Games One:Two:Three
A triangle of virtual game scenarios for architectural collaboration

Andre Brown and Phil Berridge
CAAD Research Unit
School of Architecture and Building Engineering
The University of Liverpool University

Overview

This paper is split into three parts, each of which deals with different aspects of, and approaches to, the collaboration process. Each of the approaches shares a common root in an aspect of games or gaming. Together the three approaches represent a tripartite attack on the spectrum of problems that need to be addressed to achieve successful collaboration. Our approach is summarised in Figure 1.

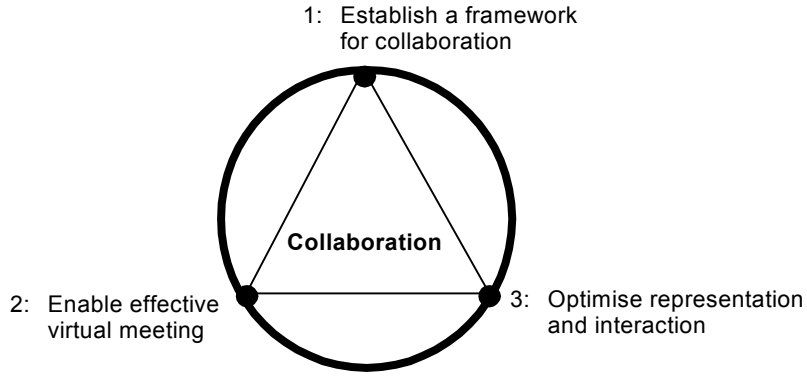

Figure 1: A triangle of gaming approaches to establishing computer mediated collaboration

The first technique is dealt with in ***Game One****. This deals with the issue of encouraging collaboration. It is based on work using a role playing game scenario and is intended to allow construction industry professionals and clients to develop a common framework for discussion. It originally existed as a paper based game and is now being tested in a web-based environment.*

Game Two is based on work that has evolved from contemporary game and meeting place environments that have been attracting attention recently. Here internet-based three-dimensional worlds are used as a virtual replacement of real spaces and participants meet as avatars. In the architectural context we have investigated the potential for application of such 3D worlds as meeting, and discussion places where architectural information and ideas can be exchanged.

In **Game Three** we take the idea that currently, virtual environments are still rather uncomfortable and unnatural in terms of human interaction, and in particular in the way that we move around and display architectural scenes. We develop the idea that games software incorporates techniques that make the representation of animated, interactive 3D architectural environments computationally efficient. We have augmented the software used in games environments and have considered how we construct architectural models and man-machine interfaces to improve the effectiveness of such environments in an architectural context.

Before we begin with the detail on how the triad of gaming scenarios have been formulated we should reflect a little on the matter of collaboration. There are fundamental questions that need to be addressed. Put simply these are:

1. **What** is collaboration?

2. **Why** should we promote collaboration?

3. If the answers to 2 and 3 above are positive then **How** do we foster collaboration?

To answer question one briefly, we can say that collaboration can be distinguished from co-operation in which the interested parties agree to work together: it involves more than that. Co-operation involves agreeing on task assignment; collaboration involves tackling those tasks together. Collaboration is also more than simply a matter of co-ordination between the interested parties. Co-ordination is helpful in avoiding errors in information transmission, but what is key to collaboration, is that the information being transmitted should be understood and agreed by the parties involved.

If we turn to the question of why should we support the idea of collaboration we should note that some of the best architecture of the past thirty years has come about via a collaborative working environment. Buildings like Center Pompidou, Paris and Lloyds of London were enriched by the positive inclusion of a range of players in the decision-making process. Those two buildings (and others) involved Peter Rice as engineer and Richard Rogers as architect. In that respect we should note that on the issue of collaboration Peter Rice, is quoted by Sir Richard Rogers as saying:

"Good teams are made up of different people; people whose separateness and attitude complement each other and who, by their individual willingness to work together and accept the presence and contribution of others, for a while at least make possible real momentum"

That quote has a resonance. If we can manage our collaborative efforts in way that optimises our performance then real momentum towards a better design solution is possible. We believe that fruitful collaboration will be best achieved through a broad spectrum of developments and our tripartite approach, covering aspects from across the spectrum is described here.

Game One: Three by three
Establishing a collaborative framework for human-human interaction

Mini-abstract 1

Game One uses a gaming strategy as its core technique to enhance and facilitate collaborative working. We illustrate its application through the example of getting a diverse group of participants in a built environment project to come to a shared way of working on, and discussing, the problem, when the common goal is to devise a project strategy which is sustainable.

The World Commission on Environment and Development (WCED), the 'Brundtland Commission', calls for participation to be at the forefront of sustainable development strategies (WCED 1987) [1]. However, in the years preceding the commission's report the mass of literature and debate concerning sustainable development has produced countless more definitions, many of which are incompatible with each other [2,3]

In order for effective participation to take place between professionals and community groups there must be continual discussion, however, communicative exchange requires some common principles if it is to be successful, so as viewpoints become more diverse collaboration becomes more difficult. Mutual understanding is a prerequisite for effective collaborative working.

The purpose of this method is to bring together all of the protagonists in a built environment project (the design professionals, the clients and the inhabitants) to discuss and develop design ideas by building a common understanding of the design problems. They do this through the concept of a shared model of the critical core issues; economy, community and environment [4].

Common Ground

> *'A planning effort seeks to debate among a range of claims for attention with respect to local environments, but these claims come from different 'thought worlds' and emphases and are particular and incommensurable. How then can they be discussed together?'* [5]

Everything we do jointly is rooted in the information we share about our surroundings, activities, perceptions, emotions, plans, interests, and such like []. For a group of individuals to hold a meaningful conversation they must share the same language (in its broadest sense), in the same way that for two tennis players to compete they must both know the rules of the game. These overlaps in two (or more) individuals' personal knowledge are what Clark refers to as Common Ground [6].

When a group of design professionals, clients and inhabitants come together to discuss a project or area strategy meaningful deliberations can only take place if they are founded in common ground shared by all participants. This becomes especially difficult when the debate is focused on sustainable development due to the mass of literature, the number and complexity of definitions and the individual thoughts, ideas and biases brought by each participant.

An important part of the collaboration process is the establishment of what common ground the participants share. When a British citizen (A) meets two non-British subjects (B and C) she does not know the extent of their knowledge concerning the UK (Fig. 1). 'A' may assume that 'B' and 'C' have basic knowledge (name of capital city, language, Prime Minister and so on) but she does not know the full extent of their knowledge and where there are overlaps. Before all three can discuss the UK some common ground must be established. When participants met to discuss sustainable development (or any design issue for that matter) they must first establish the nature and extent of their common ground.

