Reflections on the use of Project Wonderland as a mixed-reality environment for teaching and learning

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Abstract:

This paper reflects on the lessons learnt from MiRTLE—a collaborative research project to create a 'mixed reality teaching and learning environment' that enables teachers and students participating in real-time mixed and online classes to interact with avatar representations of each other. The key hypothesis of the project is that avatar representations of teachers and students can help create a sense of shared presence, engendering a greater sense of community and improving student engagement in online lessons. This paper explores the technology that underpins such environments by presenting work on the use of a massively multi-user game server, based on Sun's Project Darkstar and Project Wonderland tools, to create a shared teaching environment, illustrating the process by describing the creation of a virtual classroom. It is planned that the MiRTLE platform will be used in several trial applications – which are described in the paper.

These example applications are then used to explore some of the research issues arising from the use of virtual environments within an education environment. The research discussion initially focuses on the plans to assess this within the MiRTLE project. This includes some of the issues of designing virtual environments for teaching and learning, and how supporting pedagogical and social theories can inform this process.

Introduction – the rationale for using virtual learning environments

There is a great deal of interest in applying immersive virtual environments to teaching and learning. Much of this has been caused by the success of commercial platforms such as the World of Warcraft[1] for online gaming, and Second Life®[2] for online social networking and e-commerce. These environments have a high level of realism and associated levels of engagement as well as supporting and encouraging social interaction. A key question is whether these positive outcomes can be generalised and applied to the education community, and whether institutions can adopt these environments and provide them as part of their online ICT infrastructure.

Students at the University of Essex (for example) have the benefit of being able to use a world class ICT infrastructure that supports learning across a wide range of curricula designed for full time and part time, home and international students, engaging in programmes delivered at Foundation Degree through to Doctoral level. The ICT infrastructure at the university provides a wide range of e-learning packages and tools available for use by students and staff. These resources include the facility for submitting digital copies of assignments via the internet, a course materials repository, the use of the Moodle virtual learning environment, online assessment using Questionmark Perception, a locally developed web based facility (Mylife) that supports social networking and the development of digital portfolios, and access to the TurnitinUK plagiarism detection service.

1 http://www.worldofwarcraft.com/
2 http://secondlife.com/

Although uptake of these services is generally high within the University, there are several challenges with respect to integrating existing learning technologies as learning become less institutionally based. Work based learning, in particular, has a number of challenges. For example, it is often associated with a physical separation of the learners from the teachers, that has traditionally been addressed either by ‘bussing’ students to the teachers, or teachers to the students or some combination of the two. In all cases there is additional expense of travel and often the duplication of equipment, as well as consequences for the environment. However, the traditional approach has the advantage of face-to-face interactions, and generally provides a more socially cohesive learning community. Universities also have the added complexity of delivering teaching and learning at more than one site. This separation has implications for teachers as well as learners. The teachers, for example, run the risk of becoming socially and pedagogically isolated from each other. In terms of learners, many of the students are undertaking courses whilst still at work. For example, Foundation degree students may have a curriculum that is delivered mainly through lectures and reflective activities captured in a portfolio. In contrast Continuous Professional Development courses (CPD) demand work place supervision and reflective activities. Learners also require access to the full range of learning resources available to their campus-based peers. These resources include, for example, courseware (lectures, reading lists etc); learning resources (ICT facilities, reading materials), as well as access to tutors and other learners.

Immersive virtual environments have the potential to seamlessly integrate classroom and online participants in a shared learning experience regardless of their location in the real world. It is also possible to bring together the physical and virtual worlds such that the lecturer in the physical world can deliver the classroom session in the normal way whilst having the ability to communicate verbally, in real time, to remote students who may be represented by avatars on a screen at the back of the room. The remaining part of this paper describes some of the lessons learnt from the development of a virtual learning environment (MiRTLE) based on Sun’s Project Wonderland platform. It also considers some of the issues concerned with the choice of the virtual world platform, the deployment issues within an institutional infrastructure, and the evaluation of these new services.

