326 Helen: Peter and John
327 Helen: can you see me?
328 Helen: who is flying around?
329 Helen: what are you staring at John?
330 Helen: that's not me
331 Helen: i dont know why
332 Helen: there is the two of me
333 Jack: yes i could feel the jerk when i climb up or down the steps
334 Jack: you all can try this,,
335 [Tony has disconnected]
336 Helen: i knew it :)
337 [Peter has disconnected]
338 [lusi has disconnected]
339 Jack: so Theo u are in the water,,
340 [Jack has disconnected]
341 [John has disconnected]

A.5 (2002)

DMM, 03/07/02, 12:30 – 14:00

1 Julie: hey i think 4 column for 4 roofs
2 Sally: what is good?
3 Sally: not decorative?
4 Sally: aiya
5 Sally: yes
6 Sally: let's think how to do the roofs
7 Julie: the costumes' space too open
8 Sally: yes
9 Julie: how about cross shape
10 Julie: remember the first combination we saw
11 Julie: that's good
12 Julie: then we could put the roofs together
13 Sally: what about this
14 Julie: not very good
15 Julie: may you could move first
16 Sally: we haven't figured out the circulation
17 Julie: yes
18 Sally: let's think
19 Sally: what about this?
20 Theodor: just entered this channel
21 theodor: hi guys
22 Sally: hi
23 Julie: welcome
24 theodor: it looks like you have come to a bit of a block in your thinking
25 Julie: yes
26 Sally: you mean brain?
27 Julie: do you have any good idea[s?]
28 theodor: i noticed that you are both up in the air looking down
29 Julie: yes
30 Julie: because it is good for des[ign]
31 Sally: we think it's better to get the composition [right]
32 theodor: Julie why do you think it is better for design?
33 Julie: usually we design on plan first
34 theodor: how do you know if you have created a private space?
35 Julie: also you can imagine the space you define
36 Sally: yes, kinda like [a] bubble, basic form and composition
37 Julie: like toilet
38 theodor: so are you working as architects now?
39 Julie: i think so
40 Sally: yes, but the system is differ[ent]
41 theodor: early on [I noticed] neither of you knew about or used the plan view, instead you navigated at floor level
42 Julie: yes i know, just an option
43 Julie: he i can't see you
44 Sally: we didn't know how to [at first]
45 Julie: that's ok now
46 theodor: do you think the experience of working at floor level was different to what you are doing now?
47 Julie: but it is hard for you to control these elements [at floor level]
48 Sally: definitely, especially when you had to start with the basic form from looking at floor level
49 theodor: what about knowing that someone else was in the scene with you?
50 Sally: that helps, but the system is difficult for the communication to go smooth[ly]
51 Julie: but i think first we should arrange these element first
52 theodor: was it important to be able to "see" another avatar/person in the scene?
53 Sally: i think so
54 Sally: what the?
55 Sally: this is probably a covered pool
56 theodor: Sally: can you expand on this? in other words why was it important?
57 Sally: yes!

58 Sally: then, you will know what the person is up to, kinda speculate
59 Julie: hey we haven't finish the combination work
60 Sally: or see what the person is actually doing, or 'looking'
61 Sally: hey, our pool house is quite nice from eye level
62 Sally: try move the level
63 Julie: it is indeed a different feeling
64 Sally: i am moving the elements from eye level
65 theodor: do you think you have created the required private spaces?
66 Sally: we are next to each other
67 Sally: i thinks so
68 theodor: how do you know they are truly private?
69 Julie: if we got two doors, then we could
70 Julie: can people see you when you changing your cloth[es]?
71 theodor: so are the spaces you created private?
72 Sally: semi
73 theodor: what do you mean by semi?
74 theodor: what are you doing now?
75 Sally: the arrangement inside of the changing room, i mean the closets can be very private, but the other areas we leave it open
76 theodor: so what constitutes a private space?
77 Sally: not be seen from side ways?, in this context?
78 theodor: do you agree with this Julie?
79 Julie: agree what?
80 Julie: I agree Sally
81 theodor: so how do you know no-one can see you from the side in the virtual space?
82 Sally: yes
83 Julie: virtual and physical are different
84 theodor: ok how are they different?
85 Julie: in virtual space you could see each other even in 'private' space
86 Julie: but in physical space you can't see
87 Sally: different but similar i would say
88 theodor: so what does this mean about privacy in virtual space?
89 Sally: it is more transparent in virtual world
90 theodor: can there be such a thing as a private space in virtual space?
91 Sally: i don't think so
92 Julie: you can['t] use virtual tool to design space for physical goals
93 theodor: Sally: why not?
94 Sally: anything linked to the computer/server, satellite is not private
95 theodor: that's right Sally!
96 Julie: yes, i reckon that also
97 theodor: do you think it matters if you can see other people in the space or not?
98 Sally: it is good to test whether privacy is really necessary
99 Julie: up to different situations
100 Julie: like big brother [('Big Brother' was a popular TV programme in 2002)]
101 Sally: wow
102 Julie: you are interested in watching this programme
103 Julie: because you don't know them
104 theodor: Sally: you say it is good to test but you didn't coordinate the other person to prove it
105 theodor: Julie: what benefit was their in having Sally in the scene with you?
106 Sally: it was tempting (i can comfortably say it would improve based on the experience)
107 Julie: I can see how she moves
108 Julie: it is great experience
109 theodor: Sally: I am not being critical of your performance I am merely making observations
110 Sally: of course
111 theodor: Julie and Sally: do you think it would be easier to do this exercise on your own or with someone else in the scene?
112 Sally: what i meant is, privacy does not mean it is better
113 Sally: with someone else
114 Julie: if you cooperate well, it would be
115 theodor: Sally: why is it easier with someone else in the scene?
116 Sally: planning is critical in design, and planning is better when u can see face to face
117 theodor: Julie: how do you guarantee cooperation?
118 theodor: Sally: do you think the planning you did with Julie was face to face in a virtual world?