Another obstacle hindering effective discussion concerns a speaker's meaning and an addressee's understanding. If two Architects, one from the US and the other from England, are discussing the first floor of a building plan how can they be sure they are discussing the same floor when, although both are native English speakers, in the US a first floor is what is referred to in the UK as the ground floor? The same principle applies in the discussion of Sustainable Development. Some participants think of Sustainable Development only in terms of economics and use the language of economics to describe it, others think of it only in terms of the natural environment and use language specific to that discipline. Both of these collaborators may share common ground but their language use is a barrier to mutual understanding. It is clear that methods are required to ensure a speaker's meaning is the same as the addressee understands.

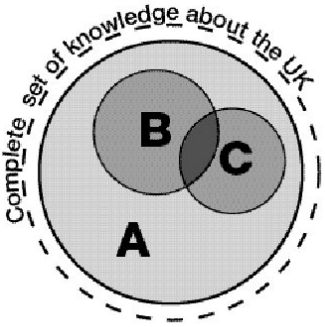

Figure 1: Individuals knowledge of the UK where 'A' is a British citizen, and therefore knows much, and 'B' and 'C' are both foreign to the UK. The dark shaded area shows knowledge shared by all three individuals (their common ground). It is this shared knowledge that they can use as a basis for discussion.

This strand of our research focuses on one solution to the problem of establishing common ground. The method introduces a shared model to participants that they then use as a basis for discussion – the model is the framework that establishes their common ground. When the participants use the model as a basis for

discussion they can also more easily ascertain other elements of common ground shared with other collaborators and later accumulate further common ground. In the next section the nature and application of this model is elaborated on.

The Model

The issues relating to sustainable development are very complex but we believe that any model used to assist in the communication process between disparate groups should be as simple as possible, whilst not trivialising the issues []. The gaming technique we have chosen is based on a simple three variable model, originally described by Mackie [8].

The model is based on a 3x3 matrix that models the interaction of the economy, community and environment (the 'stocks'). The columns represent each stock and the rows represent the possible states of each stock: robust, fragile or stable. Robust stocks are little affected by external events, stable stocks are locally well founded but subject to external 'shocks' and stocks that are fragile are locally at risk and prey to external effects (Fig. 2).

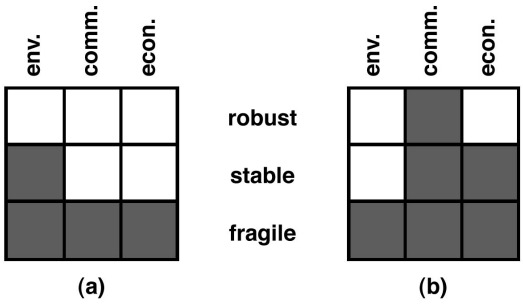

Figure 2: The three-capital model with (a) a stable environment, a fragile community and a fragile economy and (b) a fragile environment, a robust community and a stable economy.

Much discussion on development centres on the economy but this is only one of the three strands that must be considered [9]. The three capital model we are using does not force discussion onto a single issue but allows participants to share all of their knowledge. It does not focus on a single issue but concentrates on the whole system, becoming an easily accessible 'language' for facilitating a holistic discussion [10].

Although apparently simple, the model also facilitates discussion of 'complex' sustainability, where a 'project' shifts the stocks in different directions forcing a trade-off. Should the environment (natural stock) be singled out for special treatment or is it just another form of capital? Can one stock simply be traded for another? The model provides a framework for the discussion of these issues, and in doing so the local common language is reinforced.

The model has three key objectives that are applied in a number of different forms. The first is in ascertaining common ground. When participants are introduced to the model it becomes a common language they can use in discussion. It is in

these early discussions that participants discover what common ground they share.
Secondly, the framework of the model makes communication on the subject of development accessible to all participants greatly improving the communication process. This simplification of language helps collaborators to explain complex ideas that are accumulated to the group's common ground. Finally, the model can be applied to the analysis and tactical development of regions or areas (Fig. 3)

Real world examples

To date the model has been successfully used with a wide cross section of participants. It has been used in an educational environment in the form of the 'Children's Eco-city project' [11, 12]. It has been used to assess an area in Scotland by 'Sustainable Fife Roundtable' (Fig. 3). It is also used by Highland Perthshire Communities Partnership (HPCP) to ensure that all group members, ranging from oil industry executives to political journalists, have a common language for evaluating and prioritising proposed projects, thus forming the basis for collective reasoning.

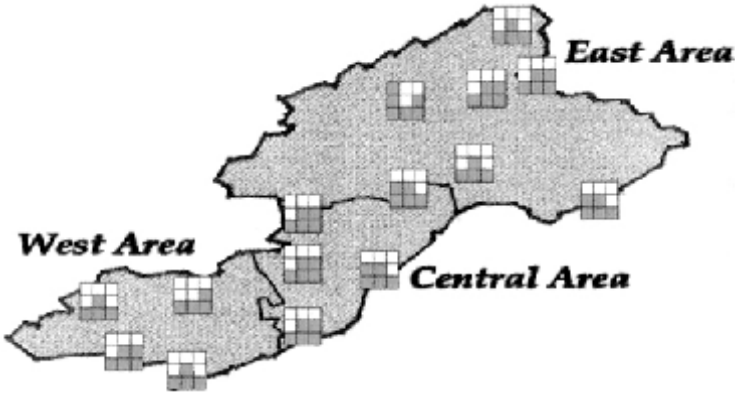

Figure 3: The model applied to various areas of Fife by the Sustainable Fife Roundtable.

Finally, the model also forms the basis for the 'sustain game', a role playing game where participants make decisions with the overall aim of achieving a sustainable community, thereby becoming familiar with the core 'vocabulary' and 'grammar' of the common language. This is the technique we have been investigating.

The paper 'sustain game'

To play the game teams use the 3x3 matrix as part of a game board and usually start with the stocks set at random levels. Then, using the model as a basis for discussion, team members determine a sustainable development strategy for their

fictitious community.
Once each team has a strategy in place they are presented with a playing card outlining a possible new project to be added to their community. The card indicates how the project will modify the existing level of the stocks, create jobs and possibly attract further projects. The teams use the model to inform their decision as to whether or not the project fits into their local sustainable development plan.
Often in the real world, local groups can only attract or discourage development projects. They are often not the ultimate decision-makers: so it is in the game. After the players have made their decision it is modified by the roll of a die; if the result is a 1, 2, 3 or 4 the decision is carried in their favour, if a 5 or 6 the decision goes against them. Some projects attract other related projects creating runs of development that teams can find difficult to stop, forcing them to adapt their development strategy (Fig. 4). The aim of the game is for teams to achieve, then maintain target stock levels for a predetermined number of rounds.