Project Wonderland

Sun’s Project Darkstar[3] is a computational infrastructure to support online gaming [Burns, 2007]. Project Wonderland[4] is an open-source project offering a client server architecture and set of technologies to support the development of virtual and mixed reality environments. A noteworthy example of this is Sun’s MPK20 application; a virtual building designed for online real-time meetings between geographically distributed Sun employees[5] which is illustrated in figure 1.

Figure 1 Sun’s MPK20 Environment

3 http://www.projectdarkstar.com
4 https://wonderland.dev.java.net
5 http://research.sun.com/projects/mc/mpk20.html

In more detail, Project Wonderland is based on several technologies including Project Looking Glass to generate a scene and jVoiceBridge[6] for adding spatially realistic immersive audio. The graphical content that creates the visible world as well as the screen buffers controlling the scene currently use Java3D. Additional objects/components to Wonderland (such as a camera device to record audio and video seen from a client), make use of other technologies such as the Java Media Framework[7]. Graphical content can be added to a Wonderland world by creating objects using a graphics package such as Blender or Maya. Project Wonderland provides a rich set of objects for creating environments, such as building structures (e.g. walls) and furniture (e.g. desks) as well as supporting shared software applications, such as word processors, web browsers and document presentation tools. Thus, for example, a virtual whiteboard can be drawn on by one or several users, PDF documents can be viewed and presentations can be edited. A user is represented as an avatar augmented with the user's login name (eventually it is intended that avatars would have an appearance similar to that of its user). A user can speak through their avatar to others in the world via the voice-bridge and a microphone and speaker, or use a dedicated chat window for text-based messages. The scene generated by Wonderland can be viewed from first-person or several third-person perspectives.

MiRTLE

The objective of the MiRTLE project (Mixed Reality Teaching & Learning Environment) is to provide a mixed reality environment for a combination of local and remote students in a traditional instructive higher education setting. The environment will augment existing teaching practice with the ability to foster a sense of community amongst remote students, and between remote and co-located locations. The mixed reality environment links the physical and virtual worlds. Our longer term vision is to create an entire mixed-reality campus but so far we have developed the first component in this process: a mixed-reality classroom. In the physical classroom the lecturer will be able to deliver the lecture in their existing manner but they will have the addition of a large display screen mounted at the back of the room that shows avatars of the remote students who are logged into the virtual counterpart of the classroom (see figure 2). Thus the lecturer will be able to see and interact with a mix of students who are present in the real world or the virtual world whilst delivering the lecture. Audio communication between the lecturer and the remote students logged in to the virtual world is made possible via the voice bridge mentioned earlier. An additional item of equipment located in the physical world is a camera placed on the rear wall of the room to provide a live audio and video stream of the lecture to the virtual world.

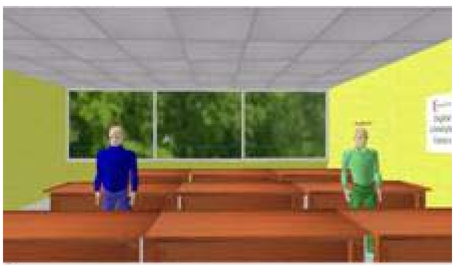

Figure 2 Lecturer view of remotely located students

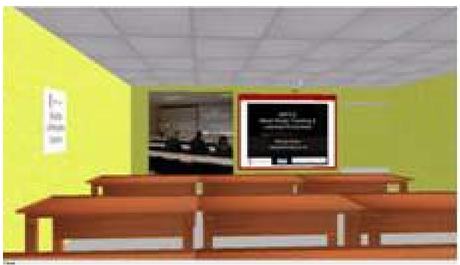

Figure 3 Student View of Lecture

6 https://jvoicebridge.dev.java.net
7 http://java.sun.com/javase/technologies/desktop/media/jmf/index.jsp

From the remote students' perspective, they log into the MiRTLE virtual world and enter the classroom where the lecture is taking place (see figure 3). Here they see a live video of the lecture as well as any slides that are being presented, or an application that the lecturer is using. Spatial audio is employed to enhance their experience such that it is closer to the real world. They have the opportunity to ask questions just as they would in the physical world via audio communication. Additionally a messaging window is provided that allows written questions or discussion to take place.

