The future of virtual worlds

Mark Childs

Abstract
The effectiveness of the experience of learning in virtual worlds is particularly dependent on the nature of the technology. This chapter reviews the previous chapters with respect to what they reveal this close inter-relationship and how the pedagogies they describe are supported and limited by the functionality of virtual worlds. The chapter also reflects on earlier predictions about virtual worlds, and identifies some of the current technological trends that will influence the future of virtual worlds, and hence the future of experiential learning in virtual worlds. Finally, the chapter attempts to create its own prediction of a virtual world learning scenario that synthesises the various elements of the technologies in evidence today.

Key Words: Virtual worlds, futurology, augmented reality, mobile technology

1. The Role of Technology in Experiential Learning
Experience mediated via technology always comprises two aspects, those of immediacy and hypermediacy. Immediacy is the direct experience of the online activity that is taking place via the technology (for example, videoconferencing, gaming or experiencing a virtual world). Technology constantly aims towards providing more complete immediacy; the sensation that we are so completely absorbed by the activity, or the technology is so transparent, or we are so accustomed to the technology that we are not conscious of the experience being mediated by technology, is held to be the best condition for communication and participation. Dobson, however, notes that “total immediacy is never possible because a trace of the media remains” and it is this perception of the technology intruding onto the consciousness when engaging with a technology-mediated activity that he labels “hypermediacy”. The unavoidable reality that the technology will always have an impact on our experiences, sometimes to a great extent, means that, in any discussion of the quality of experiential learning, a consideration of the technology underpinning those experiences plays some part. A discussion of the future of learning in virtual worlds therefore has to start with a consideration of the potential technology. As a conclusion therefore, for this collection of chapters on Experiential Learning in Virtual Worlds we will report on current and suggested developments in the technology of virtual worlds, and suggest what impact this may have on learning. Before that, however, the current state of the interrelationship between
technology and learning is reviewed, as exemplified by the research presented in the previous chapters of this book.

2. The Current State of Technology and Learning in Virtual Worlds

The technology of virtual worlds influences the work of many of the contributors to this book in the potential it provides for two elements in particular; the creation and performance of the learners’ avatars and the ease (or difficulty) and range of communication features. The courtship that Paul Jerry describes in chapter seven, and the expressions of ethnicity as described by Dean Gui in chapter 10, are only possible because the design of the platform gives people the level of functionality to support those activities, and to do so in a sufficiently immersive way. The depth and complexity of the interactions that support the leadership qualities investigated by Melissa Johnson Farrar (chapter five) are only possible because of the range and immersive nature of the communication functions that virtual worlds (in this case World of Warcraft) possess. However, it is not just the range of functionality that is crucial, but also the reliability and ease of use of the technology plays its part in the user experience. Many of the issues that Mark Childs and Anna Peachey describe in chapter two are exacerbated by failings in the technology, leading to a situation where the hypermediacy elements overwhelm the immediacy elements for many students.

The technological basis of learning is paid particular attention to in three chapters within the book. One of these is that by Sue Gregory (chapter six). In this chapter, the use of the System-Linked Object-Oriented Learning Environment, or SLOODLE, within Second Life is examined. Learning Management Systems are an integral part of learning within most higher education institutions; combining the most popular of these, Moodle, with the most popular of virtual worlds, Second Life, therefore has the potential to combine the most powerful elements of both as teaching and learning tools. Virtual worlds bring the benefit of enabling students to feel immersed and to communicate with each other at a distance as embodied actors synchronously. LMSes enable resources to be shared and learning materials to be stored and displayed. They are also effective at supporting asynchronous communication. A facility to blend the two, and move almost seamlessly from one to the other would prove to be the best of both if not for one barrier that Gregory draws attention to. This is the development required to be effective at using both. Gregory and her colleagues employ a third technology, that of machinima, in order to address this.