119 Julie: share ideas

120 Sally: it is pròved here, we can do the planning / design in a matter of 10 mins [(on paper)] as compared to lengthy time [in the 3DVE]

121 Sally: no

122 Julie: but I found it is a bit difficult to communicate with each other through online

123 theodor: Sally: does this mean it was easier to plan in a virtual world than say on paper?

124 Sally: absolutely no

125 theodor: Julie: what did the chat do to stop your communication?

126 Sally: virtual collaboration should only comes in when necessary

127 theodor: Sally: so you think it is quicker to plan on paper?

128 Sally: yes

129 Julie: take time, and hard to explain

130 Sally: a lot of communication goes not in writing, but in body language

131 theodor: Sally: if Julie was in china and you in malaysia how can you plan on paper?

132 Julie: i agree with Sally

133 theodor: Julie: can you summarise your communication problems?

134 Sally: then, i will revert to this [(is she not ready to give up ?)]

135 Julie: if i can see myself, if more detail in direction

136 theodor: Julie: why do you think it is important to see your self?

137 Sally: nothing can replace the physical properties

138 Julie: i feel i am lost in virtual world

139 theodor: Julie and Sally: how did you feel to see objects moving around on their own like ghosts?

140 Sally: i am not very confident, there might be things we missed (because of the lack in face to face discussion - 10 mins in face to face discussion is probably like 10m hrs of 'chatting', I believe)

141 Sally: interesting for me

142 Julie: yes interesting

143 theodor: Sally: i presume you are saying that the ghostly movement of objects was "interesting" (Can you elaborate please?)

144 theodor: Julie: please tell me more

145 Sally: No, what I meant is the 'flexibility of arranging the element

146 Julie: you know actually the ghost moved by somebody, and you can see the design idea of theirs instantly

147 Sally: yes Julie

148 theodor: Sally: are you talking about how you can move objects or how they seem to move on their own (that is when Julie moves them)

149 Sally: but paper is better, because instantly also you can make some points by saying

150 Julie: But in natural design, we should spend sometime on our own design first, then discuss each other

151 Sally: interesting to see other's instant act

152 Julie: I feel i were lost when I was moving these elements

153 Sally: but also important to design in 2d

154 theodor: Julie: in natural design as you say you have the freedom to think alone (In the exercise we did today do you think you didn't have time to do your own thinking?)

155 Julie: yes

156 theodor: Sally: how does 2-D help when it is for 3-D construction?

157 Sally: I agree so, because u are pressured to keep up with others

158 Julie: I also agree with Sally (and this is the distinction between designers and others)

159 Sally: 2d and 3d should go together, 2d is important in figuring out circulation, etc

160 theodor: doesn't this just reflect the way you are designing currently? Sharing a CAD file but not working on it at the same time?

161 Julie: But this experience today is indeed a very good

162 Sally: parti and schematic too

163 Julie: I am excited about this

164 Julie: especially when I saw the 'blue' Sally

165 theodor: how do you think this method could be used most effectively?

166 theodor: Julie: what did you "feel" when you saw the blue Sally?