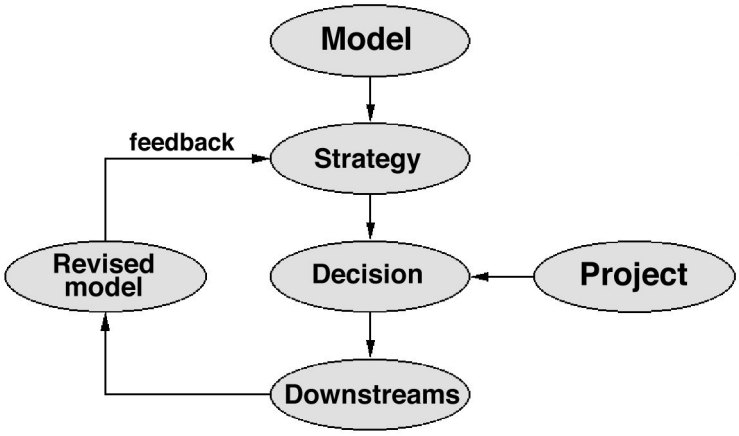

Figure 4: The process of the game. As projects happen teams must reappraise their sustainable development strategy accordingly.

The digital game

Although the real-world paper gaming sessions have been very successful in facilitating discussion on issues pertaining to sustainable development between different groups of people, one of the current strands of our research has been to establish how far we can augment and improve the system by translating the ideas to a computer based system. The starting point for this virtual-world game was that, unlike the real-world gaming technique, it must be usable in isolation, allowing individuals to access ideas about sustainability from a related database (which partly mimics the role of the expert human agent in the real-world game). The initial prototype for the digital game was created using Macromedia Director [10]. This has now been superseded by a web based version [13].

The gameplay of our virtual-world game and the real-world game is the same. Players are presented with a project and use the model as a device for integrating thinking about the interplay between the stocks in order to decide upon the project's suitability for their virtual community. The computer takes the role of the die and the game finishes after a predetermined number of rounds or whenever the user decides to terminate it. The same graphical representation of the issues is also used; ensuring the understanding of the model is transferred between different environments (Fig. 5).

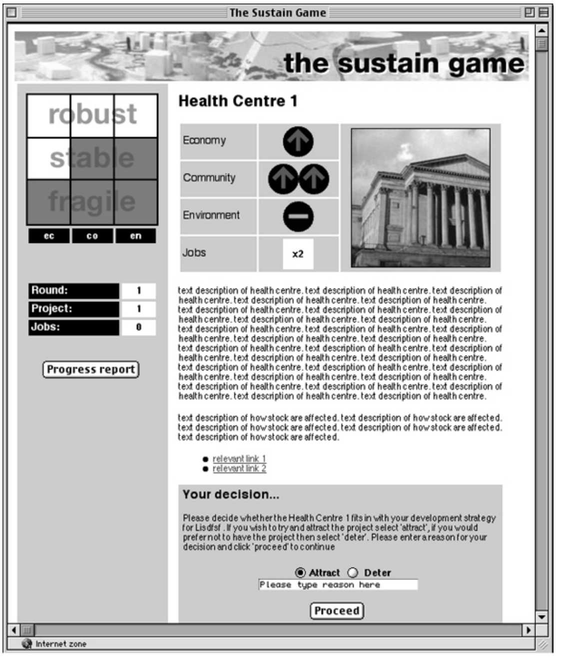

Figure 5: Screen capture of the web-based game (version 6a).

Part of the strength of the three capital model is that it provides users with a vehicle for decision making in a sustainability-led discussion. It allows users to take account of sustainability in a broad sense whilst not bogging them down with a mass of detail. This general comprehension of the issues is essential if players are to tackle the more detailed arguments that often surface during the gameplay.

The discussions that occur in the real-world gaming sessions are greatly enhanced by the background knowledge, experience and biases that players bring from their own respective backgrounds. When teams are dealt a project card they can decide on the appropriate collective action by simply considering the effects on stocks or they can delve into their combined knowledge bank for additional information. This extra information often causes players to disagree with the modifications a project, suggested by the project cards, will make to the stock levels but any additional discussion of the issues serves to further "lock the idea of the model" [14] in the minds of the participants.

When individuals use the virtual-world game, the debate and additional information that adds richness to the real-world game is often missing, as players only have their own experiences and the information they are supplied to work with. The effect of this difference is not yet clear.

Digital enhancements

As described above many projects in the real-world game attract other related projects; for example, a major manufacturing plant may attract a number of smaller manufacturers and some starter homes. Where a project encourages further development it is up to the team members to decide whether these 'downstream' projects fit in with their sustainable development strategy. The link between a major manufacturing plant and a number of smaller manufacturers is clear, in the real-world game; however, the link between a project and its associated downstream projects is random. For example, a sulphuric acid plant may attract a tourist information office.

The computer-based version of the game exercises some control over the unlikely combinations of downstream projects by selecting them from a subset of relevant projects rather than from the whole project set (as in the card game). This simple modification to the gameplay stops player's strategies being dominated by the fear of attracting unrelated downstream projects, so this is a clear improvement.

In the real-world game, as well as assisting teams in their deliberations, the game controller can intervene with announcements that affect player's plans. These usually come in the form of national effects that may, for example, force the closure of all manufacturing plants of a certain type due to a change in government policy. The virtual-world game allows a level of control to be added to these announcements, not possible in the paper game.

The purpose of the game controller's interventions is similar to that of the modification to a team's decision by the roll of the die, it shows the players there are external factors that affect local communities. However, in real-world gaming sessions the interventions do not always affect each team. In the computer based game these fictitious national trends are tailored to each player. The 'unexpected' combined effect of multiple projects also provides a basis for further interventions.

Conclusion

The paper gaming sessions have been successfully used by local groups throughout the UK in working on both fictitious and real projects. The model has been utilised, with effect, by Highland Perthshire Communities Partnership to educate members, assess areas and even contest a planning application. The digital game, although still in development, has also been used successfully to educate individual users on the principles of sustainability and has the potential to enhance the game with useful facilities.

However, we see the web based game not as a replacement for the paper game but as an additional tool to prepare participants for collaboration. If participants are to hold a meaningful discussion they must be able to communicate effectively and the 3x3 matrix provides the participants with the new shared language that they need to establish a 'Common Ground' for their collaborative efforts.
With an appropriate framework for human-human interaction established, the next step is to consider how computer mediated communication might be used to augment and expand the potential for collaborative work. Game Two looks at means for enabling such working environments through human-computer-human interaction.