A means by which a student can feedback their emotional state to the lecturer is also being investigated [Shen, 2007] [Kalkanis, 2008] [Shen, 2008] together with the use of Sun's Small Programmable Object Technology[8](SPOT) as a means of interfacing between physical and virtual worlds. The MiRTLE world has been developed using open source tools. Blender has been used to create the objects that populate the world. These objects are then exported to the X3D open standards file format for use in the world. The platform employs a client-server architecture and to aid ease of use and to ensure that users receive the current version of the client Java Web Start Technology[9] has been employed.

MiRTLE deployment issues

Figure 4 illustrates the deployment of MiRTLE within a basic institutional infrastructure.

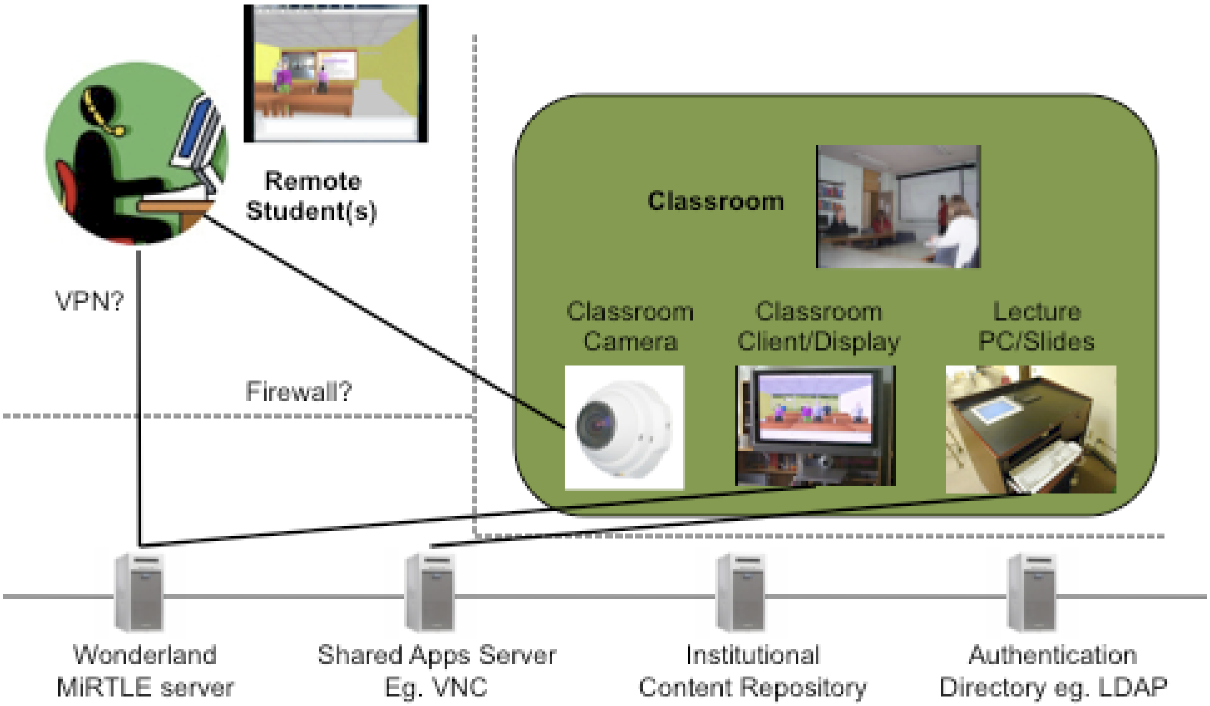

Figure 4 MiRTLE installation

The key component of MiRTLE is the Wonderland server itself which together with the Voice bridge hosts the virtual world, provides the spatial audio and manages the interaction with client machines. A special version of the client called the *Server Master Client* is used to launch shared applications in-world so that all clients may interact with them. This is used to share Open Office applications such as a spreadsheet and also Firefox. Additionally the use

8 http://www.sunspotworld.com
9 http://java.sun.com/products/javawebstart

of VNC (Virtual Network Computing) server allows the sharing of any application running on it (such as a Microsoft Windows desktop) from within the MiRTLE world. This VNC server is particularly important, as it is used by the real-time class, to host the display of the lecturer's presentation, which is then synchronised with the main display in the real lecture room and the in-world display to the online students. This will ensure that the students in the real classroom see the same slides as the students in the virtual classroom. From the lecturer's point of view this should be no different to their normal routine of using the class audio/visual podium to control their slides.

