

Serious Virtual Worlds

A scoping study



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1.0: Introduction and Background

The success, and wide reporting, of Second Life has helped to highlight the wider use of immersive worlds for supporting a range of human activities and interactions, presenting a wealth of new opportunities for enriching how we learn, how we work and how we play. In this way, Second Life, in common with other virtual world applications, has opened up the potential for users and learners, teachers and trainers, policy makers and decision makers to collaborate easily in immersive 3D environments. Through their presence as an avatar in the immersive space, the user can readily feel a sense of control within the environments and more easily engage with the experiences as they unfold. The use of virtual environments has been facilitated greatly through the web-based applications that allow us a range of options including sharing documents and files, holding meetings and events, networking and hosting virtual seminars and lectures, running research experiments, providing forums for sharing research findings and meeting international colleagues. These applications also have an even greater potential for integrating different technologies by supporting social software applications, presenting e-learning materials and content and offering users games and narrative-based social interactions.

In previous work it was identified that there were a great range of different virtual world applications (de Freitas, 2006), and in preparing this report, 80 virtual world applications were identified with another 100 planned for 2009. The field is extensive, not just in terms of potential use for education and training but also in terms of actual usage and uptake by users, and Second Life currently has 13 million registered accounts (as of March 2008). This report however is focused upon how the virtual worlds can be better understood and used in the context of education and training. The use of Second Life for supporting seminar activities and lectures and other educational purposes has been documented in a number of recent reports (eg de Freitas, 2006), and Kirriemuir (2008) lists a wide range of examples of Second Life use by UK universities.

This report builds upon this previous work, focusing upon virtual worlds for educational uses, and exploring the 'serious' – as opposed to leisure-based – uses of virtual worlds. One of the problems with this area is that there is a plethora of virtual worlds available and practitioners do not always know which one to use and in which contexts. In order to help practitioners to identify the worlds that are the most relevant for their particular learning context, the report presents an overview of the available virtual worlds, describing in particular the serious virtual worlds that have educational potential or have been used in education and training settings. However, stepping beyond this traditional mode of teacher and learner, the report also aims to foreground how learners themselves are becoming a more central component in the use of immersive worlds, creating learning experiences for themselves and adopting a more exploratory mode of learning.

The aim of the report then is two-fold: to provide a context for learning practitioners and policy makers, aiding with their understanding of virtual worlds and how they can be selected and used in tertiary education; and to highlight how learners, through greater empowerment, may play a different and enriched role in the process of forming collaborative learning experiences and engaging in activities which may support their own learning and meta-reflection.

But how can immersive worlds really enrich learning and empower the learner? Immersive world applications achieve this mainly because they have the potential to support multimodal (using different senses) communications between learners; they set up the potential for problem – or challenge-based learning and offer the learner control through exploratory learning experiences (eg Saunders, 2007). However despite this, much needs to be understood about how to best convert these spaces for learning purposes such as seminars, simulations, modelling, learning activities, networked learning experiences, cybercampuses and streamed lectures (Prasolova-Førland et al., 2006). More methodologies need to be developed for evaluating and validating these learning experiences and modes for validation and assessment need to be adopted nationally and internationally to allow for cross-border module accreditation. While the spaces are excellent for bringing together the use of a range of different media (eg streamed video and audio, email, live chat, social network software and mind mapping software), questions remain as to how best to integrate these media to support the most enriched learning experiences, so more work is needed to identify the key strengths of learning in immersive worlds and guidelines are required to support practitioners and learners.

It is quite significant that there are currently 80 virtual world applications available, with another 100 planned for 2009 [according to Oliver Goh, a specialist in virtual worlds, – see: **Appendix A**, list of experts consulted; and Hendaoui et al., 2008]. Other recent online studies have revealed more than 100 virtual worlds for children and young adults are now live or under development (Virtual Worlds Management, 2008). This explosion of virtual worlds leads to some unique problems with respect to researching the field, in terms of ready access to data, the availability of peer-reviewed literature and reliance upon grey literature. Another complicating factor is that most of the research is reported in online blogs and informal publications, making it difficult to validate key assertions. In addition, many of the definitive studies relating to the different immersive worlds have been undertaken in industrial rather than academic contexts, and as such some of the most valuable studies have not been made publicly available or open to the research community. This points to a related need to review online publication models of peer-reviewing and indicates a requirement to speed up the formal publication timescales to facilitate less of a lag between research and application. Although this situation is changing, with more peer reviewed articles in publication, the issue of validating research findings across a range of emerging sources is still a real challenge. Terminologies are also used quite differently by developers and practitioners; see **Appendix B** for a list of terms used in this report.

The review will attempt to simplify the area somewhat by creating sub-categories for different kinds of virtual worlds, providing illustrations of some key uses of the virtual worlds through case studies. The final section outlines future directions for the area, including participatory approaches to tool use and content creation and the use of mash-ups which allow the integration of different applications. In addressing the two main aims of the report, there is a clear need to identify frameworks and models for supporting learning in immersive worlds (de Freitas, 2006; de Freitas and Neumann, 2008; Dickey, 2005a, 2006). In addition, practitioner and learner practice guides to support innovators using these applications would benefit the whole community. Work on these has in part begun (eg de Freitas, 2006) but more effort is needed particularly when the potential of virtual worlds to significantly change how we learn is apparent. For example, in the recent Metaverse Roadmap Report 2007, the authors envisage a powerful scenario over the next 20 years when:

[virtual worlds] may become primary tools (with video and text secondary) for learning many aspects of history, for acquiring new skills, for job assessment, and for many of our most cost-effective and productive forms of collaboration.
Smart et al., 2007: 7

Moreover, virtual worlds in the future may provide a ‘wrapper’ for sets of educational services including e-portfolios, e-learning materials, assignments and class sessions, course module materials, learning games, tracking and monitoring assignments, communications between tutors and learners and e-assessment. But what are the real benefits of using virtual worlds over other media such as video or websites? Are they really all that engaging and how will they really change how we learn, work and play?

From previous research undertaken (eg de Freitas, 2006), and from the research undertaken for this report, some clear benefits with using virtual worlds in education and training are emerging. For example, virtual worlds provide excellent capabilities for creating effective distance and online learning opportunities through providing unique support for distributed groups (online chat, the use of avatars, document sharing etc.). This benefit has so far been most exploited in business where the tools have been used to support distributed or location-independent working groups or communities (eg see the Active Worlds Educational Universe case study in **section 3**). Virtual worlds in this way facilitate the development of new collaborative models for bringing together subject matter experts and tutors from around the world, and in terms of learning communities are opening up opportunities for learning in international cohorts where students from more than one country or location can learn in mixed reality contexts including classroom and non-classroom based groups (eg see the Project Wonderland case study in **section 3**). Virtual worlds also notably offer real opportunities for training, rehearsing and role playing. This includes the simulation of real world spaces allowing tutors to produce re-enactments of scenarios in a safe environment

(eg see the OLIVE case study in **section 3**). In some cases virtual worlds also allow for simplifying complex processes and abstractions, facilitating learners to comprehend difficult concepts more easily such as scientific theories and natural processes (eg see the Second Life SciLands case study in **section 3**). In addition, virtual worlds provide a single interface to different tools and social software capabilities allowing tutors to 'choreograph' learning opportunities more imaginatively (eg see the Croquet case study in **section 3**; also de Freitas & Neumann, 2008).

In summary, the use of virtual worlds has accelerated exponentially over the last two to three years, and in that brief time users and learners have already been taking control over experiencing virtual worlds within social groups. This control element makes using virtual worlds appealing and as such engages users. The potential for using virtual worlds has already been identified in previous work, and currently there are a growing number of examples of how these are being taken up and used in tertiary education (eg Kirriemuir, 2008). However, there are considerable challenges for the education and training sectors, such as how to select virtual worlds and how best to design activities and experiences for learners. It is necessary therefore that we explore the main benefits from and challenges to using these applications in order to support their most effective use. It is also important that we ready ourselves for the wider spread of learning in immersive worlds and identify and where necessary develop the best methods for use, evaluation, validation and accreditation in our institutions.

Learning through engagement in immersive worlds has been documented in previous work, as noted.

But perhaps counter-intuitively, the emphasis on engagement has evolved from greater empowerment of the learner through learner control (eg over their avatar). While of course this learner control does not automatically lead to exploratory, challenge and problem-based learning experiences, the opportunities for learners to meld and define their learning experiences or pathways, using the virtual mediations within virtual worlds, has the potential to invert the more hierarchical relationships associated with traditional learning, thereby leading to more learner-led approaches based upon activities for example. This implied inversion of the norms of education does of course at its heart offer a direct challenge to our understanding of how we learn. Structure for learning is no longer posited through knowledge acquisition. Instead we have the real capability to offer very practical engagement and social interactions with realistic contexts, to offer conceptual experimentation and to create role plays that facilitate for example different interpretations of historical events and more textured use of information (eg overlay of data and images) to scaffold learning.

2.0: Review of Virtual Worlds

A virtual or immersive world is an interactive environment often although not exclusively in 3D or animated graphics, for example children's virtual worlds often use animations rather than 3D representations, eg Habbo Hotel or Club Penguin. These immersive worlds can be used by many users at the same time. Immersive worlds have also been termed virtual worlds, MMOGs and simulated worlds. A longer discussion about definitions can be found in Learning in Immersive Worlds (de Freitas, 2006), and a list of glossary terms is included in **Appendix B**.

Immersive worlds can be used for a range of different applications, including cultural, business and tourism applications; see **Appendix C**, which offers an analysis of some of the main virtual worlds and their applicability to different sectors. Another useful resource for exploring the different virtual worlds that includes short descriptions is available at Virtual Worlds Review (2008), see **Appendix D**. **Appendix D** also lists other sources which can be used by researchers and practitioners wishing to find out more about virtual worlds.

Use	SL	SLG/ Open Sim	OLIVE	Multi- verse	QWAQ	Google Earth
Governance/ Meetings	High	Medium	Medium	Low	High	No
Planning	Medium	Medium	High	High	Low	High
Investment	High	Low	Medium	Medium	Medium	High
Tourism	High	Low	Medium	Medium	No	High
Community Development	High	Low	Low	Low	No	Medium
Infrastructure Management	High	Medium	Medium	Low	Medium	High
Public Order	Medium	High	High	Medium	No	No
Service Delivery	High	Low	Medium	Medium	Medium	No
Cultural Development	High	Low	Low	Medium	No	No
Historical Interpretation	High	Low	High	Medium	No	Low
Education	Medium	High	Medium	Medium	Low	Low
Health	Medium	Medium	High	Medium	Low	No
Commerce	High	Low	Medium	Medium	No	No
Social Exclusion	High	Low	Medium	Medium	Low	No
Employment	High	High	High	Medium	High	No

Table 1: Assessment of uses of different virtual world applications. Educational uses are highlighted. Table reproduced courtesy of David Burden (Daden Ltd)

Regarding defining characteristics of virtual worlds, the Federation of American Scientists (FAS) has recently published a white paper in the area. The paper provides a useful summary of virtual world attributes, and describes virtual worlds as having the following characteristics:

- Shared space
- Graphic user interface
- Immediacy
- Interactivity
- Persistence

Extending from the FAS list of characteristics, the review of virtual worlds for this report has found that the following general characteristics have recurred with most virtual worlds. The value of identifying these characteristics would be to aid the development of sets of metrics for evaluating and assessing (or benchmarking) different virtual worlds:

- Learner control. Learner/user control and interactivity through the creation of an avatar
- Collaboration. Emphasis upon collaboration and community building
- Persistence. Persistence of the world has led to the capacity for immediacy and synchronous use of the world has appeal
- Requirement for 3D interactions and experiences. While the user interface is often 3D, this is not always the case. Some social worlds, particularly social worlds for children, are animated and 2D, and some mash-up applications of mirror worlds are distinctly non-3D but rely upon a layering of data and data sets
- Inclusion of sharable and user generated digital content. Most of the virtual worlds have included digital interactive content be it games (which are particularly popular) or content generated by users to share with others
- Immersion and interactivity. Immersion and interactivity are the additional characteristics to include in any list of requirements for a serious virtual world – the user must feel immersed in the environment and fully engaged with the activities being undertaken. This is normally achieved through representation of the user and environment in-world

These characteristics are common factors observable in most virtual worlds. When considering selecting from a range of different virtual worlds, these categories may be used to create a set of metrics for comparative evaluation and assessment. They also may provide a checklist for selection and use of virtual worlds. See **Table 2** for an example of how the common factors of virtual worlds can be mapped against questions for consideration when using virtual worlds in practice learning and teaching situations. This question list can be used to help select the most appropriate virtual world, and may help to guide the learning and teaching approaches employed.