In chapter eight, Tomas Bouda outlines the range of activities with which virtual worlds can be employed to support learning, and each of these activities correspond to, or rely upon, a different feature of the technology of virtual worlds, including avatar design and animation, three-dimensional movement, camera control, group and one-to-one messaging, creation and co-creation of objects and a single interface to merge of all of these different functionalities. The implication of
Bouda’s chapter is also that the link between virtual world design and learning is intricate and mutually dependent, learning cannot exist without the necessary features, and virtual world developers have to consider all the user requirements if the platform is to be used effectively. In chapter four, by Spyros Vosinakis, Panayiotis Koutsabasis, Panagiotis Zaharias and Marios Belk, the authors look specifically at the degree to which the functionality of OpenSim and the requirements of problem-based learning correspond. Their conclusions are that virtual worlds are an ideal platform for supporting constructivist learning as they enable 1) a sense of presence within the world 2) direct manipulation and persistence 3) embodiment as avatars 4) expression and communication via metaphors and 5) real-time simulation and 3-D interaction. The implication of the work by Vosinakis et al is that pedagogy and technology are inextricably linked; for them both to work effectively the alignment between the two must be very close.

The close link between pedagogy and technology displayed by this research is a clear indication of the high degree to which the future of learning in virtual worlds will be dependent on the way in which the virtual worlds themselves evolve. In the following sections, this evolution will be considered, as well as the impact this will have on education. As an indication of how speculative predictions can be, and the difficulties entailed in anticipating how technology will evolve, the following section looks at previous predictions about virtual worlds, and how to some extent, how these predictions about the future helped define our present.

3. The History of the Future of Virtual Worlds

Predicting the future of virtual world technology has an uneven track record. In *Snow Crash*², Neal Stephenson postulated a world in which people connected to a shared virtual reality called the “metaverse” and adopted avatars in order to interact with each other. The technology resembles the virtual worlds of the early part of the 21st century, but the true quality of the prediction in the novel is in its anticipation of how social conventions evolve within the virtual world. Status within this world is not based on status within the physical world, or wealth, but on the person’s dedication to mastering the techniques of the metaverse, chiefly the design of the avatar. Stephenson also predicted the role that bots would play in these environments (here called “daemons”) and the types of environment (public spaces, nightclubs such as The Black Sun and so on). The avatars rezz in private within the world, then go out to communicate and socialise in these night clubs, but do not do so randomly in the street. The highest sophistication for users is considered to be achieving a degree of realism that matches the physical. Stephenson also predicts the social division of landowner and homeless person that are observed in Second Life.

The people are pieces of software called avatars. They are the audiovisual bodies that people use to communicate with each other in the Metaverse. ... They could strike up a conversation ... But
they probably won’t talk to each other any more than they would do in Reality.³

Your avatar can look any way you want it to, up to the limitations of your equipment... You can look like a gorilla or a dragon or a talking penis in the Metaverse. Spend five minutes walking down the Street and you will see all of these.... Most hacker types don’t go in for garish avatars, because they know it takes a lot more sophistication to render a realistic human face than a talking penis.⁴

You can’t just materialize anywhere in the Metaverse ..It would break the metaphor. Materializing out of nowhere (or vanishing back into Reality) is considered to be a private function best done in the confines of your own House. ... If you are some peon who does not own a House ... then you materialize in a port.⁵

It doesn’t pay to have a nice avatar on the Street ... But the Black Sun is a much classier piece of software... Only so many people can be here at once.... Everything is solid and opaque and realistic. And the clientele has a lot of class – no talking penises in here. The avatars look like real people. For the most part, so do the daemons.⁶

In his Bridge Trilogy⁷, William Gibson also envisaged a virtual world. In this virtual world, again status is conferred by the avatar one creates, though these are often much more fantastical. Residents of these virtual worlds also create spaces collaboratively, and for some of the characters these have more meaning in their lives than the physical world around them. The people within the virtual world in Gibson’s novels interact not only with each other but with artificial intelligences called idoru.

Novels such as these resemble in many ways the virtual worlds that are currently the focus of the studies represented here. Indeed, the language used to describe them is drawn from Snow Crash and other works of fiction. Reading these 20 years after their creation the degree of prescience displayed is remarkable; the predictions of the uses to which they are put and the impact on the users’ lives ring very true. Where they are most at odds with the present state of virtual worlds is in their description of the technology; the environments in the novels are far more immersive, and from their descriptions seem almost indistinguishable from the physical world.

Alongside technological advances, the rate of adoption of virtual worlds is also very difficult to predict. In 2007, Gartner predicted that by the end of 2011, 80%
of internet users would have a virtual life. Although their list of issues that need to be addressed by users, concerning rules of behaviour rules and impact on reputation, are accurate, the rate of take-up has been far slower. In fact, the number of residents of Second Life (defined by the number of different accounts accessed during the previous three months), currently the leading social virtual world has, of May 2012, fallen from a peak of 1.4 million to approximately 1.0 million.