Game Two: 3D Internet Game Worlds: Enabling a Virtual Meeting Place and Information Resource

Mini-abstract 2

There are practical and pedagogic implications that arise in devising a 3D web accessible, virtual meeting place as an environment to enable the display and sharing of information in an architectural setting. The first stages of the establishment of a new web-based environment are described in this section and this involves a review of some of the environments that might be appropriate for such a meeting place.

We take a particular example to illustrate the points at issue. The 3D world that is being used as a test bed is intended to:

- *display building design project work*
- *allow exchange of views; discussion; points of contact;*
- *provide educational and research information relating to CAAD.*

The range of environments reviewed offer a collaborative environment represented in a three-dimensional form. In particular those offered by Blaxxun, Holodesk and Active Worlds are reported on.
This work has been conducted on behalf of the eCAADe organisation [15] as part of the organisation's mission promote and facilitate the discussion and interchange of ideas relating to a field of CAAD. The new technologies that have come together to give us the environment that we know as the Internet has offered a range of stimuli for new initiatives.
Several notable contributions have been made to the evolution and adaptation of these contemporary Internet related technologies. The concept of the project described here has become to provide an Internet world that fully exploited the potential for sharing information whilst recognising and responding to the important observations and conclusions of researchers working in this area. The broad aim was to provide and interactive counterpart to the information gathering and design discussion processes in architectural design and architectural design education.

Background

There currently exist many two-dimensional web based galleries architecture, art and design artifacts (see for instance the display of work at Liverpool University School of Architecture [16]), but recent developments in the associated technologies offer enhanced ways of viewing, discussing and interacting. In the past five years or so various researchers and research groups have contributed to

the evolution of web based communication for architectural design and architectural education.

There has been a great deal of attention paid to the idea of the Virtual Design Studio (VDS) in which architectural design proposals are discussed and developed by groups in disparate parts of the world either synchronously or asynchronously [17, 18, 19, 20]. A particular strand of work in this area which is enlightening has been undertaken by a dynamic group who have worked together in a variety of different teams, which is itself evidence of the net fostering fruitful and flexible collaboration. The work in question has led recently to collaborative architectural projects called *Place2Meet* and *Place2Wait* [21]. The projects follow from earlier work which refined a tracking system to record interaction, and design modification, called *Phase(x)* [22]. Also in its ancestry is the development of a virtual environment for experimental interaction called *fake-space* [23].

In a broader sense Caneparo [24,25] has been involved in the notable development of appropriate worlds for synchronous interaction in a Shared Virtual Environment for architectural debate. Added to this the potential for the application of such environments for teaching [26, 27] and assessment [28] in architecture have become apparent in recent years. But it should be noted that there are significant caveats. In the evolution of an appropriate virtual world one of the temptations is to believe that enhanced technology (such as faster machines and more bandwidth) holds the key to solving the current problems evident in net-based communication. However, Winter and Taylor [29] emphasised the importance of allowing users to construct their own protocols. Koralevic and Ng discussed the application of such ideas in an architectural education setting [30] who concluded that 'flexibility in the provision of technology is more important than its optimisation'.

But, given the reservations and current pragmatic limitations, it is apparent that multi-user domains (MUDs) such as Fatal Dimensions [31] offer the potential to provide promising social workplaces and, given the advent of three-dimensional graphics and sound, to offer rich and compelling on-line spaces [32]. Even though the Fatal Dimensions domain mentioned above is only text based the interaction between architecture students in the domain is lively and diverse. A visual world has the potential to be even more engaging and appropriate for architecture students.

Interaction and its support are key issues in such environments. Participants such as architecture students need to feel they achieve something in terms of the world. The chatting element should not take over, but is an important social aspect that should not be ignored. The so-called socials, with which one can express emotions and opinions in the virtual world, are used a great deal, and fundamentally affect the user's perception of the virtual world. Research shows that avatars should have a range of appropriate expressions to support this aspect. There are many degrees of usage of MUDs. Standard players simply roam about, whilst more sophisticated users take up social roles (clan leaders say) and advise and help others.

The collaborative world developed should be one that supports and fosters discussion and exchange of information as effectively [33] and the construction of the world should be driven by this primary consideration. The physical environment in which the users experience the virtual world is clearly of fundamental importance. The nature of the image and its projection have an important role to play in the effective functioning of virtual environments [34]. However, in this report, we are only able to pay attention to this aspect in a limited way. Our focus here is, *de facto,* on screen based human computer interaction issues.

The Conceptual idea and Criteria for evaluation

The conceptual organisation of the world and its interconnections that has been initially agreed is shown in Figure 6. In devising this representation we were aware of other potential metaphors, such as ones which bear only a loose connection to a representation of a real environment. In addition to the building metaphor chosen the other two potential contenders were the city model and an abstract model. The abstract metaphor would be the result of arguing that in a virtual world the need for a real world analogy is debatable.

We envisage that the world would be entered via a Virtual Foyer [1]. From this area four other principal spaces could be accessed:

1. a public meeting space [2]
2. private meeting spaces [3]
3. a lecture room [4]
4. permanent gallery [5]

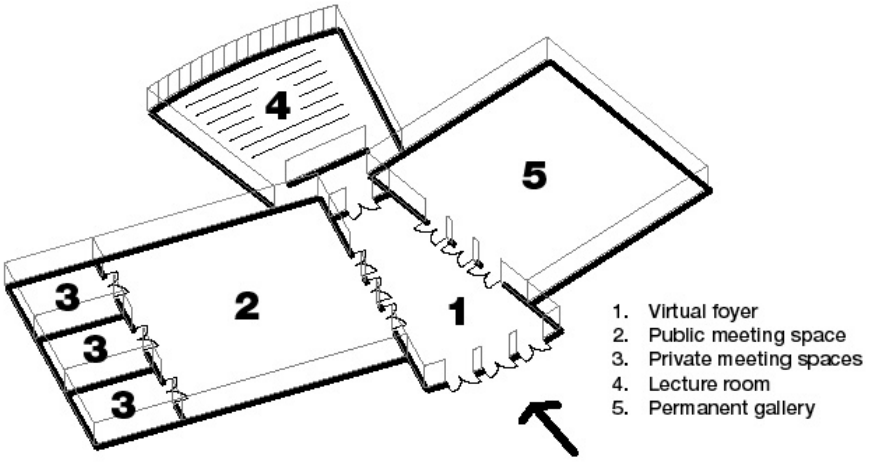

Figure 6: The initial conceptual structure of the world

Further enhancements to the world might be possible in some of the environments being considered. In some environments it is possible for users to attach (temporarily) their own subspaces to the main world. This feature then makes it possible to have the following additional 'rooms' (Fig. 7):

5. user hosted galleries [6]
6. user hosted meeting spaces [7]