It is worth noting that, while some commentators have characterised the use of virtual worlds as the 3D web or Web 3.0, not everyone has supported these terms. While the web might be characterised as an informational media, many regard virtual worlds in different ways, seeing them as centring upon social interactions and identification (like social software), rather than as supporting information exchange. Indeed social software and virtual worlds have much in common and in some cases (eg IMVU¹) are synonymous; demonstrably the two forms are converging and share similar characteristics (eg live chatting). The main aspect dividing the two at the present time is the 3D nature of virtual worlds, and the ability to move around virtual spaces, but, as with the example of IMVU, even this has been eroded. This review illustrates the range of social activities happening in virtual worlds, illustrating how the use of virtual worlds is at its heart about supporting social interactions and interchanges, but also has the capability to enrich how we share, access and analyse information.

One question that is regularly posed relates to why simulations and immersive worlds would be useful for learning, and this is an important question. Why not use videos to illustrate points, or websites to point to informational resources? Why do we need to be in a virtual space at all? There are two main drivers that explain why virtual worlds may become pervasive new learning tools. One driver relates to the wide uptake of virtual worlds among young users². Worth noting here is that the lines between virtual worlds, games and social networking are blurring significantly leading to the assertion that over the next five years the majority of young people under 18 coming into tertiary education will have avatars and be using these kinds of applications daily and therefore have different expectations about how education may be delivered to them. While this may not mean automatically that these tools are useful for learning, it implies that the potential for learning with these tools is significant, and tutors will need to work with the tools to find out the optimum ways that they may be used. This driver may well lead to the need for more integrated approaches to learning support using interactive digital media including virtual worlds and social software.

1 IMVU is an example of the convergence between social software and virtual worlds, and provides 3D chat and avatars centred more upon social interactions. Last accessed on 26 August 2008 at: www.imvu.com

2 Quoted from Virtual Worlds Management report: '100+ Youth-oriented worlds live or developing'. Last accessed on 21 April 2008 at: www.virtualworldsnews.com/2008/04/report-100-yout.html

Attribute	Description	Questions for consideration
Learner control	Learner/user control and interactivity through the creation of an avatar.	Would the learner require engagement? Would interactivity help to engage the learner or learner group?
Collaboration	Emphasis upon collaboration and community building.	Are the learning outcomes facilitated through collaborative rather than independent learning approaches? Are the learning outcomes supported through community building and ongoing support?
Persistence	Persistence of the world has led to the capacity for immediacy and synchronous use of the world has appeal.	Would the group require support beyond the seminar face-to-face contact times? Are the learners distributed across a wide geographical area?
Requirement for 3D interactions and experiences	While the user interface is often 3D, this is not always the case. Some social worlds, particularly social worlds for children, are animated and 2D, and some mash-up applications of mirror worlds are distinctly non-3D but rely upon a layering of data and data sets.	Would the learners learn more effectively in a closer to real situation? Are there scenarios of practice that could be role played in virtual worlds? Would experience-based learning benefit the learner group? Could social software and games be integrated into the experience?
Inclusion of sharable and user generated digital content	Most of the virtual worlds have included digital interactive content, be it games (which are particularly popular) or content generated by users to share with others.	Would the learners benefit from a multimodal approach which would use visual and social software tools? Are the learners engaged and motivated by making their own content and sharing it with others?
Immersion and interactivity	Immersion and interactivity are the additional characteristics to include in any list of requirements for a serious virtual world; the user must feel immersed in the environment and fully engaged in the activities being undertaken. This is normally achieved through the representation of the user and environment in-world.	How immersive does the learning experience need to be to convey the learning outcomes? What level of detail is required? Does the learner perform better with more control over what they are attempting?

Table 2: Considering the attributes of virtual worlds for usage

The other major driver relates to how we learn. Recent work in the gaming area has demonstrated how whole brain activity occurs when learners are playing games as opposed to limited brain activity when learners are learning in formal ways, and this supports constructivist approaches to learning (Kato et al., 2008). In addition, other studies are showing how mirror neurons (premotor neurons) fire both when an animal acts and when an animal observes the action performed by another animal. In this way, the neuron mirrors the behaviour of the animal as though it were doing the action itself. Ramachandran considers this discovery as one of the most important in neuroscience and it may at least in part explain why simulation and imitation with an emphasis upon visual data are such powerful learning tools (Ramachandran, 2006) and have been considered in studies exploring autism (Ramachandran & Oberman, 2006). In this way, the powerful nature of learning from doing and learning with others is maximised in simulation – and game-based learning. We can learn from doing through playing and enacting situations, problems and challenges, and at the same time we can learn socially from watching others and replicating behaviours in those we observe around us³. Learning in these contexts is enriched through

³ Martin Oliver, in his comments on this report, raised the interesting issue of whether observations of others and observations of avatars are synonymous. This opens up potentially interesting research areas comparing behaviours of humans and of avatars.

the activities and interactions that we participate in and construct. Alongside this, we are learning from social interactions. By learning from observations, active participation and concept formation then it is not surprising that game-based and virtual world interactions can leave such an indelible memory. The work around using constructive and social approaches to learning through play may be explained better through understanding how we learn in terms of our mental processes and functions. It is envisaged that this work may lead to some extraordinary conclusions about how we learn, and have implications upon the learning and teaching theories and approaches that we value and use.

By way of an example of this potential, new research has demonstrated how 'lifelike, interactive digital characters, serving as mentors and role playing actors, have been shown to significantly improve learner motivation and retention' (Sims, 2007: 75) while engaging learners in engrossing learning experiences (Veletsianos & Miller, in press). This has the potential for attitudinal outcomes and improved performance. We await more research studies and action research from innovative tutors with virtual world activities to help us to explore the most effective ways of using these worlds to support and engage learners (Veletsianos, 2008a).

Perhaps most strikingly, then, the social and the immersive characteristics of the virtual worlds are reinforcing many informal activities. As a proportion of all the activities in virtual worlds, those that centre upon educational processes and practices are extremely small. Social uses and commercial uses of virtual worlds seem a long way ahead of purely pedagogically driven learning and educational practices. Although the potential of the form for role play centred learning, for e-mentoring, for learning in distributed groups, for portfolio work based in-world, for problem-based learning and for experiential and exploratory learning approaches proffer a move from e-learning to v-learning. This may well improve the quality of learning experiences for many, making learning more engaging and motivating and based upon exploratory models. This may be more consistent with a living Socratic method⁴, predicated rather more upon dialogue than information acquisition. Perhaps rather than being concerned simply with effectiveness and efficiency, contemporary approaches to learning might also embrace engagement, enjoyment and transformation as part of everyday learning experiences (Doering & Veletsianos, in press; Wilson, Parrish & Veletsianos, 2008).

2.1: Historical perspective of virtual worlds

The predecessors to the virtual world were the popular Multi-User Dimensions/Dungeons (MUDs) and Multi-Object Orientated MUDs (MOOs) of the 1980s. These had all the characteristics of the modern virtual worlds but were text-based. These media forms provided the foundations for the development of the modern online communities that today are supported by 3D and animated spaces, providing a backdrop for the day-to-day activities that take place there. The greatest similarities lay in the dialogic dimension of the forms, and the communities that formed in the more text-based worlds were every bit as engaging as the visualised versions, friends were made there and they played games together.

Developing out of these more text-based social communities emerged the first virtual world using graphics and avatars. This was Lucasfilm's Habitat in 1985, and was accessed using a standard Commodore 64 computer. The first graphical virtual world supported a community of online participation for six years. Similar to the text-based social environments, Habitat was:

built on top of an ordinary commercial on-line service...Habitat presents its users with a real-time animated view into an online simulated world in which users can communicate, play games, go on adventures, fall in love, get married, get divorced, start businesses, found religions, wage wars, protest against them, and experiment with self-government.

Morningstar & Farmer, 1993: 273

Habitat also established a marketplace for trading virtual commodities using tokens. So in fact virtual worlds have been around for over 20 years, but it is the increased broadband capability, wider access to web services, the

⁴ Socratic methods rely upon dialogic approaches to learning, and are inherently social. The method was first put forward by Socrates, the great Greek philosopher, and recorded in Plato's work.

interoperability of web-based software, and higher specification personal computers and graphics capabilities that has led to the recent explosion in the use of virtual worlds. Growth over the last five years has been exponential. Alongside the increased speeds of PCs and improved capabilities the ideas of 'jacking in' and out of virtual worlds has been outlined in cyberpunk novels such as Gibson's *Neuromancer* (1995, originally published in 1984) and Stephenson's *Snow Crash* (1993, originally published in 1992). Here, the idea of moving between the spaces of real and virtual has been played with and the modern separation between being in-world and in the real world is blurring, to the extent that the separation at times seems negligible when the experiences either side of the dividing line seem very real and engaging (Veletsianos, 2008b; Veletsianos & Miller, in press).

Recently the main uses of virtual worlds for playing games online and for social and leisure time activities have been encroached on by educationalists hoping to use the medium for exploring educational or research objectives. One research group outlines this trend as a recent one:

Over the last five years the use of virtual worlds for educational purposes has grown, including replicating universities, museums and art galleries, and science labs to creating fictional worlds for tutoring and mentoring.

Prasolova-Førland et al., 2006

The trend for replicating existing real world buildings and institutions has been almost a first step into using virtual worlds. For instance Jennings and Collins (2008) examine 170 accredited educational institutions in Second Life. But the visualisation of existing real world spaces is just one part of the process needed to use these spaces effectively for educational purposes. The visualisation work is putting the infrastructure in place for creating engaging experiences. But the tutors and learners are required to play their own role for the second step which includes designing activities in-world. In order to achieve this next step two related aspects are required: the first is developing better metrics for evaluating virtual world learning experiences, and the second is developing better techniques for creating virtual learning experiences (eg frameworks, approaches and models).

One form of metric for understanding more about how virtual worlds work is statistical. While at least one commentator has called for a Metaverse Market Index⁵ to provide statistics on virtual worlds, this service is yet to be launched, so statistics are relatively uncoordinated. Second Life however does provide a range of statistics on users and in-world activities, and these are available from the Second Life website and in the recent O'Reilly report (Lorica et al., 2008). Gartner has predicted that by the end of 2011 80% of all active internet users will have an avatar⁶ and therefore be registered on one or more virtual worlds, indicating that uptake of virtual worlds will be over the next five rather than ten years. While this does not help us to evaluate the effectiveness of virtual worlds there is clearly some benefit to developing benchmarks and standards for supporting development of the form. We await eagerly the work being undertaken by standards bodies to provide these kinds of benchmarks but think that these may have more impact upon the development community than upon the educationalists who aim to use the systems.