The following viewpoints about the possible future of virtual worlds are highly speculative, and are unlikely to be as prescient as the quotes from *Snow Crash* above. However, it is hoped that future researchers citing this work will employ judicious editing to, retrospectively, make the predictions seem equally as incredible. In order to maximise the potential for an accurate prediction, several possible directions for the evolution of virtual worlds are considered, each depending on the predominance of a different type of technology being adopted. Five of the currently leading trends in technology have been examined, and their possible impact on experiential learning in virtual worlds has been considered. These five technological trends are the growth of many separate grids, integration with web browsers, incorporation of games consoles, the move to the use of mobile technology and the development of augmented reality.

4. Possible Futures of Education in Virtual Worlds

*The metaverse lives.* Of the chapters in this book, it is interesting to observe the current technologies used as a platform for the activities described. Four chapters use Second Life (Gregory, Childs and Peachey, Jerry and Gui), one uses OpenSim (Vosinakis et al), one World of Warcraft (Farrar), one uses a 2D multimedia website (Le Rossignol) and one began with Second Life and then, due to the price increases imposed by Linden Lab, moved to OpenSim (Bouda). From this (admittedly small) sample, it appears that Second Life is still the strongest contender for a platform to host virtual world activity, but that educators are more becoming more likely to consider alternative, though similar, platforms, with OpenSim leading the way.

Educators’ dissatisfaction with, and the expense of, Second Life is beginning to cause fragmentation of the virtual world community. Whereas before it was almost guaranteed that educators would share a single grid, increasingly they are becoming spread across a range of different platforms. One saving grace of this diaspora is that many of the most popular of these virtual worlds use the same viewer. Whether one uses the Second Life viewer, Imprudence, Phoenix or Firestorm or any of a number of others, once a user has learned to interact with the world using that particular interface, then it is of little difficulty to switch to another one. This is particularly important with virtual world as a technology (more so than, for example, with a word-processing package, or an online forum); since what is required for an effective learning opportunity is immediacy of experience rather than hypermediacy; any changes in the interface are extremely disruptive, since this makes the technology more visible and reduces the transparent nature of the interaction.
However, although they are operated in the same manner, the grids remain separate. The step that will reintegrate this fragmented community, and enable educators to once again easily share and visit their educational resources will be the successful employment of hypergridding. Hypergridding is the connecting of these separate virtual worlds to create a collection of linked worlds, an example of Stephenson’s metaverse. Once it becomes possible to move not only avatars, but also their inventories, from world to world, then these separate grids will perform as a single platform; so, for example, objects purchased from within Second Life (which has a thriving creators’ market) could be employed within OpenSim (which gives institutions greater control over privacy and ownership of the space). This would greatly expand the choices, and the flexibility of using virtual worlds for educators, and to a large extent enable far more effective collaboration. Simple and effective hypergridding is close to deployment, but, as of writing in 2012, has not been realised.

A virtual world in your browser. In her chapter, Sue Gregory refers to Lively, which was a virtual world developed by Google that ran as an application from within a web page (http://www.lively.com/). There are numerous legitimate reasons for using standard web browsers for access. The first of these is that the processing power, particularly of a graphics card, required to run a virtual world viewer is beyond the capacity of the technology available to many people, and particularly of institutions. Secondly, the bureaucratic hurdles many practitioners face when requiring additional software to be downloaded and installed preclude the use of virtual worlds in many institutions, suffering as they do from the obstructive policies of their IT departments. Finally, enabling virtual worlds to be viewable from within a web browser means that the practice of accessing virtual worlds can be easily integrated into the majority of people’s normal internet usage, and so potentially widen the demographic of users. The initial effort required to begin using them in an educational situation would consequently be reduced.

It would be reasonable to anticipate that these factors would lead to the usage of virtual worlds becoming much more widespread. Making virtual worlds viewable through the web should have been very successful, in effect though, Lively only lasted for the second half of 2008. Newer virtual worlds, such as Kitely, although trying to widen the demographic of potential users by offering other platforms such as Facebook and Twitter for access, have returned to the use of the viewer-based technology rather than be browser-based.