This is however, just the minimal set of components required to host MiRTLE. Most institutions will also make use of content repositories and learning management systems (such as Moodle) to manage their content and lecture materials. Also they will have an authentication system to control access to university resources, which will often make use of a user directory (such as LDAP) and an authentication system. Therefore a complete system implementation requires several key components to be integrated.

Further complications may arise depending on the intended use of MiRTLE. For example, if MiRTLE is only intended for internal use within a university, it is likely that most of the system components will reside behind the university's firewall. However, given that the goal of MiRTLE is to support remote students, a VPN (Virtual Private Network) may be necessary to allow remote users (e.g. students at home) to log into MiRTLE and make use of these university resources. Alternatively it is possible to consider a hybrid solution where certain components (such as the main MiRTLE server, classroom camera, etc.) are publicly accessible, and other components (such as the institutional content repository) remain behind the university's firewall. This is further complicated when more advanced scenarios are considered, such as having multiple MiRTLE teaching rooms located in different institutions, and with remote students also participating from different locations. This will then require the use of a federated access management system (such as Shibboleth) to control and manage access to all of the shared system resources within a given federation.

Virtual world platforms – key factors in choosing your platform

The development of the Wonderland platform by Sun Microsystems was originally conceived as a tool to support collaborative working by Sun employees. As such it had a number of clear design goals, which were:

- Focus on social interaction, formal and informal
- Emotionally salient
- Strong sense of social presence, allowing for discussion of sensitive topics
- Spontaneous, unplanned interactions, particularly socializing before and after planned events to build trust
- Enhance communication during formal interactions
- Design for collaboration
- Seamless document sharing with no need to switch contexts
- Extreme extensibility
- Allow developers to add any sort of new behaviour

As such the key strengths of Wonderland can be characterised as:

- Live application sharing
- Integration with business data
- Internal or external deployment
- Darkstar scalability
- Very large to very small
- Open and extensible
- 100% Java
- Open source, open art path
- Audio (spatial) as a core feature
- Extensive telephony integration

Wonderland is therefore a very different beast to the commonly used Second Life platform. The Wonderland platform is primarily intended to be tailored and integrated by organisations within their own infrastructures. Whereas Second Life is a publicly accessible online service with very large numbers of users who can make use of a virtual economy to organise their lives. However, Second Life has already been used extensively by teaching institutions to carry out online teaching (for example see [Robbins, 2007]). There is no doubt that Second Life has been used very successfully to support online teaching and learning. However, it does have several issues around its use, particularly concerned with the privacy and security for participants taking part in online sessions, and whether there are sufficient controls in place for organisations to use it as part of their formal teaching infrastructure.

At its core, Second Life is a commercial operation which has its own set of imperatives. However, it does service a very large community[10], and particularly has key strengths in a number of areas, such as the ability to add behaviours to worlds using a rich scripting language (Linden Scripting Language) and the relative ease of creating 3D objects and adding them to the world.

As an alternative to Second Life, there is the open source OpenSimulator[11] platform which can be used to “create a Second Life like environment, able to run in a standalone mode or connected to other OpenSimulator instances through built in grid technology”. The providers also claim that “it can also easily be extended to produce more specialized 3D interactive applications”.

This is in effect a Second Life compatible server (Second Life has already open sourced their client), which can be installed and modified as needed by organisations. The OpenSimulator Grid capability is particularly interesting as it allows different worlds to be linked and promises to provide an easy mechanism for users to move between different worlds. However, it is not as platform-agnostic as Wonderland as it relies on the Mono and .Net software frameworks.