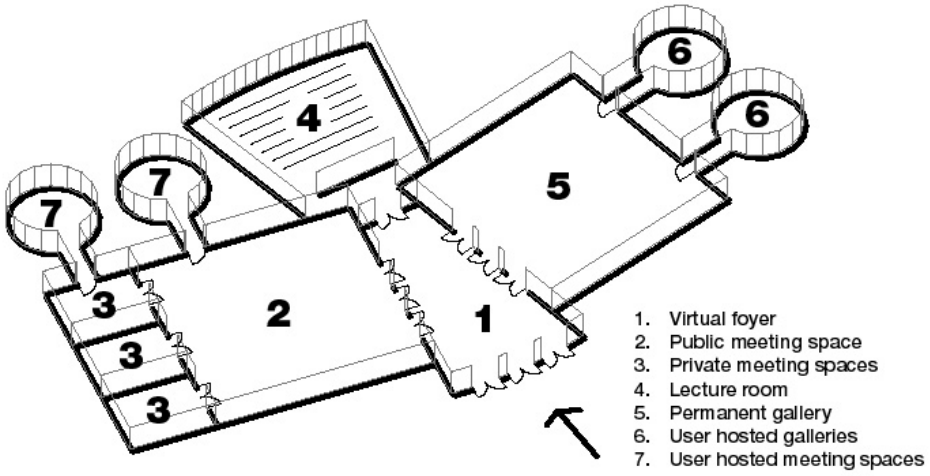

Figure 7: Potential augmentation at a local level

The critique of the 3D Internet environments needs to take in specific technical and pragmatic issues. Our theoretical and philosophical goals have to be achievable through an environment that is accessible, efficient and effective. The issues and sub-issues that we considered important initially were:

- Technical: Bandwidth; required hardware; computational power; accessibility/availability; connection speed; performance under stress; stability
- Educational: does it pose limits on possible content?; pedagogical use; gallery support; discussion support; does interacting in these worlds transmit additional knowledge/information effectively?; what do you learn from building environments?; is there a steep learning curve for advanced use?
- Human Computer Interface: Time investment/product quality ratio; Speech/ text/avatar possibilities and value; discussion of work easily possible?; private/public rooms?
- Administration: what are the respective privileges and how are they managed?

Worlds apart

We considered three Internet accessible worlds that might offer an appropriate development environment: Active Worlds: Eduverse []; Blaxxun: Cybertown and Virtual University [36]; Holodesk [37]. A brief description of each of these environments is given below. Each of the worlds is evolving so these views will, we accept, become dated rather quickly, but the broad criteria of evaluation will remain largely unchanged.

Active Worlds: Activeworlds Eduverse

Active Worlds is a very busy environment and architecture schools already have a presence there. Meetings and lectures take place there frequently. Worlds are constructed in the environment by modifying and adapting library objects available in the *Builder's Yard*. Communication can be typed (in a text window) or spoken (given the right sound cards in the communicating machines).

In its favour we would say the following: it is an established and busy world; there is a facility for whispering (private chat); it is already used for built environment disciplines. Against it we would say that: it does not import vrml; only 10-15 avatars can be seen even if there are more participants than this present; it is busy and heavily populated at times; there was a poor response and refresh rate in our tests.

Blaxxun: Cybertown and Virtual University

Blaxxun has many features that we regarded as useful and appropriate. However the organisation offering the world would have to provide a host and server from which the world could be run.

The advantages of this environment are: it is already in experimental use in education; it is in an advanced stage of development; it supports VRML import; a participant capacity of 100 (is claimed); it refreshed at a fast frame rate.

On the minus side we would comment that: it is a heavily populated world with heavy backchat; a suitable host with an appropriate server must be found; and that vrml import is not straightforward.

Holodesk

An Internet Explorer engine provides the framework for Holodesk. In terms of ease of use and clarity of the interface this environment had a lot to offer.

The best features of this world are: two-way voice chat is supported; navigation can be either by vrml interface or keyboard; it is easy to use and responsive with a small number of users; it has an effective whiteboarding facility; there is no sign-up charge; it is easy to load up vrml files and avatars; and local loading of worlds would make it easy for staff and students from a range of institutions to add their own mini-worlds.

As we see it the minus points are that; there is limited capacity for holding a large number of participants in one world; it is a new, and relatively untested system, with important developments still to take place; currently we would need to provide the server and host the world ourselves; there are still important developments to

come, for instance there is no facility for whispering (private chat); the voice facility does not work with all soundcards; the system slowed down dramatically during our tests.

Augmentation and future directions

The ideas and review outline described above were presented at the 18th eCAADe Conference in Weimar in June 2000 [38] and comments were invited. Following comments and a review by the authors a number of steps have been agreed. Firstly the conceptual idea has been expanded. It has been agreed that two new 'rooms' should be added. These are:

- A Library; an information resource on line.
- A Model Store; sharing models, particularly of cities and of significant buildings.

Second, test worlds are being constructed to evaluate the effectiveness of each environment before a major commitment is made in any of those available. The views in Figures 8 and 9 show one such test world, called Erehwon and, Erehwon1constructed in Eduverse. In this world virtual 3D meeting rooms, resource rooms and libraries have been constructed, and the effectiveness is being evaluated.