What may be helpful at this stage for educationalists, practitioners and researchers is some sort of overview of which applications are already in use. As part of the review of this report, the researcher looked at a number of different existing typologies for the many different types of virtual world applications (VWA). While clearly these are inherently problematic, as they are changing all the time and do not always fit into neat categories, for the purposes of this report the different types of applications are grouped into the following five categories: role play worlds, social worlds, working worlds, training worlds and mirror worlds. An additional category: young worlds is left out of this report which is aimed more at post-16 learners in tertiary education, but would be included in a broader study, and is an important and numerous category of virtual worlds. While these selected categories may be debated, for the purposes of ease of access for readers these categories have been highlighted and have been extensively summarised from the useful categorisations found in Second Life in Education: Virtual Worlds Resources, the Metaverse Roadmap 2007 and through consultation with experts in the field (see **Appendix A**). The categorisation is not meant to be definitive, but rather to be used as a starting point for those hoping to engage in the currently quite complex field.

⁵ Christian Reynaud, Cisco's Chief Architect, made the announcement to launch the MMI in 2007.

⁶ Quotation can be found at www.gartner.com/it/page.jsp?id=503861 Last accessed on 21 April 2008.

2.2: Role play worlds: multiplayer role play online games

Massively Multiplayer Online Role play Games (MMORGs), or Massively Multiplayer Online Games (MMOGs), as they are also termed, are generally used for leisure purposes and based upon narratives. They are amongst the best-known and most widely used examples of 3D environments. While these are generally not used for supporting formal education, some studies have indicated the use of these leisure games for educational purposes. Well-known examples of these include: Everquest⁷, Guild Wars⁸, Lineage⁹, Lineage 2¹⁰ and World of Warcraft¹¹. For comparative figures of usage of these Massively Multiplayer Online Role play Games (MMORGs), see MMOG Data¹². See **Appendix B** for a glossary of terms.

In practice, the line between multiplayer virtual worlds for leisure purposes such as Everquest, Guild Wars and World of Warcraft and the open-ended social virtual worlds such as Second Life are often blurred, particularly as 'goal-directed games always emerge inside social virtual worlds' (Smart et al., 2007: 7). This distinction, Smart and colleagues argue, will be further eroded by increasing interoperability. In particular moving avatars, assets and interfaces between worlds seems to be a topic under debate by leaders in the field. However, as the report points out, in order to move beyond the 'walled garden':

not only new standards and syndicates, but better systems for user identity, trust and reputation will be needed to ensure player accountability to the unique rules of each world.
Smart et al., 2007: 7

The related issue of open source versus proprietary platforms is another topic of debate, and this report covers both types of virtual world platforms.

It is also worth mentioning that a convergence between social worlds and role play online games is quite possible. The new open source platforms such as Uni-Verse¹³ make probable the blending of games and virtual worlds to an even greater extent, and games such as Guild Wars offer both the rule-based appeal of a game with the social activities of a virtual world. It is envisaged that these categories will merge and blur more over time. However, in general, these have not been widely used for educational purposes (de Freitas & Griffiths, in press; de Freitas & Griffiths, 2008; Griffiths & de Freitas, 2007). It is worth noting however that some current studies are exploring the use of Massive Multiplayer Online Role play Games (MMORGs) for supporting learning (eg Carr, 2008), but to date there has been no substantial work published that points to efficacy of using this approach for supporting learning. However, the author is aware of a number of studies beginning data collection in this area.

2.3: Social worlds: open-ended exploratory immersive worlds

As mentioned earlier, virtual worlds are particularly numerous in the area of supporting social networks and social interactions and processes, particularly for informal purposes. In this way, social worlds have been incredibly popular and successful, especially when bringing groups and communities together. Examples of these worlds include Active Worlds Educational Universe¹⁴, Second Life¹⁵ and There.com¹⁶, which outside of MMORGs consistently have the highest numbers of users. These worlds place a greater emphasis upon social networking including live chat, sharing resources and swapping multimedia content. Another popular example of a social world is Cyworld¹⁷ which has been extremely widely used in Korea with 90% of 20-somethings being listed as

7 Everquest can be accessed at: <http://everquest.station.sony.com>

8 Guild Wars can be accessed at: www.guildwars.com

9 Lineage can be accessed at: www.lineage.com

10 Lineage2 can be accessed at: www.lineage2.com

11 World of Warcraft can be accessed at: www.worldofwarcraft.com

12 MMORG/MMOG Data can be accessed at: www.mmogchart.com

13 Uni-Verse can be accessed at: www.uni-verse.org

14 Active Worlds can be accessed at: www.activeworlds.com/edu/awedu.asp

15 Second Life can be accessed at: www.secondlife.com

16 There.com can be accessed at: www.there.com

17 Cyworld can be accessed at: <http://us.cyworld.com>

registered users. The social element of these worlds clearly has synergies with the processes of learning, and as such they do lend themselves to use in educational contexts, examples of which are noted in Kirriemuir (2008) and in de Freitas (2006).

If anything, this trend is amplified in the realm of young adults and children, with a proliferation of animated 2D/2.5D environments targeted at children, such as Habbo (formerly Habbo Hotel)¹⁸ or Gaia Online¹⁹. An example of a 3D immersive world for teenagers is Teen Second Life²⁰. Although somewhat outside of the age served by the UK Joint Information Systems Committee (JISC) community, which has a focus upon post-16 education, it is interesting to see the sheer number of young worlds emerging each week. These are primarily social worlds for young people, and in general have generic characteristics that focus upon avatar creation, social software, content creation and/or sharing utilities. In the authors' researches, these worlds were almost exclusively social – but the capability of these to address educational and learning activities is clear and in need of further exploration.

One of the interesting aspects of this genre of virtual worlds is the way that it is predominantly not task-centred, but rather more of a social and socialising tool. In-world entertainments can range from concerts to just chatting with friends and family. The social interactions are deeply personal and can be intimate. Research focusing upon understanding these social interactions is clearly needed. Virtual ethnographic studies would be welcome, as would work that centres upon understanding the role of identification in social interactions in-world. Learner control and the part of role play are areas that may provide the key to understanding the effectiveness of learning in immersive worlds. In addition, the role of immersion in identification is beginning to be understood through new models (eg de Freitas and Neumann, 2008; McMahon and Ojeda, 2007) but more work is needed to test these models, to validate the use of current pedagogic approaches and to bring together research methodologies, eg inductive (Gill and Johnson, 1997).

2.4: Working worlds: corporate and business 3D spaces and intranets

The role of the workplace in supporting learning – both formally and informally – has been a matter of discussion and debate with respect to e-learning. In particular the need to create a better join-up between work, learning and play reflects social changes that are predicated upon a certain blurring between our different areas of activities and outputs. In the context of virtual worlds the blurring has continued as a theme, and some really exciting virtual world capabilities are emerging that can support corporate and business collaboration and help to join up previously unconnected modes of learning and working. The tools take us on further perhaps than mere collaboration, into realms of interworking, flexible working patterns and distributed leadership and towards new models of working (Jameson et al., 2006).

With many workers now based outside of offices and working independently, opportunities for collaboration and serendipity may ostensibly have lessened, and yet new tools are emerging to make this in fact more possible. Working in non-located groups has the capability to open up new possibilities and scope for collaboration and support of non co-located groups and teams. The prospect is beginning to be realised in virtual world applications seeking to support businesses. While companies such as IBM are using Second Life extensively for their business communications, for commercially sensitive meetings and primary business communications they have produced their own world: IBM Innovate Quick Internal Metaverse Project²¹.

Another example of the trend for large corporations producing their own in-house virtual worlds is Project Wonderland²², developed by Sun Microsystems using the Project Darkstar platform²³. The application has a focus upon using a 3D environment for business meetings, supporting communities and undertaking key training.

18 Habbo Hotel can be accessed at: www.habbo.com

19 Gaia online can be accessed at: <http://gaiaonline.com>

20 Teen Grid of Second Life can be accessed at: <http://teen.secondlife.com>

21 Quick Internal Metaverse Project can be accessed at: <http://eightbar.co.uk/2007/05/08/the-ibm-innovate-quick-internal-metaverse-project>

22 Project Wonderland can be accessed at: <https://lg3d-wonderland.dev.java.net>

23 Project Darkstar community can be accessed at: <http://projectdarkstar.com>

One of the main differences between the social and working worlds is cost. With social worlds such as Second Life, often the barriers to entry are kept low to entice people to register. Once in, the users will form communities and keep coming back, and charges for avatar textures, objects and buildings and the annual costs of land ownership can provide enough revenue for the hosting companies to make a profit. With working worlds the barriers to entry are often higher with, for example, large licensing costs, which can be very high and can prevent most users from entry. However the cost benefits emerge when the numbers of trainees is high, the group is distributed and the companies have high revenue for training budgets. Initial high costs can then be justified as they are lower than standard face-to-face costs especially when groups are internationally distributed and travel costs are high for training in traditional ways.

Category of virtual world	Examples	Value for learning and education
1. Role play worlds	World of Warcraft, Everquest, Guild Wars	Potential for learning in vicarious ways. Team-working skills, leadership skills, communications. There has been little research into the learning or educational benefits of MMORGS, however anecdotal evidence implies there may be potential here. The scope for learning may be in role play approaches perhaps focusing upon professional development.
2. Social worlds	Second Life, CyWorld, ActiveWorlds For children Habbo Hotel, Club Penguin	Social worlds tend to be immersive worlds without specific quests. The worlds are social primarily and focus upon community building activities and social communications between friends and colleagues. Social worlds for children and young adults are often animated and 2D/2.5D. Children use these environments for communicating with other friends, or sharing content. The success of these environments has led to a proliferation of formats and worlds. Some virtual worlds for children have tie-ins with toys or films, eg BarbieGirls World, and are marketed as part of the franchise.
3. Working worlds	Project Wonderland, IBM's Metaverse	These worlds focus upon corporate communications and business support facilities. Project Wonderland is a form of interactive video conferencing with capabilities for voice and document sharing. Increasingly businesses are global concerns and often staff are location independent workers without access to offices; this makes the use of 3D rich environments for collaboration appealing and cost saving.
4. Training worlds	America's Army, platforms such as the OLIVE platform	These worlds are specifically for training. They are focused upon particular professions and aim to provide training that may not be possible in real situations, is life threatening or has many possible scenarios or outcomes. While to date these have often focused upon military training, increasingly medical education and training are making use of the tools.
5. Mirror worlds	Google Earth, Planet Earth, Unype	Mirror worlds are quite literally worlds or 3D visualisations that mirror the physical world. Google Earth is the most well known of these worlds. Increasingly through mash-ups mirror worlds can be embedded into other unrelated applications. The bringing together of different applications is facilitated by interoperability – and this presents interesting options for education and training especially where a blend of real and virtual spaces may be beneficial, eg field trips, multimedia production.

Table 3: Five categories of virtual worlds.

This table is not meant to be a definitive categorisation of virtual worlds, but can be used as a starting point for understanding the wide range of applications that are currently available.

2.5: Training worlds: 3D training simulations and serious games

Another area that maps onto that of virtual worlds is the use of 3D visualisations for supporting specific training needs, such as training for health, business and the military (de Freitas, 2006). A new area of research is centring upon training simulations and 'serious games'. The terms can be confusing, but serious games are games used for non-leisure purposes and virtual worlds are 3D environments that can also be used for serious applications, such as training. The two areas may be considered quite separately, but with the growth of the serious games area in research and development, serious virtual worlds are being considered in many contexts as related media forms. An early example of a serious virtual world, indicating the proximity between a serious game and a virtual world, is America's Army, developed by the Moves Institute. America's Army is an online game for training US army recruits, but as it is persistent it also has attributes in common with virtual worlds (de Freitas, 2006).