The reasons for the failure of Lively are still being discussed. The direct experience of those contributing to this chapter, however, is that reducing the functionality of the virtual world in order to enable it to work within a browser removed the elements that made a virtual world worth pursuing. The sense of immersion was reduced, the opportunities to create and interact with virtual artefacts within the world were lessened, and consequently the rapid adoption by the marketplace, needed for the survival of any social medium, did not materialise.
Lively disappeared before many people realised it had been launched, and new web-based viewers have not emerged to take its place.

Move to games consoles. A move in the other direction, to more sophisticated technologies, is the repositioning of virtual worlds to run on games consoles such as the Playstation 3, or the Xbox 360. Games consoles have very sophisticated graphics processors, and the quality of the rendering of games is much higher than is available using most PCs. Many Massive Multiplayer Online Games are already available on games consoles, and shared virtual worlds such as Minecraft, previously running on PCs have made the transition to this technology. In the Minecraft case this has proved immensely popular. The advantages of running virtual worlds on games consoles is due not to just the more sophisticated graphics available, but also the control devices. Many people find games controllers a more intuitive mechanism to control the movement of an avatar than keys on a keyboard. However, text chat and a drag and drop functionality are less well integrated.

The next generation of games controllers offer even more interactivity as they allow detect physical interaction by the users, through the use of cameras and motion detectors. Devices such as the Xbox 360 Kinect controller have already been used to animate avatars. There are two ways in which this can be done, either avatars can be animated inworld through physical actions triggering pre-set animations, (for example, the act of raising your hand triggers a hand-raising animation) or, as in the work of Fumi Iseki and a team at Tokyo University, the animations are used to animate avatars in realtime, but in a local viewer only. Because avatars are animated inworld using preloaded animation files, there is no way with current technology to map motion capture to inworld movements of avatars in realtime.

This opens up the potential to a new, closer relationship between user and avatar. As Jelena Guga notes, this will be the next step change in the developing degrees of immersion that have been enabled by the changes in technology. Although the sense of immersion may be increased, requiring the user to be physically active may also, simultaneously, make the user more aware of their physical body while interacting inworld, so their sense of embodiment may actually be reduced. As noted in the chapter by Childs and Peachey earlier, the individual experience of virtual worlds varies enormously, and a likely discovery will be that whether physical operation of an avatar increases or reduces the sense of engagement inworld will be different depending on the person. Another consideration is that a one-to-one correspondence between physical action and resulting motion of the avatar is, as Stelarc points out, possibly the least interesting way in which to use motion recognition to animate avatars. In his performances, Stelarc uses his body to create inworld performances, but his gestures cause his avatar to fly, float, operate cyborg attachments and so on.

From a learning point of view, a move to games consoles could have advantages and disadvantages. The move would overcome some of the objections to
virtual worlds with regard to the low resolution graphics, and technical issues such as slow rendering times and lag, however, they could marginalise activity even further, since few computer suites in universities have games consoles, and it cannot be guaranteed that all users will have access to them. Developing motion controlled interfaces would address some of the issues that some users find; that operating within a virtual world is too sedentary an experience. Offering the opportunity to operate avatars through physical motion may appeal to these users, though indications are that these users actually find the virtual nature of these experiences intrinsically problematic, equating the virtual with inauthentic. However, the use of a motion recognition system will have interesting opportunities for performance.

**Gone to mobiles every one.** As noted above, the rate of take-up of virtual worlds anticipated by Gartner in 2007 has not been realised. Some predictions also state that the rate of development of the high end graphics technology required for virtual worlds will be slowed by the adoption of mobile technology. Essid notes that the tablet PCs owned by students cannot run the viewers required for Second Life, and these are now the predominant technology with which students access online learning. In addition, many apps provide innovative and offline education, such as the use of Google Sky, Zenith or Sky Safari for learning astronomy. In these apps, the learner holds up their tablet PC and through global positioning and inbuilt sensors that detect orientation, the tablet displays the position of stars, planets and Messier objects as they appear in the sky in the direction in which the tablet is pointed. This provides learning that is interactive, kinaesthetic, and in situ. Essid’s prediction is that the predominant use of mobile technology as the new wave of learning will stall the uptake of virtual worlds. As Essid states in his blog post on the subject:

> One does not wish to be on the wrong side of history, and I think SL evangelists are clearly on the wrong side, unless they are early in their careers and have a Plan B for research and teaching.