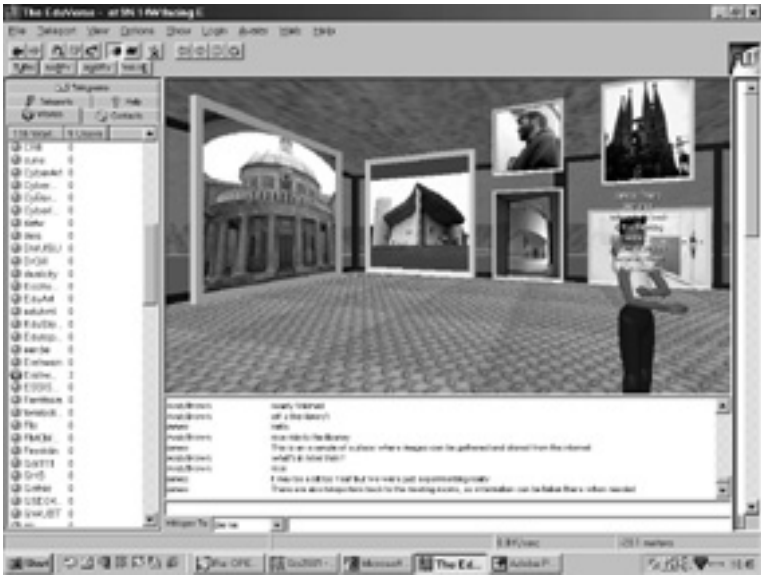

Figure 8: An initial test world – Library in Erehwon1

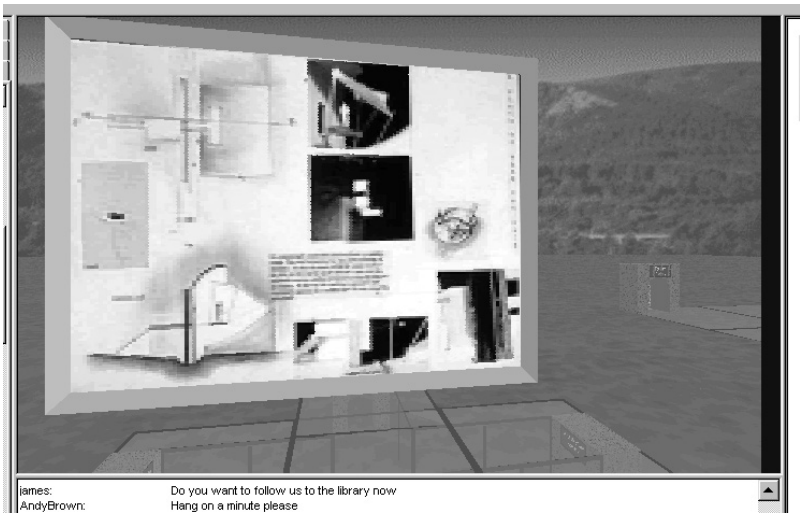

Figure 9: Meeting Room in Erehwon1: the drawing and information currently being discussed is pinned up against the translucent walls of the meeting room.

These 3D worlds clearly have the potential to be the medium through which physically remote individuals and groups can collaborate. Having said that there are practical problems that might constrain the potential. Speeds of connection, local hardware requirements, the mix of voice and text chat and local 'Firewalls' represent practical obstacles that require further development.
Added to that there are the functional and psychological issues related to communicating through this digital medium. These too must be given attention. Slater et. al [39], have, for instance, noted that:

> '*Group accord tended to be higher in the real meeting than in the virtual meeting. Socially conditioned responses such as embarrassment could be generated in the virtual meeting, even though the individuals were presented to one another by very simple avatars. The study also found a positive relationship between presence of being in a place and co-presence - the sense of being with the other people. Accord in the group increased with presence, the performance of the group, and the presence of women in the group.*'

Such observations should condition any attempt to establish an environment for effective collaboration. In Game Three, that is presented next, some of the practical obstacles and functional issues begin to be addressed, by looking at a potential interface and means of navigation for effective communication and working in a virtual built environment context. Issues dealt with range from computational effectiveness to increasing the sense of presence.

Game Three:
nAVRgate: powered by a games engine

*a **n**atural **gate**way to collaborative working through **A**rchitectural **V**irtual **R**eality*

Mini-abstract 3

The physical and visual natures of the interface devices and media that enable the human agent to interact with a virtual world have evolved over the past few years. The games industry has been at the forefront of developments in this area and the techniques described here use representation and animation techniques that are taken from that industry. We have married modified versions of games industry software with ideas on navigation and improving the quality and effectiveness the quality of the Cyberplace.

The work described here emphasises the Navigation aspect of our Virtual environment. Sometimes navigation is confused with locomotion but, as Darken et. al [40] note:

> *'Navigation must be seen as a process. We often make the mistake of seeing it as its end result – locomotion- navigation's most visible attribute. However, the cognitive subtasks that drive locomotion…are an integral part of the overall task'*

Inextricably linked with the idea of navigation is the mental representation, the cognitive map, of our understanding of the environment. In other disciplines concerns over the visual representations of information in virtual environments raises new issues. But in architecture there is a legacy of visual representation in the real world that we need to examine and take account of in designing new virtual environments. Maher et. al. [41] make the point:

> *'Although architectural design is noted for the forms and places created, the semantics of these places lies also in their function. The functional aspects of physical architecture can influence the design of virtual worlds'*

Our aim is to be able to comment on the effectiveness of the systems that have been devised from a number of points of view. We consider the physical and software-based aids for navigation; the nature of the representation of architectural worlds; strengthening 'groundedness'; the inclusion of 'otherness'; and reinforcement of the idea of 'presence'.

The goal in devising this system has been to enable interaction with a virtual architectural environment in a way that is effective (taking into account the issues raised above), but such that it is possible to construct the system at reasonable cost. The system is also intended to be Network-Internet accessible, so that it has

the potential to be used are the vehicle to facilitate interdisciplinary collaborative discussion with parties involved being located at remote sites.

Introduction

Many contemporary developments in the evolving ideas on how design can be transacted focus on the use of virtual environments. The apparent potential is enticing. But questions relating to how Human Computer Interaction (HCI) issues should be addressed and how we extract the best of best practice from Human-Human Interaction (HHI) studies remain largely unresolved. How should architectural images and ideas be most appropriately represented, and how should designers and design project collaborators interact and develop ideas through this computer-mediated medium? More importantly, how do we do this in an optimal way? Whilst there is never likely to be unanimity in answer to such questions, we can develop new ideas and new systems, test them, report on them and invite comment. The nature and novelty of virtual environments is such that refinements and innovations are likely to come from a variety of sources and in a variety of ways.

This section of our tri-partite study reports on the nAVRgate project, which is now in its second phase. In the first phase a low-cost, but effective virtual environment system was developed. The software used was computationally efficient, and the physical interface was direct and effective. The keyboard and mouse were replaced by an interaction device that was more familiar and appropriate to navigating through urban environments, the bicycle. In this respect the system bears similarity to the Legible Cities idea suggested by Jeffrey Shaw [42]. The nAVRgate-1 system has been demonstrated and reviewed. Following that review a second stage of development has taken place. The paper here will present a summary of the nAVRgate-1 system, the principal points arising from the review process and a description of the current stage of development, nAVRgate-2.

nAVRgate-2 brings together three strands of refinement. First, new ideas on low-cost, but natural and appropriate interaction devices have been developed. Second, ideas on how the shortcomings of the software in nAVRgate-1, without the loss of computational efficiency, might be addressed have been investigated. Thirdly, ideas that have arisen from parallel work in the authors' research group on the nature and differences in perception of architectural images in a computer-mediated environment are being drawn in.