In a period when user generated content is moving up the agenda, a range of construction tools are available that can assist users with creation of content and worlds. These are platforms that can be used to develop your own virtual worlds, and at least in part account for the proliferation of virtual world applications. As with software development kits used for crafting games, some platforms are considered more as construction tools for developing new worlds. Examples of these platforms include Croquet²⁴, an open source platform, and Forterra Systems' Olive²⁵, which is available via licence.

The licence-based OLIVE platform, based on there.com²⁶ technology, is an interesting example of this type of virtual world, and has been used almost exclusively for professional training purposes within military and medical user groups in the US, although new research projects are seeking to use the platform for UK multi-agency training and for school education (eg Chen et al., 2008). One study of the efficacy of this approach to training has been produced by Stanford Medical School who have been using the platform extensively. See the OLIVE case study in **section 3** for more details. The main reasons why the platform has been used in professional contexts only is due to the cost of licensing and the fact that the world is private, not available for the public. Here the barriers to entry are relatively high but the benefits lie in the increased security, being able to host the world behind institutional firewalls and a safe and controllable environment for training.

In the future, we may use public and private worlds depending upon the purpose of usage. The use of private worlds does have a certain appeal for those working with vulnerable groups, although the capability to 'lock down' areas of Second Life is already available; it is envisaged that the emergence of OpenSim²⁷ may also offer that level of control, allowing users to close off areas from the public, giving them the security of a private world and allowing for greater functionality. In the future then public and private areas of virtual worlds will in all probability operate side by side, and it will be interesting to see how the licence-fee based worlds will survive against the open source ones.

2.6: Mirror worlds: using geo-spatial databases and mapping services

Mirror worlds are enhanced virtual models or replications of the physical world. They entail sophisticated virtual mapping, modelling and annotation tools, geospatial, sensor technologies and location-aware and lifelogging (recording) technologies (Smart et al., 2007: 9). These replicate or mirror the real world and include: Google Earth²⁸, Microsoft Virtual Earth²⁹, NASA World Wind³⁰ and Unype³¹. The open source version of these applications includes Planet-Earth – the Open Source, Open Content, Free 3D Earth³².

24 Croquet can be accessed at: www.opencroquet.org

25 Forterra's OLIVE is a closed platform for professional uses and can be accessed at: www.forterrainc.com/products.php

26 There.com can be accessed at: www.there.com

27 OpenSim can be accessed at: <http://opensimulator.org/wiki>

28 Google Earth can be accessed at: <http://earth.google.com>

29 Virtual Earth can be accessed at www.microsoft.com/virtualearth

30 NASA World Wind can be accessed at: <http://worldwind.arc.nasa.gov>

31 Unype can be accessed at: www.unype.com

32 Plant-Earth can be accessed at: www.planet-earth.org

The main developments in this area relate to the use of mash-ups, which bring together different applications, including mirror worlds, to enrich experiences and are facilitated by service-orientated architectures which allow different applications to be integrated. The scope for learners using these and other applications could provide some real innovation in the processes of learning and sharing content globally. This approach could lead to the formation of global self-organising communities that form along interest lines, to support particular aims or as part of experimental work. Clearly it is not enough to have the technologies available, or to produce visualisations; the real innovations will take place in the uses of the technologies, applications and toolkits and the processes by which outputs are shared and are used by and within communities.

Mash-ups also have benefits for education and training, allowing data to be layered to augment the learning experience. They may aid learning about complex concepts and enrich role play exercises, assist visitors to virtual museums and provide wider opportunities for networking at virtual events.

These different types of virtual worlds together offer wide scope for social interactions, collaborations and innovations in learning and teaching practices. The following section offers some examples from practice indicating how virtual worlds are currently being used to support learning and training.

3.0: Case Studies of Practice

This section will explore examples from immersive virtual worlds in more detail to provide illustrations of how virtual worlds are currently being used to support specific learning activities. The section is intended to highlight some of the educational examples that may help institutions to envisage how virtual worlds might be best used in familiar contexts of practice.

In terms of costs for using the worlds, in general there are public and private options. The former are open to all and usually have user registration costs (a joining fee or an annual fee, or both). Most of the worlds reviewed here have additional licensing costs associated with purchasing islands and worlds. To take an example of a public world, Second Life is free to register and use, but has licensing costs for setting up islands and moving them around. The private worlds are in general closed to the public and utilise licensing models based upon continuous users. An example of this is the OLIVE platform which has licensing costs based upon synchronous user numbers.

3.1: Active Worlds Educational Universe: supporting science teaching in schools³³

Active Worlds is one of the oldest social virtual worlds, with six million downloads of the Active Worlds browser, and several hundred universes. Active Worlds can be downloaded by users, and there is an annual subscription fee for citizenry. Launched in 1997, Active Worlds also includes a dedicated educational world, called Active Worlds Educational Universe (AWEDU), which is an entire Active Worlds Universe for dedicated educational activities, such as virtual seminars (Jones, 2005). As a result of being around for longer, there are a few more academic studies published that examine this virtual world (eg Corbit, 2002; Dickey, 2005b; Prasolova-Førland, 2008). By making Active Worlds technology available to the educational community, tutors can explore concepts and theories of learning and may foster creative curriculum design approaches.

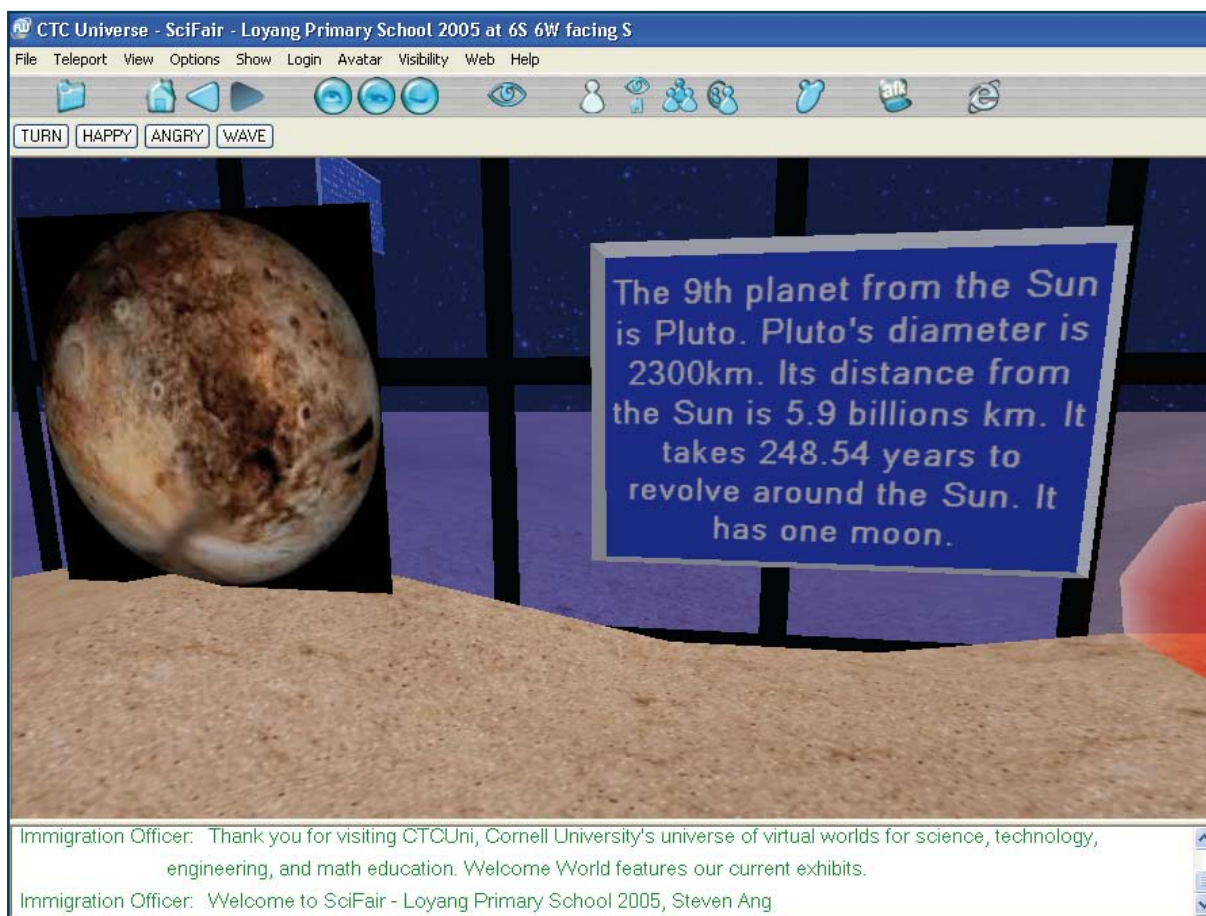


Figure 1: Active Worlds: Student's assignment work from Loyang School, Singapore. From Ang & Wang, 2006

33 Active Worlds Educational Universe can be accessed via: www.activeworlds.com/edu/awedu.asp

The idea of Active Worlds came from developers in San Diego, USA in 1994. Alpha World was the first attempt and soon had several thousand users. Active Worlds Educational Universe was set up in response to the community, and now has hundreds of educational institutions in-world. One of the advantages of the world is that you can make worlds private, making them safer environments for learning and teaching, particularly with younger learners. However, the world is sparsely populated, so learners may be alone if they come at a time when there are no events taking place.

Users can chat with others (through instant messaging and voice chat), construct and own worlds and develop 3D content. While there is free exchange of content there is also a market place for textures, avatars and models.

'Bots' are applications that are developed in-world using the Active Worlds software development kit (SDK) that allows users to undertake simple tasks, eg chat relay and providing tours. Interestingly, the SDK can be used to develop games, which can be used to interact with databases, providing a simple gaming platform.

Some academic studies have found educational value in using virtual worlds such as Active Worlds particularly for supporting constructivist informal science and technology education (Corbit, 2002; Prasolova-Førland, 2005; Prasolova-Førland et al., 2006).

An example of how Active Worlds has been used is provided by Ang and Wang's (2006) study of primary school pupils using Active Worlds for studying science. The pupils, all based at a primary school in Singapore, were given the learning activity of building a 3D model of the solar system with nine planets. The learning outcome of the activity was to be able to identify and describe each planet and to become more interested in learning about science. The ten learners selected were 11 years of age and were considered 'underachievers' due to consistently low grades in tests. The study involved eight sessions of two hours each within a month and during out-of-school hours.

The study findings showed a substantial impact upon learner behaviour:

When the tutor was demonstrating some basic features of the program, [pupils] were totally attracted, engrossed, and also very quiet. They behaved quite differently compared to how they performed in traditional classes, where they were very disruptive, talkative, and show[ed] no interest in lessons.

Ang & Wang, 2006: 8

There were also improvements in attendance for the classes, with 100% attendance, and there were notable improvements in engagement: 'interactivity was [a] factor that helped to engage the students in learning' (Ang & Wang, 2006: 8). The activities also encouraged use of the internet for sourcing information, as well as promoting social interaction through the chat facility. Some technical issues such as slow download times were recorded in the study and these were frustrating for learners; also one student did not have broadband at home and therefore worked at school. However, although using a very small sample size, on the whole the study indicated a positive response from the student group, and one comment 'I prefer to study Science in this way than the normal traditional classroom teaching' (Ang & Wang, 2006: 9) indicates how for some learners virtual and interactive environments can be more engaging and motivating. Improvements in grades attained attest to changes in performance (see *Figure 1: Active Worlds: student's assignment work*).