10 comScore reported nearly 1.3 million people logged in during March 2007
11 http://opensimulator.org

Privacy issues and control of virtual environments

A key concern for the use of online services like Second Life is the potential lack of control of the online space, and the privacy of participants taking part. As after all this is an open access commercial platform. This issue is particularly addressed by the Wonderland platform, which aims to solve the problem through the use of its open client-server architecture, which can be fully integrated with whatever access and control mechanisms are required.

This increasing need to protect data and resources available within virtual worlds is considered by Timothy Wright from the University of Notre Dame in the WonderDAC project [Wright, 2008]. In this project, access in virtual worlds is broadly classified into the following 3 types:

- spatial access (i.e., who can move their avatar where)
- media access (who can view which images or hear what sounds)
- object use/mutability (who can use and change which VR objects)

Most commercial online systems only consider rudimentary spatial access control and ignore more detailed control requirements. WonderDAC (Wonderland with discretionary access control) has developed a simple prototype, to add basic discretionary access controls to the Project Wonderland platform. Further plans are in place to evolve WonderDAC along several lines: spatial object access, non-spatial object access, audio chat access, avatar cloaking, and access to WonderDAC information through a user interface. This is illustrated in figure 5, where the avatar *twright* is able to see more content than the avatar bench-40 based on the access control settings.

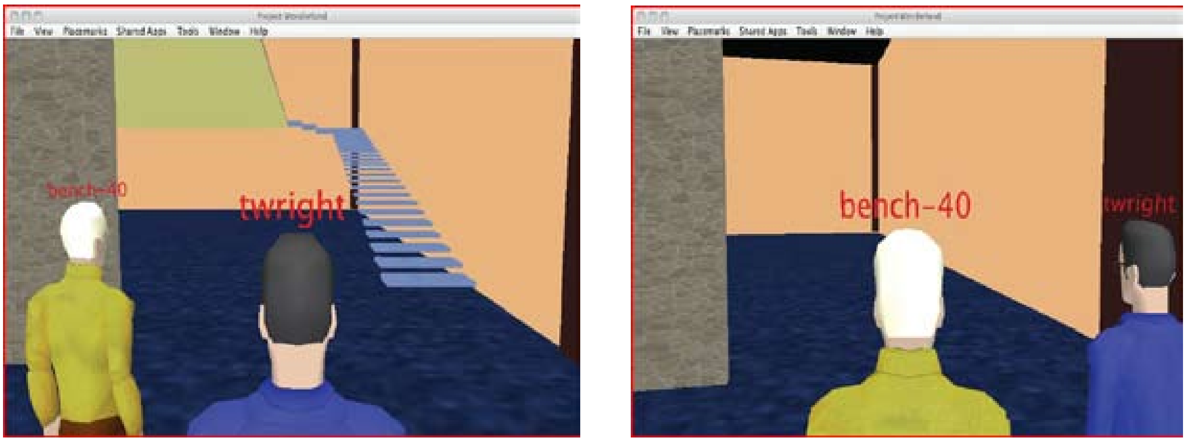

Figure 5 Discretionary access control in WonderDAC

Evaluation of MiRTLE

We are currently planning to deploy and test MiRTLE in several settings. The main evaluation of MiRTLE will in conjunction with the Network Education College of Shanghai Jiao Tong University (SJTU), which currently delivers fully interactive lectures to PCs, laptops, PDAs, IPTV and mobile phones. The core of the platform includes a number of “smart classrooms” distributed around Shanghai, the Yangtze River delta, and even in remote western regions of China such as Tibet, Yan’an, Xing Jiang and Nin Xia.

The MiRTLE simulation will be developed to closely model the SJTU smart classroom. Sun Microsystems are providing a Darkstar server for the project, which is located at the University of Essex and will host a MiRTLE server. A server will offer a forward-looking camera view of the smart-classroom (i.e. from the students' position, towards the teacher), together with a number of simulated instances of the smart-classroom (each instance being a particular student's environment and view). The Darkstar server will be interfaced to the existing smart classroom servers and processors, enabling Darkstar-based students to access the full range of educational media available in the smart-classroom. To access the system, students will need to use the Internet (broadband or GPRS) to log into the Sun Darkstar server in Shanghai which will create an avatar representation of them (which they will have previously selected as part of customising their account). We are planning to use this customisation as one of the vehicles to explore the effects of cultural diversity by providing a rich set of operational modes, which will reflect social preferences. For example, students will be able to create environments in which they are isolated or highly social avatars. Likewise the amount of personalised information available to other online students will be under their control, as will some of the options for interaction with lecturers and other students.