There are two interesting projects that gave some early inspiration and direction: the "Legible City" and Char Davies' "Osmose" [43] projects. Both developed a body-driven navigation interface for the particular non-realistic environments (a text-analogised city in the case of Shaw and a surrealistic environment for Davies). In the case of the Legible City, the interface was an exercise bike and for Osmose, a scuba diving metaphor was used. In both cases, users could almost immediately concentrate on experiencing the VE rather than learning the navigation method, that is the interface very quickly became transparent to them. Just as importantly,

the sense of presence and connection with the VE was very strong [44]. The aim of the nAVRgate project is the same rapid transparency and sense of presence. In this sense the work of others such as Regenbrecht et.al. [45] also aims to move the developments in this area in a direction that will produce more effective and appropriate systems for navigation and interaction.
It is, though, easy to fall into the trap of assuming that natural locomotion is best most appropriate for virtual environments. Thus far we have found it to be very effective, but are aware of the fact that assuming 'natural' is best may imply "questionable assumptions concerning distance and direction estimation and maneuverability" [40]. In addition there are several pieces of work that show that spatial skills are not completely innate [46], and such findings have particular consequences when we consider designing virtual environments of architecture and for architects

Implementation in the nAVRgate system

The importance of retaining a sense of orientation in a VE has been [47]. Furthermore, the problems of scaling and scalelessness in the locomotion through, and perception of, the virtual space require attention in developing such environments. It has been shown that proprioceptive information aids the human agent in relating motions of the body to movements in space. Loomis et. al. [48] have shown that distance and direction estimation in virtual space were improved by the introduction of proprioceptive feedback. Such ideas will be responded to as the nAVRgate project evolves.
Our initial intention in the nAVRgate project (the AVR being a sub-acronym for Architectural Virtual Reality) was to develop a generic navigational metaphor, that incorporates a variety of natural locomotion methods. We initially developed an architectural VE using a commercially available gaming engine and, initially, revisited the use of a bike for navigation.

Figure 10: The interface for nAVRgate 1

nAVRgate-1 was ruthlessly pragmatic. An exercise bike **(**Knight and Brown; [49]) has been modified to give the basis of the system using a radically modified serial mouse. Left and right movement of the handlebars is translated into movement in the X-axis, pedalling into the Y-axis. Whilst this has overcome some of the problems some other researchers have found, such as the optical speed tracking of the wheel, it has raised others that we are addressing.

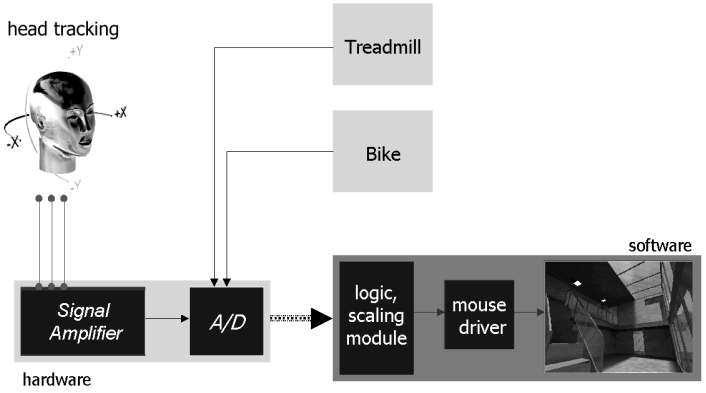

Figure 11: The extension of nAVRgate 1: enhanced by head movement and walking controls.

In the enhancements to nAVRgate-1 experimentation with augmented forms of locomotion and control by walking and head movements are being undertaken. These additions are, again, aimed at making the virtual environments more comfortable and natural to use. This aspect, added to the computationally efficient visualisation and animation techniques now adopted, have the potential to amalgamate to give a virtual environment that is both effective and appropriate for collaborative projects in the field of building design.

Acknowledgement: the research work described in 'Game Three' has been undertaken in collaboration with our colleague Mike Knight in the CAAD Research Unit School of Architecture and Building Engineering, The University of Liverpool, UK

Game One: References

- [1] World Commission on Environment and Development (WCED). Our Common Future. Oxford University Press, Oxford. 1987
- [2] Pearce, D., Markandya, A. and Barbier, E. Blueprint for a Green Economy. Earthscan Publications Ltd., London. 1989
- [3] Turner, R.K., Pearce, D., and Bateman, I. Environmental Economics. Harvester Wheatsheaf, Hemel Hempstead, UK. 1994.
- [4] Economic Commission for Europe. Research on long-term perspectives for human settlements development in the ECE region. United Nations, New York. 1986
- [5] Healey, P. Collaborative Planning. Macmillan Press, London. 1997
- [6] Clark, H. H. Using Language. Cambridge University Press, Cambridge. 1996
- [7] Casti, J.C. Would be Worlds: How simulation is changing the frontiers of science. John Wiley & Sons, Inc., New York. 1997
- [8] Mackie, D. Gaming Sustainability, in Simulation and Gaming across Disciplines and Cultures, the proceedings of the 1994 ISAGA conference, University of Michigan. Sage Publications. 1995
- [9] Smith, A. The wealth of nations. 1776
- [10] Duke, R.D. and Greenblat, C.S. Gaming-Simulation: Rationale, Design and Applications. Sage Publications, New York, 1975
- [11] T.A.S.C. Agency. Eco-city goes to Craigmillar Video. T.A.S.C. Agency, Edinburgh. 1996
- [12] Brown, A.G.P., Berridge, P. and Mackie, D. Gaming as a vehicle for collaborative design, in Challenges of the future the proceedings of the 15th eCAADe conference, Vienna, 1997
- [13] www.liv.ac.uk/abe/sustain/index.html
- [14] Mackie, D. The Sustain Game. Presentation at the ACTAC Green Buildings Fair and Conference. ACTAC, Leeds. 1996

Game Two: References

- [15] www.ecaade.org
- [16] www.liv.ac.uk/abe
- [17] Chen, N., Kvan, T., Wojtowicz, J., Bakergem, D., Casaus, T., Davidson, J., Fargas, J., Hubbell, K., Mitchell, W., Nagakura, T. and Papazian, P. (1994) Place, Time and The Virtual Design Studio , Reconnecting [ACADIA Conference Proceedings / ISBN Washington University (Saint Louis / USA) 1994, pp. 115-132
- [18] Wojtowicz, J., Papazian, P., Fargas, J., Davidson, J.N. and Cheng, N. (1993) Asynchronous Architecture , Education and Practice: The Critical Interface [ACADIA Conference Texas 1993, pp. 107-117
- [19] Wojtowicz Jerzy and Butelski, Kazimierz (1999) Lessons from Distributed Design Practice, Architectural Computing from Turing to 2000, eCAADe Conference Proceedings Liverpool (UK) 15-17 September 1999, pp. 482-487
- [20] Russell, P., Kohler, N., Forgber, U., Koch, V. and Rügemer, J. (1999) Interactive Representation of Architectural Design: The Virtual Design Studio as an Architectural Graphics Laboratory, Architectural Computing from Turing to 2000, eCAADe Conference Proceedings Liverpool (UK) 15-17 September 1999, pp. 459-465
- [21] Donath, D., Kruijff, E., Regenbrecht, H., Hirschberg, U., Johnson, B., Kolarevic, B. and Wojtowicz, J. (1999) Virtual Design Studio1998 - A Place2Wait, Architectural Computing from Turing to 2000 [eCAADe Conference Proceedings, Liverpool (UK) 15-17 September 1999, pp.