167 Sally: if this can help in the planning stage

168 Julie: Give cooperators more time to think about the tasks

169 Julie: I feel like I was playing 'game' with her

170 Julie: which attract me

171 theodor: Do you think it would make a difference if you didn't know who the other person was?

172 Sally: yes

173 Julie: yes

174 Sally: i already know how Julie works, so many of my suggestion is based on that (If I had not known

the person, it would have been harder, longer)

175 theodor: In other words, how would it make a difference if you didn't know the other person?

176 Julie: it is better you know whom you will work with

177 Sally: more difficult

178 Julie: if I worked with a child, and he/she played 'roof' as 'ground'

179 theodor: Sally

180 Julie: it is more funny

181 theodor: Sally: how is it more difficult?

182 Sally: to firstly understand the person, what she likes, then have to figure out whether she agrees, a whole lot of figuring out

183 theodor: Julie: so you think if you didn't know who the other person was it would be more serious?

184 Sally: not me,

185 Julie: yes, it would

186 Julie: I also agree with Sally

187 theodor: Sally and Julie: thank you both very much for your help today!

188 Julie: Just now what Sally said, i think it is a part of what 'cooperation' means

189 Sally: thank you, thanks for sparing time and be patient with us

190 Julie: thank you, theodor

191 Sally: just logged off

A.6 (2003)

DMM, 14/05/03, 11:25-12:30

1 Peter just entered this channel
2 Peter: dont move the roof
3 Jack: ok
4 Jack: theodor u keeping in mind the privacy issue
5 Peter: we only have half an hour
6 Peter: yes i am
7 Peter: can i start arranging
8 Jack: ok
9 theodor just logged off
10 theodor just entered this channel
11 theodor: hi again guys
12 Peter: hi
13 Jack: hello
14 Jack: where do we keep the table base plates/floor was interesteing
15 theodor: what you were saying about the walls being different sizes to the
16 theodor: do you want to discuss this with Jack?
17 Peter: Jack can u move back a bit
18 Peter: yur avataris is obstructing my vision
19 Peter: Jack zoom back a bit
20 Peter: ur avatar is right in front of me
21 Peter: JACK
22 Peter: yes better
23 Peter: THANKS
24 Jack: no worries
25 Jack: window pannels theodor not fitting
26 Peter: yes
27 Peter: im trying to sueeze in
28 Jack: we need to putr the columns close
29 Jack: yes
30 Jack: yes that is fine
31 Peter: yup
32 Peter: now back to the changing rooms
33 Peter: i cant view it from the back
34 Peter: damn
35 Jack: me either
36 Jack: zoom in a bit
37 Peter: ok
38 Jack: just place the yellow wall
39 Peter: ya
40 Peter: i am getting it now… cool
41 Jack: cool
42 Peter: there is one yellow wall left
43 Peter: and the suare blocks
44 Peter: i fixed that
45 Peter: we can use them as steps
46 Jack: square blocks theodor the stepping stones
47 Peter: ya
48 Peter: i have done a trick here
49 Peter: will tell u later
50 Peter: :P
51 Jack: o k
52 Jack: so it's finished it seems
53 Jack: what do u say
54 theodor: have you isolated two change areas?
55 theodor: are they private?
56 Jack: yes
57 Peter: yeah
58 theodor: what is privacy in a virtual world?

59 Peter: look loke
60 theodor: is there such a thing?
61 Peter: VERY PRIVATE
62 theodor: sorry Peter i don't have a copy of the scene on my pc
63 Peter: i have tried to be quite liberal with the planning thing
64 Peter: wanted to put a glass pane in between the changing rtooms them later
65 theodor: take some screen grabs and save them to the desktop so i can see
66 Jack: so do i come
67 Jack just logged off

A.7 (2003)