**Augmented reality.** One function of many mobile devices is that they can combine the camera images with an overlay of additional information. In the same way that a global position and orientation can be used to calculate the position of stars as seen from a particular viewpoint, these can also be used to determine at which geographical location the tablet is being pointed. These data can then be combined with a database of information to create an overlay of text to explain, for example, the historical background of a building, or the direction and distance of the nearest Underground station or Irish pub. Locations can be digitally tagged, either with additional information (such as in a learning exercise with students adding their own content to locations), artwork, or even graffiti. As with the astronomy apps described above, this provides learning in situ, and provides a kinaesthetic element to the activity.
The potential of combining geotagged images onto the physical world is indicated by augmented reality games such as *Paranormal Activity: Sanctuary*. In this, images of ghosts are located at particular physical world co-ordinates, which can be seen with a dedicated iPhone app that overlays these images onto a camera image. Players can create sanctuaries, or cast spells, at locations which then influence the experience of other players. The game therefore becomes a massive multiplayer roleplay game played in a blending of the physical and a virtual world.

Greater precision than that enabled by global positioning can be provided through Radio Frequency Identification (RFID) tags, the technology for recognising which will soon be available on mobile technology. By placing an RFID tag in clothing, or furniture, or on a person, information about that object or person (i.e. metadata) are then always available, whenever a device is pointed at them. For example, products could be linked directly to their user manual; simply hold your tablet PC over your oven and pop-up boxes appear over the knobs decoding the icons, or attend a conference and each person there could have information linked to them, such as name, institution and research interests, which is revealed by holding up your phone and tapping their image on the screen. Several museums and exhibitions already have augmented reality exhibits; when a room is looked at through an AR viewer, the physical objects in the room are overlain with animations or animated characters, bringing the static displays to life. A further enhancement of augmented reality is achieved by enabling the animated characters to address the attendee directly, with their gaze following the attendee around the room, as they are tracked through the use of an RFID bracelet. The characters can address many attendees simultaneously since, from the perspective of each, the character is looking at them individually, a transformed social interaction known as non-zero sum mutual gaze. These interactions can be made more seamless by plans to create AR projections within glasses. Rather than clicking on a screen, input can be through the detection of hand movements or, for the mobility-impaired, deliberate blinking.

If this is possible with pre-recorded characters, then it is only a short leap to enabling this to take place with avatars or bots in realtime, by layering the virtual world image onto the physical as it is created. This activity resembles the mixed reality performances created by Joff Chafer and Ian Upton; originally these performances used images from a virtual world projected onto a gauze, so that they could share the stage with physical world actors, and more recently Chafer and Upton have used 3D imaging to bring the virtual world images out from the screen and into a physical space. Capturing the images of avatars in the virtual world, and geotagging them, would enable people with the appropriate AR viewer to see avatars moving and communicating all around them. As the sophistication of bots develop, then the use of them as companion agents, guiding learners through virtual learning scenarios, could be brought into the physical world as guides and mentors seen only by the learner through their AR viewer. With ways of imaging the avatars through
something as immersive as AR glasses, physical world participants and avatars could interact on an equal footing.

For learning and teaching, the advantages of blending the functionality and flexibility of the virtual and the real are enormous. For the learners who see virtual learning as inauthentic, relating the virtual world learning directly to the physical may overcome many of their objections. The integration of an object and its metadata as well as data providing context for that object (called paradata) is easily done in a virtual world; AR in combination with RFID tagging enables this feature to be deployed in the physical world too, since information, ideas and artefacts can be intrinsically and easily linked. User generated content, which again is simply created and shared in the virtual, can also be introduced to the physical. Participation at a distance, on an equivalent footing with participation face-to-face, could be achieved by the appearance of avatars in the physical environment and RFID tagging the physically-present participants and objects.