We are also planning a number of other evaluation trials, including using MiRTLE to link the various campuses of the University of Essex, and also to provide English as a Foreign Language courses from Essex to Shanghai. MiRTLE is also part of the Education Grid, which is provided free of charge to the general public and members of the Sun Immersion Special Interest Group (ISIG)[12]. The plan is that members of ISIG can conduct classes and meetings within Wonderland virtual worlds on the Education Grid. ISIG members can also use the Education Grid to build custom Wonderland virtual learning worlds, simulations, and learning games.

With the increasing global outreach of online education, designing online learning that can be engaging to a global audience is critical to its success. Recent studies have found that students learn better when they are socially, cognitively, and emotively immersed in the learning process [Wang, 2006]. Social presence is about presenting oneself as a "real person" in a virtual learning environment. Cognitive presence is about sharing information and resources, and constructing new knowledge. Emotive presence is about learners' expressions about their feelings of self, the community, the learning atmosphere, and the learning process. Learners' cultural attributes can affect how they perceive an online learning setting and how they present themselves online, cognitively, socially, and emotively [also see Wang 2004 and 2007]. A key objective of our approach is to counter the isolation of remote network-based learners, engendering a sense of community and social presence which can improve student engagement and the overall learning experience. At the heart of our vision is the hypothesis that a mixed reality version of the smart-classroom, with avatar representations of teachers and students, will help the social environment that has been shown by Wang can help to improve student engagement in online lessons.

The wider pedagogical implications for the use of virtual environments

We have reported before (see [Gardner, 2003] and [Mayes, 1995]) on the need to consider pedagogical principles in the design of new e-learning services. Much of our previous work has been based on adapting the Mayes conceptual framework as a tool to aid in the design and

12 http://sun-isig.org/

evaluation of e-learning services. We particularly needed conceptual frameworks that bridged the theory and design. Mayes offered such a framework. This framework described three broad modes of learning and then mapped these onto appropriate design principles. The modes or stages of learning were:

Conceptualisation	The coming into contact with other people's concepts
Construction	The building and testing of one's knowledge through the performance of meaningful tasks.
Dialogue	The debate and discussion that results in the creation of new concepts.

It is important to note that 'conceptualisation' is about other people's concepts, 'construction' is about building knowledge from combining your own and other people's concepts into something meaningful. 'Dialogue' refers back to creation of new concepts (rather than knowledge) that then triggers another cycle of the re-conceptualisation process.

Much of this previous work was based on the use of so-called Web 1.0 technologies, and mapping these to appropriate stages of the Mayes conceptual framework. We now need to consider how this can be extended for the new generation of Web 2.0 and particularly immersive virtual environments. [Fowler, 1999] considered this in terms of social networking theories and particularly explored the notion of different types of learning relationships. However, in terms of virtual environments we now need to consider how guidance can be provided to fully exploit the characteristics of these environments. We need to go beyond just purely emulating current practise (which in effect is what MiRTLE is doing in terms of using a virtual environment to support online lectures), to exploring new innovative ways of exploiting this technology, which exploit the key affordances of VR.

Once characteristic of virtual environments which seems to offer the most opportunity for innovation is that of '*immersion'*. In that it is possible to immerse students in different ways according to their educational need. This can then be mapped back to the Mayes framework and is illustrated in figure 6.

In this figure, we have identified characteristics of immersion which are relevant to each of the three stages of the Mayes framework. So for the conceptualization stage, the main emphasis should be on the psychological immersion of the student in the abstract space of the learning domain. This could be achieved by graphically representing the key concepts and relationships of the subject matter, and allowing the student to explore these concepts within the 3D space. For the construction stage, the main emphasis should be on the physical immersion of the student within the context of the learning domain. Here we might consider simulating a particular problem-based learning scenario, and allowing the student to experiment with the course of their actions, through this scenario. Finally for the dialogue stage, the main emphasis should be on the social immersion of the student with a given social network. Here we might consider how the virtual world could facilitate social interaction and collaboration around different domains.