The ActiveWorlds case study demonstrates the power of virtual worlds for engagement and motivation, better retention and increased performances for this user group are notable benefits of using virtual worlds in this context. In this way, virtual worlds may be used for supporting hard-to-reach groups. In addition, the format may be used for supporting science teaching, in particular where visualisation methods may provide more memorable learning aids.

Specification for Active Worlds platform	
Licensing/costs	Subscription fees and licensing costs for worlds
Engine	RenderWare
Version	4.2 released 2008
Platform	Windows, World Server SDK: Windows, Linux.
Media	Download
System requirement	300MHz (800MHz recommended) CPU 128MB+ RAM, Windows 98 or later, Windows Media Player 6.4 or later, 3D acceleration (64MB+ video RAM recommended)
Objects	Developed using RenderWare Script RWX and trueSpace objects COB and .X format

3.2: SciLands in Second Life: science education and virtual conferences³⁴

Second Life has a large number of users, just under 15 million registered accounts in August 2008 with over 50,000 registered users online at any one time. Although free to register for non-land owners (since 2006), an island in Second Life equates to 512 square metres in area and currently costs around \$9.95 per month to rent (see <http://secondlife.com/whatis/landpricing.php> for more details).

The SciLands project is a specialised area of Second Life dedicated to science and technology where organisations have docked their islands together to create a virtual archipelago or continent. The SciLands real (virtual) estate includes a pure science area centred upon the space industries and contains the well-regarded International Spaceflight Museum. The SciLands, supported in Europe by Dave Taylor from Imperial College, London (or Davee Commerce in Second Life parlance), aim to provide a centre for science and technology and include participation from a wide range of scientists, with real applications for research and development as well as teaching. There are 23 science and technology organisations and the lands have their own membership rules and a planning authority. SciLands also has an extremely good orientation island worth visiting for novices aiming to get involved with virtual worlds.

The projects going on here are all inherently educational and include a range worth mentioning. In general work falls into four main categories: research, learning and teaching, collaboration and public awareness. One Elon University Astronomy professor, for example, developed a planetarium in Second Life for his students to develop planetarium shows instead of written projects. More examples of educational uses are provided by the US National Oceanic and Atmospheric Administration (NOAA), who are hosting many interesting educational resources, for example a 3D real-time weather map, a 3D submarine ride and a tsunami demonstration.

Imperial College London and the London Strategic Health Authority (SHA) have developed a large area in the archipelago for the visualisation of a local hospital of the future. The purpose is to promote public awareness of health reform within London and, by utilising the social context of the virtual world, to help inform future health policy. Other nearby facilities have been created for training clinical staff. Findings from preliminary educational studies suggest that the virtual environment provides a compelling and robust environment for teaching interdisciplinary medical teams. The area has been used to hold the first international Virtual Association of Surgeons (iVAS) where talks were given by speakers in the USA and the UK on surgical robotics, education and simulation. Forty-seven delegates from five countries attended, ranging from professors to students of medicine and engineering. A questionnaire survey was completed by the delegates; of those who responded, 96% 'agreed' or 'strongly agreed' that the overall experience was highly rated, and all delegates 'agreed' or 'strongly agreed' to attend another meeting in the same medium. This approach provided several key benefits over current real world conferencing, including less time taken out of delegates' days for travel and participation and reduced environmental impact of attending the conference. Imperial College have also done testing comparing

³⁴ Second Life can be accessed via: www.secondlife.com

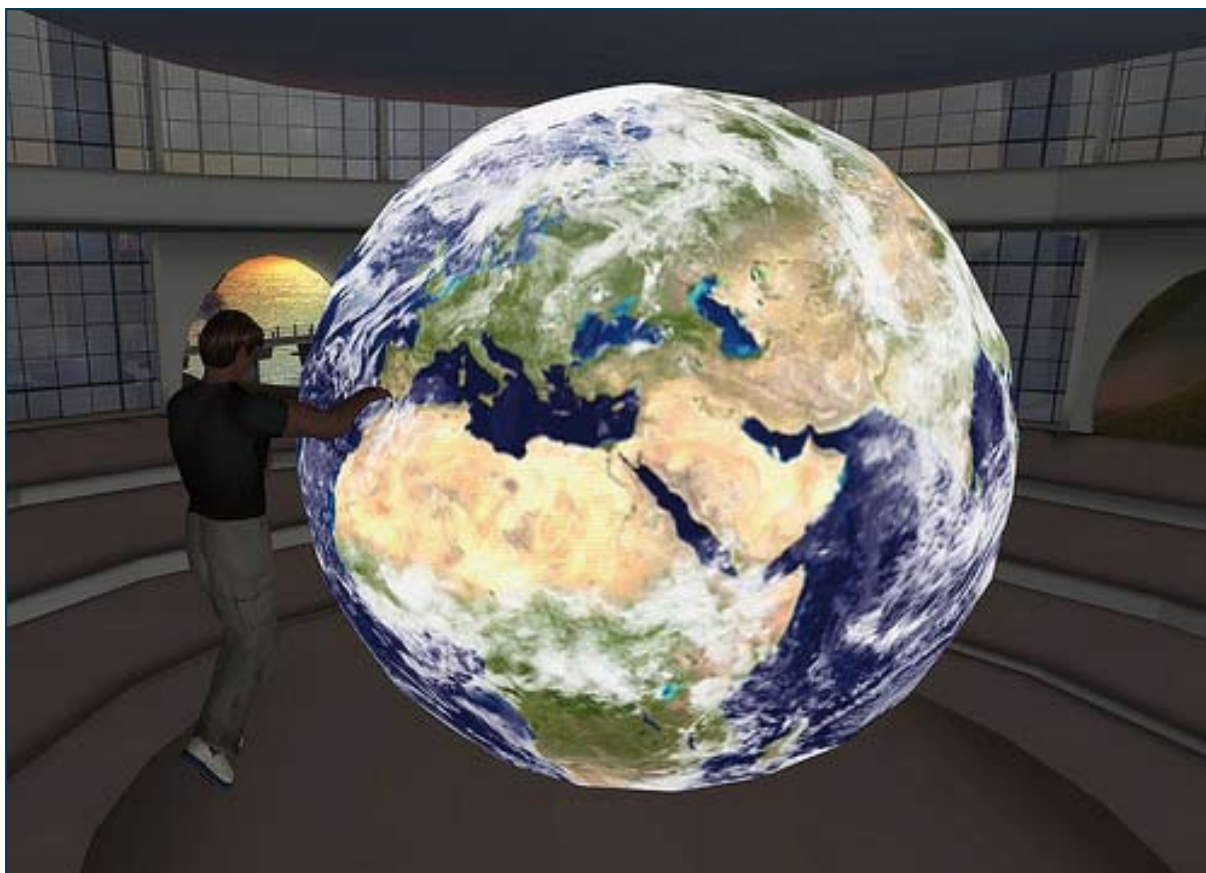


Figure 2: SL SciLands: NOAA's 3D weather map. Source: Dave Taylor

standardised modules for surgical students taught by lecture, in a simulated operating suite and in a Second Life version of the operating theatre. The findings, due to be published shortly, have shown 'no significant difference' between the simulated operating suite and Second Life model, and students displayed less anxiety when going into a live theatre after using Second Life than with the operating suite or lecture approach.



Figure 3: Second Life: SciLands Second Health project. Source: Dave Taylor

NanoLands was established by Dave Taylor whilst at the UK National Physical Laboratory. It aims to foster academic collaboration and public awareness around the area of nanotechnology.

The idea of serendipity in the grouped organisations is an interesting one, and the proximity of specialists in related areas in-world can offer new opportunities for collaboration that may not have seemed likely in other contexts. The SciLands project opens up the possibility of other groupings of UK universities in a similar way to provide a less scattered and more focused UK HE presence in Second Life. This would be world leading and could provide a vital link for supporting truly innovative collaborative research and development within the UK. It might also provide a focus for international collaboration and research clusters for taking leading edge technologies and applications forward for supporting educational purposes, an area that, considering the range of social activities happening in virtual worlds (as evidenced in the list of virtual worlds in **Table 4 – Appendix C**), has played a relatively small role in leading edge activities in-world.

These kinds of uses of virtual worlds suggest a wide range of uses for learning and teaching, including holding virtual events, undertaking learning quests and tours, supporting virtual conferencing for distributed research communities and using simulations and modelling in-world. Science education is one area, but virtual worlds can support diverse disciplinary interest areas, and may support distributed specialist groups well. Holding seminars in-world and undertaking assignments in-world are other possible uses.

Specification for Second Life platform	
Licensing/costs	Free to register. Licensing costs for island ownership
Engine	Second Life platform
Version	1.2
Platform	Windows 2000, XP, Vista, Mac OS X, Linux.
Media	Download
System requirement	Broadband internet access. 256MB RAM (Win, Linux), 512MB RAM (Mac). 800MHz CPU. 1GHz G4 or higher/ Intel Core Processor (Mac). NVidia GeForce 2 or higher

3.3: Croquet Community: supporting forums for research³⁵

The Croquet Consortium comprises an international group of industrial and academic institutions that promote the open source Croquet technologies. The consortium includes Duke University, the University of Minnesota and the University of British Columbia, as well as Hewlett-Packard and Intel. The toolkit supports the creation of multi-user virtual 3D applications and includes a range of educational pilots.

Designed to enable the creation of large-scale virtual worlds, Croquet has been implemented in Squeak (Smith et al., 2003), a language based originally upon Smalltalk³⁶, and has a flexible peer-based architecture allowing for rapid prototyping. Applications that are created may allow for visualisation, virtual learning, 3D wikis and online gaming environments for private and public purposes. The project is still under development and new tools such as Cobalt³⁷ (a browser and toolkit) are emerging for users. The project is one of a range of new open source projects and has been used for a number of educational projects.

Croquet is not as high fidelity as some of its rivals, and the look of the world can be described as Alice in Wonderland-like. Movement of the avatars is more gliding than walking, and the world clearly has some distance to go in terms of usability. However, the project is worthy of inclusion here, as it has a greater focus upon learning and teaching purposes. One of the past prototype projects was an Immersive Language Instruction Tool.

³⁵ Open Croquet can be accessed at: www.opencroquet.org

³⁶ Smalltalk is an object-oriented programming language. For more information see: www.smalltalk.org

³⁷ Cobalt is an open source and multi-platform virtual world browser being developed for Croquet. For more information see: www.opencroquet.org/index.php/cobalt



Figure 4: Second Life: Meeting being held in NanoLands. Source: Dave Taylor

The prototype illustrates how Croquet may be used to support language teaching, and uses a narrative-based activity where two players are dropped into a space and sent on a quest. The prototype is game-based in structure, but it is clear that the tool could be used for language teaching using the whiteboard and possibly with remote learner groups (or tutors).

Another Croquet project that has educational value is the Arts Metaverse, which has been created by the University of British Columbia's Arts Instructional Support and Information Technology unit. So far the Machu Picchu site has been reconstructed using Croquet. The EduSim 3D smartboard application was developed in Kansas by the Greenbush Southeast Kansas Educational Service Center and allows tutors and learners to link up multiple whiteboards in-world; Greenbush are developing resource packs for schools. The work of Ohio State University in Second Life³⁸ has shown that virtual worlds also offer potential for real time art installations, and Igrische is a Croquet version of this, allowing for real time performances and multimedia use, and can also be used in the real world for projecting video and art works.