DMM, 14/05/03, 12:35-13:40

1 John just entered this channel
2 John: where are you, Denis?
3 Denis just entered this channel
4 Denis: hi John\ dioganally in the middle
5 Denis: lets place the walles on teh corners... then we can put one wall
6 theodor: ok guys do you understand the task?
7 Denis: kinda
8 John: ok
9 theodor: that sounds like a good idea Denis
10 John: two exits
11 John: now it is one exit
12 Denis: how do u rorate individual element?
13 John: is this the private room
14 John: maybe it can not be rotate
15 Denis: can we rotate individual element?
16 Denis: the s key is not working properly
17 Denis: all my elements are becoming singular\
18 Denis: anyway
19 John: this is not private enough
20 Denis: i kinda like the way its sitting right now
21 Denis: sure it is
22 Denis: what do u think, theodor?
23 John: you can see the things from the exit
24 John: too open
25 John: we need more walls
26 John: I think the room is too open
27 John: you can see people changing clothes inside
28 Denis: aww... let them change in the open
29 John: we don't have enough walls
30 John: so maybe we need to build the room smaller
31 Denis: try it... i personally think this is fine but u can tyry
32 John: how about this
33 John: but it is small
34 John: just for one person
35 seperate ones for m and f
36 Denis: well do we need one private space or two? i think we'll need
37 Denis: theodor?????
38 John: but not enough walls last design was fine
39 Denis: listen if we need two spaces, one for male and one for female, the
40 John: ok
41 Denis: John decide quickly... i think lets stick to the previous one
42 Denis: theo has disappeared peobably gone to eat
43 John: ok
44 John: i have changed it
45 John: is it ok?
46 Denis: cool now lets place them correcctly
47 John: is the blue water element represent the pool?
48 Denis: probably
49 Denis: yeah i guess it is
50 John: maybe the glass need to be on the other side
51 Denis: ya
52 John: the glass not big enough
53 John: good
54 John: done?
55 Denis: thats it
56 John: how about the other two roofs?
57 John: do we have to use all the elements?
58 theodor: hi i'm back!!!!!

59 John: we have done
60 Denis: i think were tyru
61 Denis: through
62 Denis: lets take screenshots
63 theodor: have you determined what privacy means in a virtyal world?
64 theodor: screenshots is a good idea
65 John: privacy means you can't see them changing clothes?
66 Denis: lol doubt its that easy to determine theo
67 Denis: digital voeuyers
68 John: now you can see them changing clothes from the top
69 John: what happen to the roof?
70 John: why remove the roof?
71 Denis: just discussing
72 Denis: we dont need the roof
73 Denis: coz u vcan look in anyway
74 Denis: u there???
75 Denis: a firewall is a useful wall in the virtual woirld... these are no good!
76 Denis: i can see you!!!
77 John: i can see you
78 Denis: yeah well im not hiding
79 Denis: im bored
80 John: now i am in private space
81 John: can you see me?
82 Denis: ok ill loiok for u again
83 Denis: i can see you!!!nin cyberspace!
84 theodor: you may have created a physically viable private space but it is not
85 theodor just logged off
86 John just logged off

A.8 (2003)

DMM, 16/05/03, 12:00-1300

1 Peter just entered this channel
2 rod just entered this channel
3 rod: lets just play around with the controls first
4 Peter: ok what u going here
5 rod: n try to identify the elements 1st
6 Peter: ok
7 theodor just entered this channel
8 rod: hi theodore
9 theodor: ok guys need to chat a lot and let each other know what is going on
10 theodor: if you have time please take screen grabs
11 rod: troy can u see the stepping stones?
12 rod: i cant see them
13 theodor: start working on a stategy for collaborating on the project
14 theodor: remember to make private spaces
15 rod: we theodor identifying the elements 1st
16 rod: ok
17 rod: i found all the elements
18 rod: hav you seen all the elements troy?
19 Peter: yes
20 rod: can u save some screen prints?
21 Peter: we get limited elements!
22 Peter: let me try to save that!
23 rod: saved that?
24 Peter: yes
25 Peter: i did
26 rod: how u do tat
27 rod: quick tell me
28 Peter: screen save 1
29 Peter: what u asking to making ?
30 rod: press alt n print scrn?
31 Peter: yes
32 rod: n where to find the file?
33 Peter: i saved on this comp~ at desktop
34 rod: ok
35 Peter: let go to make this buliding
36 rod: lets make the pool house 1st
37 rod: u try 1st 1st
38 Peter: i think u don't have much ele~ so we need to think
39 rod: just paly around 1st
40 rod: then see how
41 Peter: can u see me
42 rod: no
43 Peter: i am on the top v1
44 rod: just use 4 walls for the house
45 Peter: os i can see what is going on plan \
46 Peter: no for house
47 Peter: for pool to chang cloths thing
48 Peter: u understand
49 theodor: ok I'm back
50 theodor: if you want to save screen grabs put them on the desktop please
51 Peter: theodore
52 Peter: i hav crashed!!!!
53 Peter: not me i rod
54 Peter: hey tho!!!!\
55 Peter: u get me
56 Peter: theodor !!! u get me
57 Peter just logged off
58 Peter just entered this channel