5. Conclusion: the Best of Both Worlds

Arriving at a single conclusion is difficult, since any of these technologies and, almost inevitably, some unforeseen technology, could have a dominant influence on the future of virtual worlds, and hence on the role of experiential learning in virtual worlds. In the short term, the directions seem reduced to two major considerations; on the one hand, the simplicity and ubiquity of devices, and as diametrically-opposed characteristic, the sophistication and degree of immersiveness of the technology. The use of mobile devices offers the highest degree of accessibility, and the widest possible demographic, but the functionality of these with respect to virtual worlds is limited. Virtual worlds in a browser offer slightly more functionality, but fewer users than mobiles, but still more than use the current range of viewers. These routes may make online interaction more commonplace, and bring it into the classroom with fewer barriers, but the sense of this interaction being a direct emotional, immersive, transforming experience (the theme of this entire book, after all) is limited. Games consoles offer more sophistication, and motion-detection interfaces may make interaction more seamless, but these may place this beyond the scope of many institutions and offer greater barriers to adoption by learners (and, to an even larger extent, educators). Augmented reality offers almost unlimited opportunities for imagination and creativity to bring the best of the physical and the virtual together, but at the moment, the hand-held devices used for these interactions limit that sense of immersion. Longer term, however, a prediction that will almost certainly hold true is that as the mobile devices develop greater and greater processing power, (if Moore’s Law holds true, doubling every 18 months) interaction through them will become ever more seamless. Once AR glasses, or even contact lenses, become commonplace, then we truly will have the blending of the best of both worlds, perhaps to the extent that we no longer see them as two separate worlds.
To serve as a coda to this exploration, and while in no way possessing the prescient power or writing talent of a Stephenson or Gibson, the following scenario is presented as an attempt to predict a teaching scenario 20 years hence in the same manner as Snow Crash anticipated 20 years ago.

As the teacher enters, she notes that some of the physical world students are already here. They’ve sat around the edge of the room that will become the learning space, some on chairs, some on the floor. About half the seats are empty. She puts on her glasses and sees that some of the virtual students have arrived too, and are filling the gaps the other students have left.

Most of the avatar students are almost indistinguishable from physical students, but some have chosen to adopt other forms. She sees the vampire fad has come back again and three avatars and one physical vampire have clustered in a corner. In the teleport corner the Deep One appears. She’s asked it to cut its size to human to fit more easily into the room and she sees it’s done so. It’s the only dress rule she insists on; that and no talking penises.

With the arrival of the last of the students, she blinks twice in succession to call up her TAs. They’ve been personalised to look like the seven dwarfs from the Disney cartoon, and she is still wondering if this would constitute copyright infringement now that the film is public domain. However, she finds the names a useful mnemonic for the separate groups that have been set up so has decided to keep them. Once she sets the students their group tasks she’s planned to spend a bit of extra time with the Dopey group this time round.

She introduces the tasks to the students. It’s to create interactive 3D forms representing various endocrine systems. She is still a bit unsure of some of the students’ names, but a quick gesture with her hand and their nametags appear above their heads. Another flick and she can see which assignments they haven’t completed yet. She sees most of the Sneezy group are lagging behind and two are still on long term sick leave. The teacher revises the previous sessions, making sure she particularly motivates the group who don’t seem fully awake yet, and then sets them to work. The students move into their groups and begin talking to each other, planning out the model they want to create and then building the
objects in the air between them. Each object is invisible to her and the other groups, but she has the access permissions to flip between them.

She walks over to the Bashful group; comprised of two physical and two avatar students. They still aren’t communicating effectively and she plans on a team building exercise first. She interrupts the Bashful TA in the middle of his explanation of the role of adrenaline, and suggests they switch to their virtual classroom. She goes with them. The physical classroom disappears and now is replaced by a virtual representation of a campfire in a forest. She sits the group down around it and passes them a ball and tells them the rules to the game. As she switches to physical mode again she sees the two physical students, the avatars and the bot passing it between them.

Back in the room, most of the groups seem to be progressing well, though the Doc group are nearly finished and may soon need to be set some follow-up activity. She calls up her to-do list in front of her. There may be time to get some marking done....

6. Acknowledgments

Thanks to Jelena Guga and Paul Jerry for reviewing this chapter.

Notes

1 S. Dobson, ‘Remediation’, p.2
2 N. Stephenson, Snow Crash
3 N. Stephenson, Snow Crash, 33
4 N. Stephenson, Snow Crash, 34
5 N. Stephenson, Snow Crash, 34
6 N. Stephenson, Snow Crash, 51
7 W. Gibson, Virtual Light, Idoru, All Tomorrow’s Parties.
11 J. Guga, ‘Redefining Embodiment through Hyperterminality’, Virtual Futures 2.0, University of Warwick, 18th – 19th June, 2011.
12 Stelarc, Keynote, From Black Box to Second Life: Theatre and Performance in Virtual Worlds, University of Hull, Scarborough, May 20th, 2011

Bibliography