Qwaq Forums³⁹ is a closed version of Croquet and is being used imaginatively to support a range of academic groups. The set up can be hosted remotely by Qwaq or on the users' own servers, and the pricing varies according to number of users. One such group is based at Princeton University and is using Qwaq Forums as a collaborative tool. Based upon peer-to-peer communication it has better potential for scaling, and it is very easy to share web documents. Piet Hut has set up two user communities: Meta-Institute for Computational Astrophysics

38 For more information about Ohio State University and its work in Second Life, see: <http://telr.osu.edu/secondlife>. The SLURL for visiting TELRport, Ohio's pilot Second Life project, is: <http://slurl.com/secondlife/TELRport/89/211/24>

39 Qwaq Forums can be accessed at: www.qwaq.com. The application can be purchased in two deployment options, with Qwaq hosting servers or self-hosted.

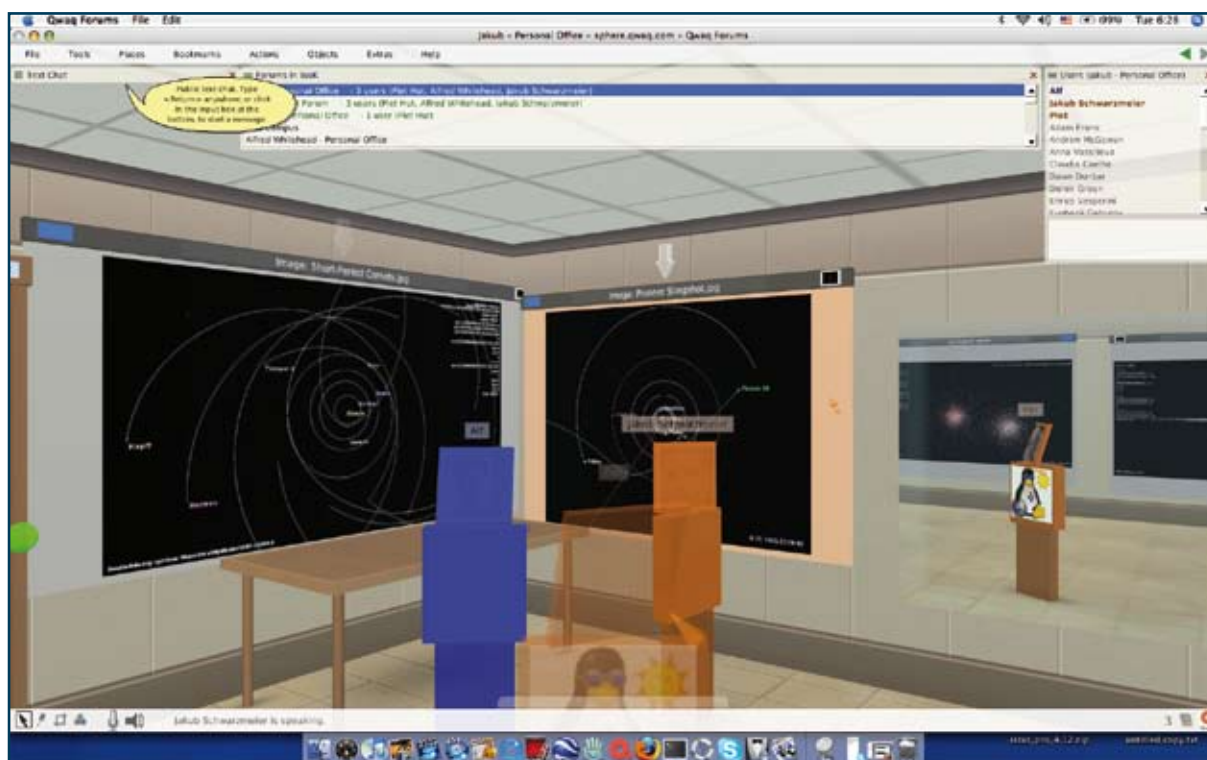


Figure 5: Qwaq Forums: Astrophysics simulation in-world Source: Piet Hut

(MICA), aimed at astrophysics colleagues, and Ways of Knowing (WoK) Forums, aimed at an interdisciplinary group of scholars (Hut, 2008). Hut found that the international interdisciplinary group of scholars took well to the technology, something he explained in the following terms:

It took a while before it dawned on me what was happening. The main reason was that widely interdisciplinary activities do not have any traditional infrastructure, in terms of journals, workshops, societies and other channels to fall back on...By offering a forum for discussions, I was effectively creating an oasis in the desert, attracting many thirsty fellow travellers.

Hut, 2008: 94

Piet Hut found that it was not the tools that were attracting colleagues into the environment:

[t]he main attraction for coming into Qwaq Forums was presence. Presence in a persistent space, a watering hole that quickly became a familiar meeting ground, this is what was felt to be the single most important aspect of the whole enterprise. Everything else was clearly secondary.

Hut, 2008: 92

One of the major challenges for the groups was reconciling the time zones; it was difficult to manage meetings with an international group. This was overcome by setting meetings at optimum times. Despite these hurdles, both groups are now very active and Piet Hut aims to continue to support his groups, and sees particular value in distributed open source writing using this tool (Hut, 2007).

Clearly this case study highlights the effectiveness of virtual worlds for supporting distributed research communities, but it also indicates the potential for supporting wider international collaboration. In a recent study for the JISC, the MyPlan study investigating the use of Second Life for mature and college students found that 81% (n=16 students) saw real potential in international collaboration between students⁴⁰. See Appendix E for more information about the MyPlan project.

⁴⁰ The paper will be referenced as: de Freitas, S., Rebollo-Mendez, G., Poulouvassilis, A., Magoulas, G. & Liarokapis, F. Developing an evaluation methodology for using virtual worlds to support specified learning activities. To be presented at the First IEEE Serious Games and Virtual Worlds Conference, Coventry, UK. March 23/24 2009. The IEEE Serious Games and Virtual Worlds conference web site can be accessed at: www.vs-games.org.uk.



Figure 6: Qwaq Forums: Way of Knowing Forum meeting. Source: Piet Hut

Specification for Croquet platform	
Licensing/ costs	The licence is open source and freely available to download, but to set up Croquet SDK you need specialised technical knowledge. For Qwaq Forums licensing costs apply
Engine	Croquet (open source)
Version	1.0
Platform	Windows, World Server SDK: Windows, Linux.
Media	Download
System requirement	300MHz (800MHz recommended) CPU 128MB+ RAM, Windows 98 or later, Windows Media Player 6.4 or later, 3D acceleration (64MB+ video RAM recommended)

3.4: Project Wonderland: teaching tool for collaborative learning in mixed reality spaces

Project Wonderland is an open source – and freely available – toolkit for creating collaborative 3D virtual worlds, based upon Project Darkstar game engine technology⁴¹. Although it requires some technical development knowledge to set up the system, Project Wonderland allows users to communicate with high fidelity audio and immersive graphics. It also allows users to share applications in real time, eg web browsers, word documents and games. The project is led by Sun Microsystems who have played a significant role in the open source community.

Sun Microsystems, the University of Essex and other partners have been exploring the potential of the tool for education and training purposes. Driven by an imperative to provide communications for their distributed workforce, the tool improves upon teleconference facilities by offering a greater sense of 'presence' and aims to support virtual serendipitous meetings and interchanges. Although very much in beta stages of development, its open source access and multidimensional nature show educational potential.

⁴¹ Project Darkstar is the underlining technology for Project Wonderland. More information for developers about the community can be found at: <http://projectdarkstar.com>



Figure 7: Project Wonderland: MiRTLE project using virtual world and real world in the classroom. Source: Bernard Horan

One of the ideas driving the project is to support mixed reality rather than purely virtual encounters, bringing together opportunities for mixing real and virtual interchanges, such as in the MiRTLE project. In the future it is hoped that the platform might be used for lecture-based activities providing a means of bringing together learners from a wide geographic area either purely in-world or in a mixed reality setting. This means that courses that would perhaps not be economically viable can be offered to larger numbers of internationally distributed learners. This tool also could support institutions that have a central campus and several satellite locations. In this instance, courses offered in the hub and attended by learners on the main campus could also be attended virtually by learners in the satellite locations. Using the system for tutorial-based activities (constructivist/constructionist model) provides an environment for learners to engage with simulations of course materials or to collaborate on course assignments. Bernard Horan forecasts that the use of teaching applications could be extended:

[I]n the future I think that we could expand this to be able to include all kinds of applications such as being able to demonstrate Hooke's Law [about springs] or many physics-based simulations. There is also potential here for language-based teaching – being able to include very widely geographically spread students in a language class.

Horan, email correspondence, 16 April 2008

One of the interesting projects piloting these suggested approaches using the platform is the Mixed Reality Teaching and Learning Environment (MiRTLE) project. Sun Microsystems are working with the International Academy at Essex University (UK) and the Shanghai Jiao Tong University in China to set up a deployment of the project. This project aims to combine local and remote learners in a traditional university lecture-based setting. The idea of the project is to augment traditional face-to-face teaching practice allowing for fostering a community feeling between the local and remote learners. This is achieved by having the physical room set up as per normal layout with a large screen at the front, microphones and a camera at the back of the room. The learners

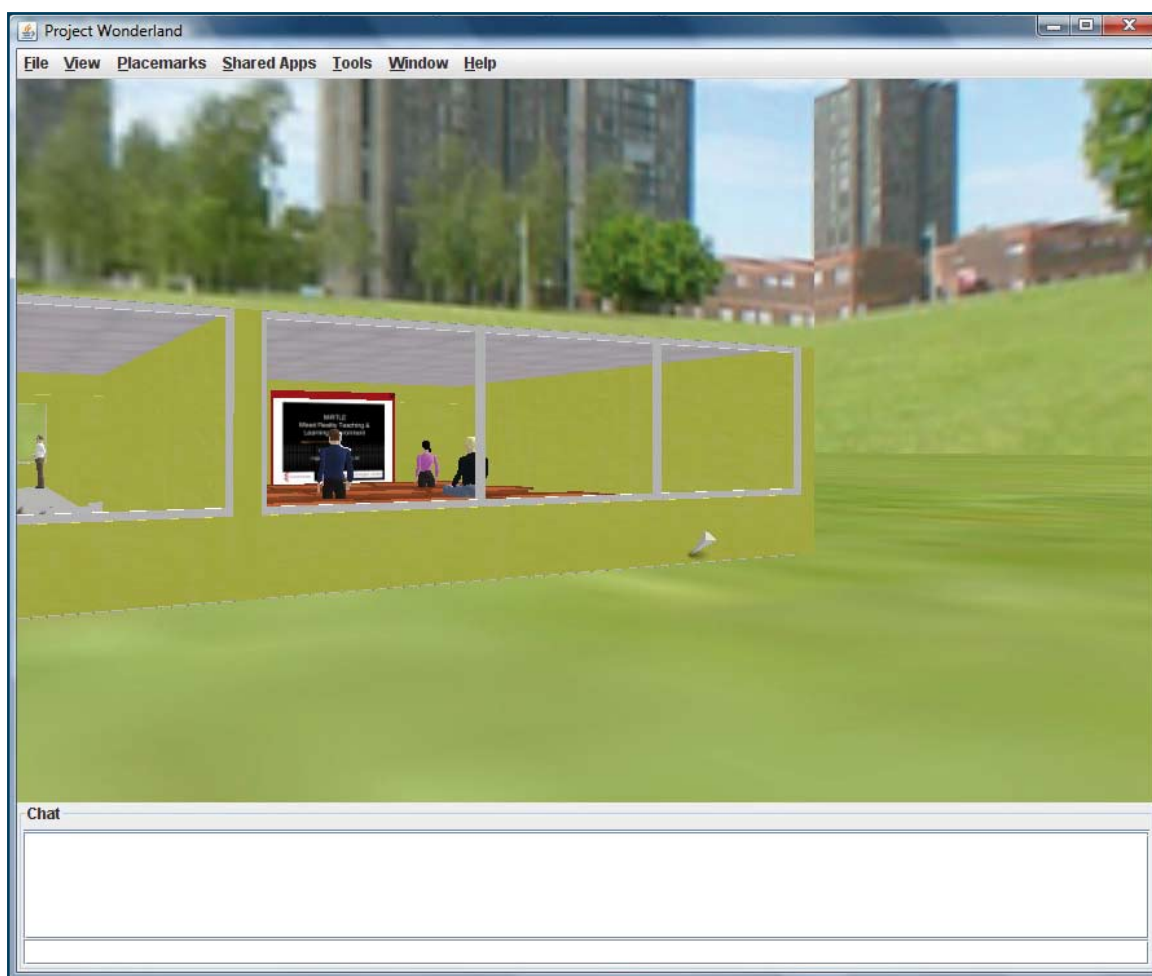


Figure 8: Project Wonderland: Campus. Source: Bernard Horan

attending remotely are displayed as avatars represented in the virtual world on the screen at the front. In this way, the remote learners are part of the classroom environment, and can communicate via text and audio links with the physically located class members. The remote learner can see the classroom, the virtual world and a map view that combines both. Evaluation of the test-bed project is underway and the results may have interesting implications for the use of mixed reality systems in educational settings.