59 rod just entered this channel
60 rod: troy i m back
61 rod: lets build the pool house wif these orange walls
62 theodor: hi guys
63 rod: helo
64 theodor: ok back to work
65 theodor: what i saw looked interesting
66 theodor: can you reconstruct it?
67 Peter: ok i acsn see u then
68 theodor: what you had before rod crashed and burned?
69 rod: arrrrrrh
70 rod: troy let the columns for the pool house
71 Peter: rod what u think?
72 rod: troy dun put the columns in the toilest
73 rod: not enuf structures for the pool house
74 Peter: hi rod i am at top
75 rod: i try to go to the top... good idea
76 Peter: so i can see plan but i can't see section
77 Peter: do u understand what i am try to say now?
78 rod: ok
79 Peter: so let make rlues
80 rod: no columns for the toilets
81 rod: glass for pool house
82 theodor: i like the idea that you are devising some rules!
83 rod: use solid walls for toilets only!!!!!
84 Peter: ok i can't see what u doing now ?
85 Peter: get me some~~~~~\
86 Peter: hey rod!!!!!!
87 Peter: tell me what !!!!!!!!!!???
88 rod: hi
89 rod: i m trying to go to the top view
90 Peter: we don't need
91 Peter: i am here
92 theodor: take plenty of screen grabs guys!!!!!!!!!!!!!!
93 theodor: what happened? no chatting?????
94 rod just entered this channel
95 rod: ok
96 Peter just entered this channel
97 rod: i m back
98 rod: lets get back
99 Peter: also me
100 rod: troy
101 rod: put the roofs together
102 rod: yes
103 rod: put the roofs in one line
104 rod: i m on the elevation view
105 rod: u go back to the top view
106 theodor: howdy
107 rod: put the roofs in one line above the toilet
108 rod: ok
109 rod: u hav a new idea?
110 Peter: can u get in room
111 Peter: ahve look ?
112 Peter: have look ?
113 rod: this is good
114 rod: why not we move the toilets out of the roof
115 rod: toilet no need roof
116 Peter: how was it
117 rod: also pool no need roof
118 rod: move the glass to the roof
119 Peter: we finshde isnn't it
120 rod: yeah!!!
121 theodor: ok guys I will come up and have a look

122 rod: troy
123 rod: stop
124 rod: its finished
125 Peter: hey how we gona suppor cloumns
126 Peter: rod ?
127 rod: tose theodor stepping stones!!!!
128 Peter: we need footing for cloumns
129 rod: not footing!!!!!
130 rod: stepping stones!!!!!!!!

A.9 (2003)

DMM, 16/05/03, 13:00-14:00

1 Ann just entered this channel
2 Helen just entered this channel
3 Helen: Ann, what are you doing???
4 Ann: I am disassembling and having a count of elements
5 Helen: oh oke
6 Ann: Pick blue water and put in the middle
7 Ann: and next to that white block for paved aarea
8 Helen: is that correct??
9 Ann: i am assembling walls and if you are not happy correct when i am done m
10 Helen: where is the stepping stone??
11 Ann: I think that table
12 ted just entered this channel
13 Ann: how do you rotate walls
14 Ann: seems good
15 ted: hello
16 Helen: just rotate it
17 ted: you cannot rotate the walls
18 Helen: is that you theo???
19 ted: yes
20 Helen: oke
21 Ann: no i cannot find grey stepping stones
22 Ann: yes
23 Helen: yes, where is it??
24 ted: can you describe what you are doing?
25 Ann: paved area is stepping stones Helen
26 Helen: oh oke
27 Ann: I want to use walls for making private area and use glass as doors
28 Helen: the right and left side is the changing room
29 Ann: how to fix this if cant rotate?
30 Ann: good
31 ted: so you guys are talking to each other and then making gestures in the world?
32 ted: in other words, when Ann says rotate does Helen fix it?
33 Helen: nope
34 Helen: cant
35 Helen: i tried
36 Ann: changing room!!
37 Helen: Ann
38 Helen: we have to make 2 changing room
39 Helen: on the left and right side
40 Helen: got it?
41 Ann: no cant rotate... Theo said
42 Helen: yes i know
43 Helen: the left side has too many walls Ann
44 Helen: sorry, the right
45 Ann: ok try but because you cant scale and rotate walls its tricky
46 Ann: try
47 Ann: yup!!
48 Helen: we just cover the room
49 Helen: so they cant see each other
50 Helen: what is the red one for??
51 Ann: i am not able to see hence iam aPeterusting screen
52 Helen: for jumping to the pool??
53 ted: its a bit like walking onto site and finding all the pieces but you can't cut or join or rotate pieces
54 Ann: Helen can you fix the screen for me
55 ted: if you can please take screen grabs and save them to the desktop
56 ted: what do you mean fix the screen Ann?
57 Ann: thats a poolside table i suppose!
58 Helen: the screen??