453-458

- [22] Wenz, Florian and Hirschberg, Urs (1997) Phase(x) - Memetic Engineering for Architecture Architecture, Challenges of the Future, 15th eCAADe Conference Proceedings
- [23] Hirschberg, Urs (1998) Fake.Space - An Online Caad Community and a Joint Enquiry into the Nature of Space, CAADRIA '98, Proceedings of The Third Conference on Computer Aided Architectural Design Research in Asia, Osaka (Japan) 22-24 April 1998, pp. 281-290
- [24] Caneparo, Luca (1995) Coordinative Virtual Space for Architectural Design, Sixth International Conference on Computer-Aided Architectural Design Futures, Singapore, 24-26 September 1995, pp. 739-748
- [25] Caneparo, Luca (1997) Shared Virtual Reality for Architectural Design, CAAD Futures 1997 Conference Proceedings, München (Germany), 4-6 August 1997, pp. 431-442
- [26] Kvan, Thomas (1997) Studio Teaching Without Meeting: Pedagogical Aspects of a Virtual Design Studio , CAADRIA '97 [Proceedings of the Second Conference on Computer Aided Architectural Design Research in Asia Taiwan 17-19 April 1997,pp. 163-177
- [27] Woo, Sungho and Sasada, Tsuyoshi (1998) Shared Virtual Space for Architectural Education , CAADRIA '98 [Proceedings of The Third Conference on Computer Aided Architectural Design Research in Asia, Osaka (Japan) 22-24 April 1998, pp. 291-298
- [28] Johnson, Brian and Kolarevic, Branko (1999) EVAL: A Web-based Design Review System, Media and Design Process ACADIA '99, Salt Lake City 29-31 October 1999, pp. 30-39
- [29] Winter, S.J. and Taylor S.L. (1996) The role of IT in the transformation of works:A comparison of post-industrial, Industrial and proto-industrial Organisation, Information Systems Research, Vol. 7, No. 1.
- [30] Kolarevic, Branko and Ng, Edward (1999) Net enabled Collective Design Authorship, Media and Design Process, ACADIA '99 Salt Lake City 29-31 October 1999, pp. 302-315
- [31] http://fataldimensions.nl.eu.org/
- [32] Anders, Peter (1999) Extensions: Some Implications of Cyberspace for the Practice of Architecture, ACADIA '99 Salt Lake City 29-31 October 1999, pp. 276-289
- [33] Kalay, Yehuda E. (1999) The Future of CAAD: From Computer-aided Design to Computer-aided Collaboration, Proceedings of the Eighth International Conference on ComputerAided Architectural Design Futures, Atlanta, 7-8 June 1999, pp.14-30
- [34] Vásquez de Velasco, Guillermo and Hutchison, David (1999) Virtual Reality Meets Telematics: Design and Development of the InfinityRoom, Architectural Computing from Turing to 2000 [eCAADe Conference Proceedings / ISBN 0-9523687-5-7] Liverpool (UK) 15-17 September 1999, pp. 466-472
- [35] http://www.activeworlds.com/edu
- [36] http://www.blaxxun.com/
- [37] www.holodesk.com
- [38] Brown, A.G.P., Gavin, L., Berridge, P. Achten, H. and Knight, M. (2000) Virtual eCAADe Galleries and Meeting places, Proc. eCAADe 17 Conf, Weimar, Germany, June 2000, pp 157-164
- [39] Slater, M., A. Sadagic; M. Usoh; R. *Schroeder Small-Group Behavior in a Virtual and Real Environment: A Comparative Study*, Presence: Teleoperators & Virtual Environments, Volume: 9 Number: 1, pp. 37 – 51, 2000, MIT Press

Game Three: References

- [40] Darken, R.P., Allard, T. and Achille, L.B., 1998, "Spatial Orientation and Wayfinding in Large Scale Virtual Spaces", *Presence: Teleoperators and Virtual Environments*, 7(2), p. 101-107.

- [41] Maher, M.L., Simoff, S., Gu, N. and Lau, K.H.. 2000, "Designing Virtual Architecture", in: Tan, Tan and Wong (eds.) *CAADRIA 2000, Singapore May 2000,* pp 480-490
- [42] Shaw, J. "Keeping fit (Mind and Body)", in: *Proc. @ HOME Conference: Doors to Perception 2, Amsterdam, Netherlands,* Netherlands Design Institute, Nov.1994
- [43] Davies C.**,** 1996 *The Paradox of Being in Immersive Virtual Space*, SIGGRAPH 96, Soul in the Machine; The Search for Spirituality in Cyberspace.
- [44] Davies C., 1998 *Changing Space, Virtual Reality as an Arena for Embodied being* in The Virtual dimension, Architecture, Representation and Crash Culture ed Beckmann, J.
- [45] Regenbrecht, H., Kruijff, E., Seichter, H. and Beetz, J. 2000, "VRAM: a virtual reality aided modeller", in: Donath (ed.) *eCAADe 2000: Promise and RealityWeimar, Germany, June 2000,* pp 235-238
- [46] Carpenter, P.A. and Just, M.A. 1986 1992, "Spatial Ability: An information processing approach to Psychometrics", *Advances in the Psychology of Human Intelligence,,* Vol.3, Hillabdale, NJ.
- [47] Bridges, A.and Charitos, D, 1997 "The Architectural Design of Virtual Environments", *CAAD Futures 1997 München, Germany*, Kluwer Academic Publishers, pp. 719-732
- [48] Loomis, J.M., Da Silva, J.A. Fujita, N. and Fukusima, S.S. 1992, "Visual Space Perception and Visually Directed Action", *Journal of Experimental Psychology: Human Perception and Performance,* 18(4), pp. 906-921.
- [49] Knight, M and Brown, A.G.P., "Working in Virtual Environments through appropriate Physical Interfaces", in: Brown, Knight and Berridge (eds.) *eCAADe 17: From Turing to 2000, University of Liverpool, UK,* Sept. 1999, pp 431-436

Endnote: Some of the work described in Game 2 was undertaken in collaboration with the following partners:

- Mike Knight, School of Achitecture and Building Engineering, The University of Liverpool, UK
- Lesley Gavin, School of Graduate Studies, The Bartlett, University College, London, UK
- Henri Achten, Technical University of Eindhoven, Netherlands.