The main strengths of Project Wonderland, as with many social worlds, are its focus upon collaboration and information representation, through using stereo audio, shared applications and video streaming. Bernard Horan argues that this 'gives users a better sense of presence than other Virtual Worlds, which hopefully means that users are more engaged' (Horan, email correspondence, 16 April 2008). The tool is also a business level virtual world where use of the system is aimed at single institutional usage meaning it can sit behind a firewall. The advantage of this is that existing institutional authentication can be used, which may allay security and identity issues. The new release, in the autumn, aims to improve the look of the avatars and the ease of use of the artwork. Future functionality may also include the ability for users to create their own content, using tools such as Sketchup⁴² and 3ds max⁴³.

One of the interesting aspects emerging from the review underpinning this report has been to note the progression of the processes of converging technologies, for example between games and virtual worlds technologies. One example of this is outlined by Nicola Yankelovich from Sun Microsystems who argues that 'one of the ways you can think of Project Wonderland is as a serious game' (video interview, last accessed on 17 April 2008 at <https://lg3d-wonderland.dev.java.net>). The fact that it is based upon Project Darkstar multiplayer game technology indicates the level of technical convergence between the games and virtual world technologies.

⁴² Sketchup can be accessed at: <http://sketchup.com>

⁴³ 3ds Max [formerly 3D Max] is an Autodesk product for modelling 3D objects and environments. For more information, see: <http://usa.autodesk.com>

While still in early development stages, Project Wonderland is an interesting variant of the virtual world, and perhaps falls more neatly into the corporate worlds than social worlds category. Both in business and educational contexts the advantages of this system may lie in its capacity to bring virtual and real spaces and individuals together to facilitate collaboration through serendipity and proximity of users.

Specification for Project Wonderland platform	
Licensing/costs	Open source and freely available to download, but need for high level technical skills for deployment as still in beta
Engine	Project Darkstar
Version	MPK20
Platform	Linux, Windows XP, Solaris x86 (with patch), MacOSX
Media	Download
System requirement	PC (1.5GHz+, 1GB RAM) with good graphics card. OpenGL drivers. Solaris and Linux (with Nvidia cards/drivers). Java SE6 (JDK 6)

3.5: Forterra's OLIVE platform: supporting surgical education and major incident training

Forterra's OLIVE (Online Interactive Virtual Environment – 1.0) platform allows developers to build and maintain persistent virtual worlds, supporting users for training, rehearsal and analysis. The software includes integrated modules and tools and uses avatars, Voice Over Internet Protocol (VOIP) technology, text chat and body language. OLIVE uses a client-server architecture where PC clients connect to a central server. One of the strengths of the system is its scalability, it can support thousands of geographically distributed concurrent users. The use of more extensive hand and body gestures particularly has relevance for training situations where expressive communications are needed. To date the platform has been used mostly with the military in the US, but recently it has been used for road planning, major incident planning and for medical training. New projects commencing in the UK are seeking to use the platform to support professional training, multi-agency training and school education pilots (eg. Chen et al., 2008).



Figure 9: OLIVE: Major incident training event. Source: Forterra

The case study outlined here involves the leading edge work that Stanford Medical School have been undertaking with the virtual world platform. Led by Dr Leroy Heinrichs, the Stanford University Medical Media and Information Technology (SUMMIT) group have been innovating practice through using the tool for supporting cardio-pulmonary resuscitation (CPR) training (Youngblood et al., 2007), mass casualty training (Kusumoto et al., 2007) and team training and assessment in acute-care medicine (Heinrichs et al., 2008).

In the study undertaken at Stanford Medical School the OLIVE platform was used to support training of medical staff. Using the OLIVE platform, developers created a replica of the Stanford emergency driveway, entrance, waiting area, acute five-bed suite, treatment area, hospital beds and equipment (Heinrichs et al., 2008). In addition, they created a number of avatars as hospital staff and patients. Physiologically realistic avatars were created that had complex embedded medical models that could be programmed to enable the avatars to exhibit the signs and symptoms including physiological and biochemical parameters of a range of disease states. In addition these physiologically realistic avatars were 'treatable' in that the correct or incorrect interventions produced medically realistic effects.

Two scenarios were mocked up: one for a Sarin (chemical) exposure incident and one for trauma injuries from a 'dirty (radioactive) bomb' explosion. Clinicians created virtual patient models, ten with a nerve toxin and ten with blast trauma, with a total of 20 injured victims. They arrived at the hospital at around the same time and needed to be triaged (arranged into order of urgency):

The vital signs of these virtual victims, related to the dose of the toxin or the severity of the blast injuries as well as to age, sex, and co-morbid conditions...The vital signs are also responsive to fluid, blood, and drug therapy and appear on real-time monitors 'in-world' allowing trainees to make decisions about clinical management.

Heinrichs et al. 2008

A customised pop-up interface was also developed for interactions with the virtual patient models, with resources for queries, examination results and reports from diagnostics (<http://summit.stanford.edu/research/VEDII.html>).

The main learning goals for the study centred upon:

- Performing different roles (team member and team leader) in the area of triaging
- Implementation of the disaster management guidelines and codes for a mass casualty incident
- Assessment and management of patients (from either scenario)

Although the numbers of trainees testing the system was relatively small, interesting findings emerged from the study. The study involved an introduction to the study and a 30-minute hands-on training with the software session. The team then selected a leader, who assigned roles, and then the virtual casualties arrived. The session was followed by a debriefing session, then the exercise was undertaken again, followed by a second debrief. There were 13 volunteers on the study (seven doctors and six nurses). 69% had never played games. The exit survey demonstrated that most were immersed in the exercise and that the training increased their confidence. Most saw the potential of the training for supporting team working as well as learning the necessary clinical skills.

The main strengths of the new learning method included:

- Capacity for distributed teams to train together
- Reproduction of life-threatening trauma cases in safe and reproducible contexts
- Capacity to support team training in lifelike settings
- Capacity to create immersive training conditions

The OLIVE SDK includes development tools, avatars and options for 3D content customisation to allow for distance education, group collaboration and network communities. The case study indicates particular strengths for using the tool for reacting difficult to reproduce in real life situations. The tool allows for diverse scenario training opportunities, and can be used with a wide variety of user groups, from clinical staff to emergency services. Olive is more of a training world than social world, and it has been used exclusively for supporting training needs.



Figure 10: OLIVE: Surgical training. Source: Forterra

Specification for OLIVE platform	
Licensing/costs	OLIVE is available as a licence (per user)
Engine	OLIVE platform
Version	1.0
Platform	Windows, Linux
Media	Licensing

Together the case studies reveal a wide range of applications for virtual worlds. These studies are examples that are in current use. While it is fair to say that educational uses of virtual worlds are behind the uptake in medical, military and emergency training uses, this situation is changing rapidly, and within the next five years virtual worlds are set to become much more widely used in educational contexts. The kinds of uses outlined here will become more developed and refined, and new uses will inevitably emerge. To summarise, these worlds can be used to support virtual events, seminars, campuses and lectures, they can be used to produce hybrid events and experiences that traverse between real and virtual experiences and can be used to integrate a range of applications from document sharing to content production. The potential is being revealed in engaging new learners, supporting scientific simulations and for supporting distributed and international research and learning communities. Virtual worlds will not replace face-to-face learning but will supplement traditional approaches, offering new scope for role plays, scenarios and more learner-driven opportunities for creating learning activities and experiences.

4.0: Challenges and Opportunities in using Virtual World Applications

As this report has noted, there has been a proliferation of virtual world applications over the last five years, and has highlighted how social worlds, training worlds and corporate worlds have particular uses for education and training today including in-world activities, such as virtual lectures and seminars, portfolio production, pre-work training scenarios, role plays and quests (see also Kirriemuir, 2008). With this proliferation of virtual worlds more educational uses and dedicated education-based virtual worlds will continue to emerge supporting different and more specialised learning scenarios, enabling the formation of conceptual skills and greater reflection.

In the future, it is envisaged that multiplayer role play games and mirror worlds also will offer real opportunities for learning. For example, multiplayer role play games may support social learning and mirror worlds may support learning through augmenting and overlaying information. Already, these approaches are being explored in current research projects. However, as with any innovation there are clear challenges as well as opportunities.

Challenges noted here include accessibility and the need for broadband capability, the requirement for open standards and more support for tutors and practitioners aiming to use virtual worlds such as guidelines, case studies and implementation models. To a great extent the technical challenges at least are being overcome, and studies are producing guides for tutors (eg the JISC-funded MyPlan project report guidelines for practitioners using virtual worlds⁴⁴).

The shift to 'exploratory learning', with its greater capacity for modelling learning experiences, in itself provides a central challenge for teaching practitioners well versed in traditional approaches to learning where information transferral from tutor to learner is more characteristic (de Freitas & Neumann, 2008). Placing as it does greater emphasis upon the learner, their pathways and learning design, learning and teaching in this environment becomes rather a production (or 'choreography') of learning activities and experiences (de Freitas, forthcoming). This shift is perhaps a small step towards using virtual immersive worlds for learning and training. Future capabilities of the technologies and our willingness to support them may mean that learning alongside other activities increasingly takes place in 3D or mixed media spaces that blend physical with virtual experiences, offering potential for multimodal learning that blends usage of different media for a seamless learning experience.

An interesting example of how this may work is the emergence of alternate reality gaming (or mixed reality gaming), which allows us to 'blend' experiences in physical worlds with experiences in virtual or web-based worlds. Alternate reality games allow for lower cost alternatives to serious games and virtual worlds, whilst offering potential for getting students out into the physical world to play a casual game based upon a quest. Students may be collecting information about the natural world, following a narrative or recording events. All these have options for learning and may support social learning, as well as fostering exploratory learning skills.

Blending between virtual and real space is taking place in different ways, as virtual spaces impact upon physical spaces, changing how we design and use physical spaces, and conversely as virtual spaces become shaped by buildings and places in the physical world (often replicating them)⁴⁵. Hybrid spaces that allow learners to use elements of both in their learning may become more pervasive as mobile devices proliferate and as online activities come to involve activities in the physical spaces (eg mixed reality gaming). The implications of this trend are leading to greater potential for moving between virtual and real spaces, providing greater scope for mixed reality learning interactions; changing how we design physical learning spaces, leading to notions of 'smart

⁴⁴ For MyPlan project report D6.2, see www.lkl.ac.uk/research/myplan.