59 Ann: I cant see all the elements
60 ted: what screen are you talking about?
61 Helen: me neither
62 Ann: how to do zoom extent
63 ted: are you talking about the computer moniot or a screen element in the virtual world?
64 ted: Ann you are thinking like CAD
65 Ann: yes move it lil back
66 ted: but you are in a virtual world
67 Ann: game screen icant see left spaca
68 Ann: virtual world!!! I switched red button off and then tried but it iis not working
69 ted: has your screen frozen?
70 ted: are you still there Helen?
71 Ann: did it now it i can see all the elements
72 Helen: yes??
73 Helen: there's extra roof
74 Helen: Ann
75 Ann: hi Helen how are doing?
76 Helen: what about the extra roof??
77 Helen: at the back
78 Ann: to cover spaces or may be pool as well
79 Helen: oh oke
80 Helen: where's the other one?
81 Helen: you cant move that columns Ann
82 Helen: oh i got it
83 Helen: that's the step
84 Ann: hey EUREKA!!! found those stepping stone
85 Helen:
86 Helen: Ann, what are you doing?
87 Ann: Helen just lil bit we have to do with glass panels
88 theodore just entered this channel
89 Ann: Watching and figuring out how to do aPeterust walls and panel
90 Helen: yup
91 Ann: Het its done
92 Helen: we have 4 roof Ann
93 Helen: do we have to use all of them?
94 Ann: move right room back to get access
95 theodore: theodor u taking screen captures?
96 Ann: not left right
97 Ann: NO!!!
98 Helen: what do you mean?
99 Helen: did you say to me, or theo?
100 Ann: fix the roof over the pool
101 Helen: the size doesnt match
102 Ann: Helen make lefy room the way did it right
103 Ann: i know we cant scale it either
104 theodore: u shd both be taking screen captures
105 Ann: Coover that table area with roof and then cover the pool over the walls and then private rooms… Ithink roof problem is solved
106 Helen: where is the other one?? (roof)
107 Ann: There were four roof?
108 Helen: yes
109 Ann: I cant see… as well
110 Ann: how ?
111 Helen: no idea
112 Helen: we lost it
113 Ann: I know there was TORNADO last night… flew off
114 Helen: i found it
115 Helen:
116 Ann: All riht keep this table portion same and keep it aside
117 Ann: how to make these faces?
118 Helen: you mean this??
119 Ann: play with only rooms or willbe doing g this game for ever and ever
120 Ann: yeah!!!

121 Helen: i tell you later :
122 Ann: Take snap shots… how?
123 Ann: Theo?
124 Helen: i already take print screen
125 Ann: Dont touch that table part
126 Helen: i am still thinking what is the red one for??
127 Ann: Table!!!!
128 Helen: and the stepping stones
129 Helen: yes i know that is the table
130 Ann: Hey we have two extra wall?
131 Helen:
132 Ann: Wow seems good!
133 Ann: paper says only four we have six
134 theo is back just entered this channel
135 Helen: hahaha
136 Helen: we buy it
137 Ann: Theo we have two walls extra… Are we supposed to use all?
138 Ann: ha
139 theo is back: use the printscreen button to do screen capture
140 ted: you can use what ever pieces you want
141 Helen just logged off
142 Helen just entered this channel
143 Helen: did it
144 Helen: and we can choose not all of them either?
145 Helen: what are you doing Ann?
146 Helen: flying wall
147 Ann: seems completed
148 Helen: oh you want to erase these two walls
149 Ann: Yeah!!! If you want you can use
150 Helen: nope, thx
151 Ann: Want to try some more designs?
152 Helen: have you done your print screen??
153 Helen: i did it
154 Helen: we have to discuss it with theo
155 Helen: through this channel
156 Ann: Helen we have to tell Theo why do we think it is private?
157 Ann: yeah!!!
158 Helen: i took three
159 Helen: but i think only one is private
160 Helen:
161 Ann: I rthink we need to sshift that table part other side of the pool. Otherwise if we wre changing in rooms any cheeky male can peepthrough the glass
162 ted: so what is it about your spaces which makes them private?
163 ted: if one of you hides in the private space can the other see you?
164 Helen: nope
165 Helen: because there's a wall
166 ted: if someone can see you then it is not private?
167 Ann: I presumed glasses are transluscent
168 Helen: i think it is private enough
169 Helen: you cant see others from your changing room
170 Helen: because it's separate with the pool
171 Helen: and we use walls to cover it (pool elevation)
172 Ann: But what about the person who is boozing next to table
173 Helen: theo?
174 Ann: It seems alright and more private space. Do you agree Helen? Is it completed
175 Helen: yes Ann
176 Helen:
177 Ann: OK then write yiur comments wwhy do you think it is private space?
178 ted: keep discussing I will come up soon to look at your work
179 Helen: it is private because we cant see each other
180 Helen: is it right, Ann?
181 Ann: Yeah!!!
182 Helen: good