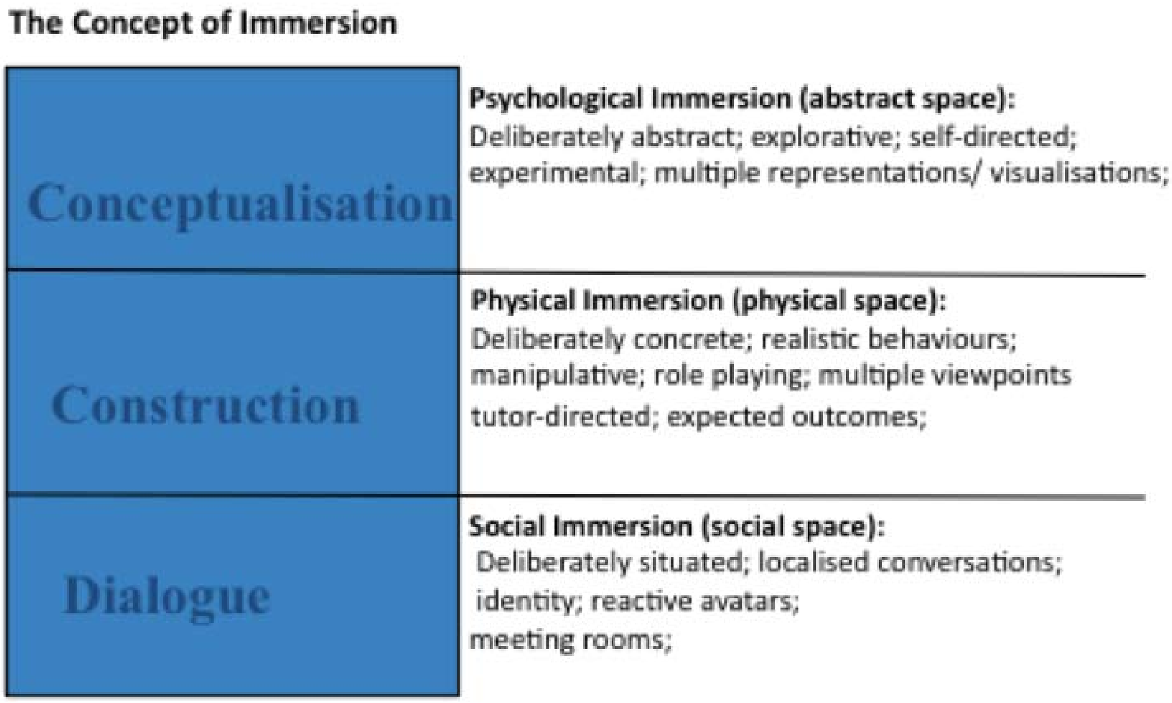

Figure 6 Mayes and virtual reality

There is still some way to go in fully developing these ideas. However, if we are to truly offer new and innovative teaching and learning within virtual reality then it is vital that the development of these systems is grounded within an appreciation of the pedagogy and proper design guidelines.

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John has been involved in the Research and Development of Education and Training software and systems for the past 13 years. His recent projects include:- the JISC Desk Top Study[13] that aimed to improve effective practice by increasing understanding of the models, tools and methods that inform the good design and evaluation of current and future e-learning activities; the DELTA[14] system that enabled the tagging and sharing of learning resources by using both pedagogical and subject ontologies; the East of England Educational Resource Network[15] and the eProfile[16] social networking system. His current role is the development and deployment of MiRTLE.

13 http://www.essex.ac.uk/chimera/projects/JISC/index.html
14 http://www.essex.ac.uk/chimera/projects/DELTA2/index.html
15 http://www.essex.ac.uk/chimera/projects/EERN-DELTApilot.html
16 http://www.essex.ac.uk/chimera/projects/eProfile.html

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