183 Ann: I too think so!! if we are bboth are in different rooms we cant see each other. There is no direct vishal contact
184 Helen: yes
185 Ann: I mean visual contact
186 Helen: we have to swim first
187 Ann: I dont know swimming. I am scared of water
188 Helen: Ann
189 Helen: so there is no privacy in the virtual world
190 Helen: are you there Ann??
191 Ann: Alright we were designing the space keeping physical world in mind but there exists nothing like PRIVACY in virttual world
192 Helen: yes
193 Helen: that's true
194 Helen: so what is privacy?
195 Helen: is there any privacy in the real world also?
196 ted: what is privacy in the physical world?
197 Ann: Everthing is there in Yeah!!! we can lock our doors and we have visual barriers
198 ted: when you design as architects you think physical-world thoughts
199 ted: but what about survellance cameras in the street etc
200 Helen: we can have privacy in the physical world
201 Helen: but not all the times
202 ted: one can escape the physical world survellience by running home an hidding in the cupbaord
203 Ann: Walls, roof and it depends on the material
204 ted: but when you go to the bank and get money out of the atm the bank knows where you are
205 ted: when you make a telephone call the receiver knows what your number is hence where you are
206 Ann: Ok if we have two plots aPeteracent to each other and allocated on different m=names spo it becomess PRIVATE
207 ted: what are you talking about Ann?
208 Ann: We have some rules in Physical world - Those rules are PRIVACY
209 Helen: but someone can break your rules
210 ted: thats right Helen
211 ted: is there any privacy in cyberspace?
212 Ann: I mean we can control extent of privacy in physical world. May be I couldn't put what I wanted to say
213 Helen: cyberspace??
214 ted: you have both just spent more than an hour constructing what you thought was a private space
215 ted: but as it was shown privacy exists only if we agree to the same rules!
216 ted: what were you saying about emails Ann?
217 Ann: No there is no privacy. Emails are not private as well
218 Ann: Everyrthing is there on yyour server when you are exchanging any data which can be easily hacked
219 Ann: Yeah!!
220 Helen: so privacy is there, if we agree to the same rules
221 Helen: is that right Theo?
222 Ann: Publish on web can only be private if you abide the rules made by WWW consotorium
223 Helen: the key word is RULES
224 Helen: what do you think Ann?
225 Ann: Yes!!! But it is very hard for everybody to follow rules
226 Helen: of course
227 Helen: because all of them want to make their own rules
228 Ann: You cannot take it for granted hence bottom line is in cyberspace ther exists no word like privacy
229 Helen: yeah
230 Helen: so
231 Helen: there's someone here
232 Helen: i am afraid i am disturbing him
233 Ann: yeah!!! collecting ideas
234 Ann: disturbing whom?
235 Helen just logged off
236 Ann just logged off

A.10 (2003)

DMM, 21/05/03, 11:00-12:05

1 theodor just entered this channel
2 TREVOR just entered this channel
3 TREVOR: ok what are we looking at? can u see?
4 theodor: hi Trevor
5 TREVOR: hello
6 theodor: ok so the first thing is perhaps to look at what elements we have to play with?
7 TREVOR: theodor u the red ball?
8 theodor: i have never actually played this game myself so it will be interesting
9 TREVOR: is there a library of elements?
10 theodor: if you look at the instruction sheet you will see that the red ball turns the move sensor on and off for moving objcets around in the scene
11 theodor: i am the red avatar
12 TREVOR: ok let me explore the tools first, ok?
13 theodor: this is a WYSIWYG program so the library is in front of you
14 TREVOR: theodor we able to change the z axis of elements?
15 theodor: the elements only move in the x,z plane at this moment
16 theodor: remember that y is up in this world
17 TREVOR: x,y?
18 TREVOR: ok
19 TREVOR: let's start with all elements away, shall we?
20 theodor: so do you have any ideas?
21 TREVOR: we'll look at blank space and stare till an idea comes along
22 theodor: i like arranging the different elements to get a feel for what is possible
23 TREVOR: ok
24 theodor: have you got any ideas for the floor layout?
25 TREVOR: we have the change room ready, rite?
26 theodor: what or where is the change room
27 TREVOR: I'm not very good at typing can we have voice, instead?
28 theodor: have we runout of columns?
29 theodor: the view is quit nice from down here
30 theodor: if you come down here have a look at what i can see
31 theodor: what are you doing up in the sky?
32 theodor: from up there you are not "experiencing" the space
33 TREVOR: and I've got the position wrong from up there, huh?
34 theodor: are you able to join me on the ground?
35 theodor: thats interesting what are you doing with the table?
36 TREVOR: what do you think of eating/drinking with your feet in the pool?
37 TREVOR: do we have the private change areas yet?
38 theodor: i can see why participants spend so much time just playing with the possible spaces its endless and quite evokative of japanese box-like construction
39 theodor: i like the idea!
40 theodor: are you still up in the sky?
41 TREVOR: how about making it not so private?
42 TREVOR: I'm at eye level. I think you are too low?
43 theodor: seriously if you come down here you get quite a diferent feeling for the spaces
44 theodor: well thats interesting. you say i am too low but i seem to be able to go into the spaces without hitting my head
45 TREVOR: I'm ok too
46 theodor: i saw you drop onto the water this indicates the acrtual ground level
47 TREVOR: need proxy authentication
48 theodor: perhaps this world needs a base plate under everything??
49 theodor: what do you feel when you can see my avatar floationg around in the space?
50 theodor: when you are up in the sky you are working in a traditional manner
51 theodor: you are assuming the superior god-like overview
52 theodor: this is how architects read plans
53 theodor: you have become so adept at abstracting the space of a plan that you don't need to be 'in' the space to know it
54 theodor: but this can also be a trap

55 theodor: space is not 'lived' in its abstracted form
56 theodor: users of architectural spaces do so from within them
57 TREVOR: I think it gets a lot more challenging if objects are not fixed and you will have to create them
58 theodor: they do not 'see' the spaces the way architects 'image-ine' them
59 theodor: on the contrary with so few elements to play with it is quite challenging to construct something meaningful
60 TREVOR: I think we can visualise the space without even be in them
61 theodor: that is what i am saying but what you image is different to what it is
62 theodor: how would you have me enter this buidling?
63 TREVOR: I agree, that it could be useful to gauge how the spaces arrngement, but to have the limitation is much a constraint, don't u think?
64 theodor: oh by the way can you take some screen grabs at pertinent momnets please?
65 theodor: in view of the exercise at hand if you were able to start with a clean slate and model everything from scratch the results would be fairly predictable?
66 TREVOR: as this is a poolhouse, much like a pavilion, and could be placed in an open space in a backyard or similar, maybe there should not be a marked entry point?,
67 theodor: thats a fair comment. But what I wanted was for you to guide me through your pool house
68 TREVOR: u can follow me
69 theodor: ok where are you?
70 TREVOR: in the tea house now
71 theodor: can you describe the rooms as we go through them?
72 theodor: i'm having trouble keeping up
73 theodor: its difficult to understand what you ravatar is doing - Rotating on the spot etc
74 theodor: i think it would be really interesting to record this as a movie?
75 theodor: perhaps with the chat as subtitles?
76 theodor just logged off
77 theodor just entered this channel
78 theodor: back again and Trevor is not wasting any time reconstructing the scene
79 trevor just entered this channel
80 trevor: let's do something different,shall we?
81 theodor: i was just going to suggest that!
82 theodor: can i have a go at desiging this time?
83 trevor: ok, go ahead, I'll supervise
84 theodor: and perhaps you go down in to the space and tell me what it feels like
85 trevor: it feels disarray now
86 theodor: i am up in the sky desginig like an architect
87 trevor: u could look from below too, if you like
88 theodor: ok
89 trevor: as long as u can 'see' the space above
90 trevor: do can do some fine tuning at eye level
91 trevor: the x-z co-ordinates are different
92 theodor: what do you think Trevor?
93 trevor: pretty good
94 trevor: for someone who design from the sky
95 theodor: yes y is up z is towards you and x is to the right (that is when you first enter the world)
96 theodor: ha ha!
97 theodor: would you like to follow me through the space and i will describe as i go?