⁴⁵ Research at the Serious Games Institute (SGI) for example is exploring the notion of 'smart spaces' whereby links between real and virtual spaces are supported. One project looks at using control systems in virtual worlds for controlling interactions, energy management and user movement flows in real buildings. Another SGI project is overlaying avatars in virtual worlds onto real spaces using chroma key methods in order to support virtual-real interactions. A third project is using sensor technologies in the real environment to promote changes in-world, reflecting building usage and content delivery. For more information see www.seriousgames.org.uk

spaces' and more interactive and flexible spaces; and presenting opportunities for hybrid teaching scenarios, leading to, for example, more opportunities for multimodal learning and teaching. While the full potential for using these approaches is not clearly defined, it is worth thinking about how virtual and real interactions could support practical learning and teaching strategies particularly with regard to supporting and augmenting e-learning.

The proliferation of virtual worlds has led to major technical differences between platforms, and because of this open standards in the field are required. The number and diversity of virtual worlds presents a major challenge for educationalists and others aiming to produce seamless experiences that cross between the boundaries of virtual and real, leisure and non-leisure, work and play, learning and relaxation. IBM and others are exploring virtual world open standards and the capability for moving avatars between worlds could open up interesting potential for supporting more seamless flows between worlds, as well as allowing users to move assets.

Opportunities include more engaging learning experiences, particularly useful for hard-to-reach learner groups and those that are currently unengaged or for teaching subjects such as maths and science. The real opportunities for virtual worlds, like game-based learning, lie in increasing learner empowerment over activities and assignments undertaken in-world, that is through giving the learner control over their avatar, encouraging more personalised learning pathways and providing more opportunities for learner reflection. This may be well exploited by distributed, distance and online learner groups, or for unmotivated and unengaged learner groups; also learners with disabilities or with mobility issues may be supported via virtual worlds, overcoming as they do the need to travel. Virtual worlds also provide an excellent infrastructure for distributed research communities to interact and work collaboratively providing significant advances in terms of functionality and engagement from teleconferencing and videoconferencing. Scope for cross-disciplinary interactions and training may also be well supported through this means due to its support for global interactions and integrated functionality such as oral communications, integrated simulations and sharing documents.

With gaming and virtual worlds the boundaries of our lived world have extended beyond physical space, and this has huge potential for learning (and learning through play). It is notable that there are many virtual worlds rather than one virtual world emerging, and with these worlds there are many potentialities for how we learn. Reflecting upon this, the model for assessment in the future may rest upon a more flexible model of assessment consisting of traditional approaches based upon oral presentation (eg vivas) and written outputs (eg dissertations) that are based upon 'shared knowledge' (or curriculum), with new multimodal methods of assessment consisting of self- and peer-assessment strategies reflecting different approaches to analysing and interpreting learning activities and experiences. This may have implications upon how we create and guide activities in those training and new educational worlds. However, it would be essential that new multimodal approaches to assessment integrate analytical as well as descriptive skills.

An innovation here might include the more dynamic, personalised and integrated 'living curriculum'. This might include greater learner involvement in developing learning 'trails' or pathways which may lead to a balance of exploratory and experiential approaches based upon grounded life skills, reflection and life-planning. Reflecting the trend for e-portfolios, this may integrate scope for personal mentoring and tuition as well as collaborative learning, role play, and scenario-based and game-based learning. An example of this trend is the increasing participation of learners in the process of developing worlds, co-constructing content and undertaking activities in-world. For instance, with social software tools often dominating students' social life, the tendency to photograph, video and blog about daily activities is becoming more pervasive reflecting this shift to perhaps more subjective modes of learning and known collectively as 'life-logging' (Smart et al., 2007).

4.1: Participation of learners in constructing spaces, content and activities

Nowhere is the trend of 'self-organising communities' more pronounced than through the use of virtual worlds and social software tools (discussed in de Freitas, forthcoming). Online communities are evolving as we have seen in considerable numbers, eg 15 million in Second Life in August 2008, up from 6.7 million in 2007. See **Table 5**. As

an instance of this growth, Linden Lab (Second Life developers) are adding 120 servers each week and increasing land mass size rapidly. While active users (who spend more than one hour per week) may be considerably smaller in number than registered users, Linden Lab estimates that half of all first time users do not return, a factor attributed to scalability and stability of the platform and usability issues: currently only 70 avatars can be hosted on each island simultaneously. However, for those users that do return, the range of activities and engagement of these users is considerable (Lorica et al., 2008).

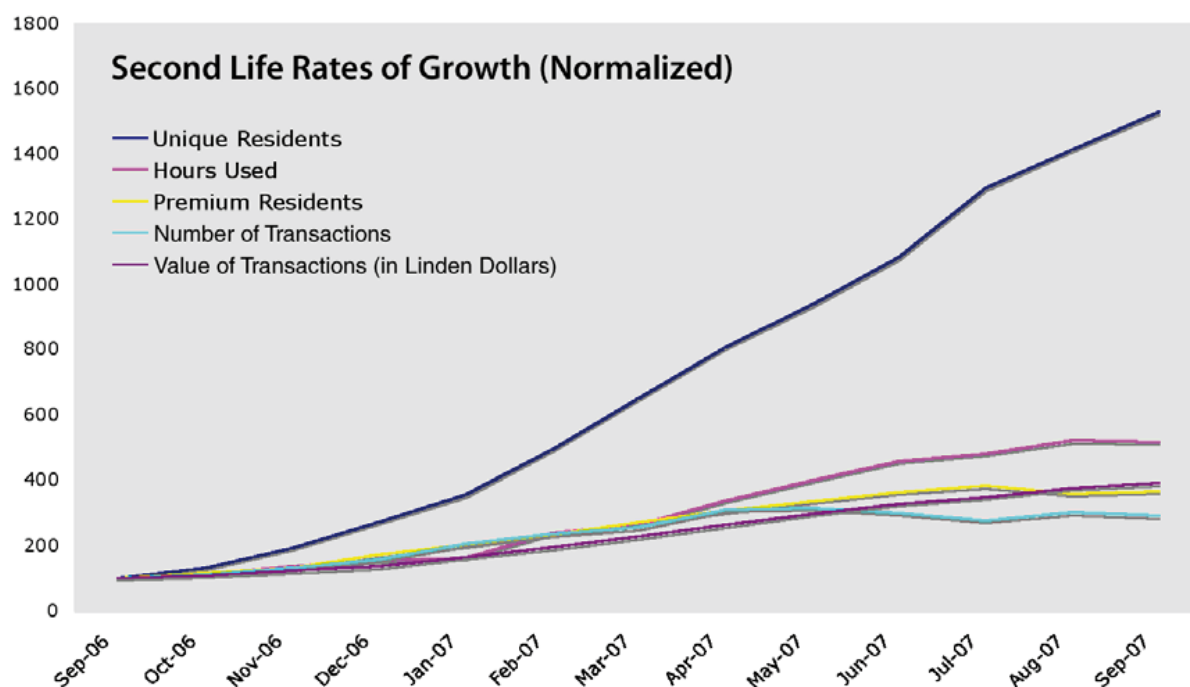


Table 5: Second Life usage growth rates, 2006–2007. Reproduced from Lorica et al. 2008

These online virtual communities are growing rapidly particularly for younger learners, with more than 100 virtual worlds for children and young adults now live or under development (Virtual Worlds Management, 2008). This is clearly not a flash in the pan, in fact the uptake of virtual worlds, with their blend of user control through avatar use, development of content and objects through construction tools and collaborative interactions through social and collaborative software tools, is integrating a wide range of functionality that has increasing appeal to younger and older users. Second Life has an average age of 35 indicating how engaging these tools are for older learners as well as younger ones. In earlier user studies conducted by the author, it was striking how much more functionality younger learners could manage than had been expected according to standard usability best practice (user studies undertaken in the JISC-funded L4All project, de Freitas et al., 2006), and in current user studies with younger and older learners being tested using Second Life both groups have been engaged with the medium, although in the study with mature students, one female user did find the interface difficult to adapt to and was put off by the SMS-style text-based communications used (results and guidelines to be published from the JISC-funded MyPlan project study).

Self-organising communities, such as those found in online virtual communities, are all about extending communications and collaboration with often distributed groups. Apart from social networks analysis of online communities, online gaming communities have not been extensively studied, due to the recent nature of the field and the comparative lack of methodological tools. Therefore more evidence-based research and new methods for data collection and analysis supporting this area would be invaluable. What are the patterns of self-organised communities? Will they build up and then collapse as users migrate to new worlds? Will the communities reform in different ways? What longevity will they enjoy? What elements of virtual worlds are most engaging? Studies that focus upon these issues may help us to identify how best to support these communities in relation to learning support, pedagogic modelling and institutional and public policy development.

Clearly there are challenges that we need to be fully aware of, and that have been highlighted in some of the reports reviewed here (eg Lorica et al., 2008; Smart et al., 2008), and these include the issues of security, intellectual property rights, open standards and interoperability. In addition there is a need for guidance, as well as legal checks, to ensure that the virtual worlds we will inhabit conform to real world levels of quality and support. Issues such as 'griefing' (eg restricting the movements of other avatars, disrupting in-world events through nudity and denial of service attacks), as has been seen in Second Life and other virtual worlds, indicate that there will always be a small minority of users who will try to flout laws and regulations, and the availability of cybersex and gambling also needs to be considered, especially when working with vulnerable adults and children (Lorica et al., 2008).

The use of avatars is an integral aspect of the success of virtual worlds, and theories such as the Uncanny Valley theory consider how life-like an avatar needs to be for the user to identify with it. The Uncanny Valley theory, developed in 1970 by Japanese robotics engineer Masahiro Mori, argues that the robot can only become so life-like, if too life-like it becomes repulsive for the user (Mori, 1970). This theory has yet to be proven, however avatars are clearly powerful for identification of users. An interesting observation is that children think of their avatars as other than them, while adults identify closely with their avatars. This throws up scope for analysis around issues of identification and avatar usage in particular with implications for the development of 'chat bots' (machine driven avatars) and the use of artificial intelligence.

One last aspect worth mentioning briefly here with respect to the role of the learner lies in the area of interface development; it is here that some of the great breakthroughs for the next five years will take place. We are already seeing innovations such as Neurosky, a headset application which allows users to interact with immersive environments using their brainwaves. More user devices are to come including more sophisticated handheld and wearable devices. Together these will aid the process of immersion and help users to engage more closely with the 3D environments that they inhabit. More research is needed that helps to integrate these devices with a focus upon seamless experiences. This may provide real potential for education and training over the coming years, particularly for learners with disabilities such as visual or aural impairments, and 3D sound interfaces and perambulatory interfaces are already at the installation stage in some of the UK research labs (eg Serious Games Institute, the Digital Laboratory). We will continue to see these in development and use over the next five years.

It is clear that the learner is a fulcrum around which social interactions occur in-world. In the context of virtual worlds and social software, the learner is part of a set of self-organising communities. In addition, the learner is also a producer of content with control over how the environment looks and how social interactions are supported. But the learner is also a sensing individual interacting within multiple and sophisticated environments, one that is moving to centre stage with regards to the 'virtual world revolution', technological advances and the prevalence of social software applications. This holds different messages for learners, tutors and institutions and for policy makers as well as developers. For learners, the future holds a vision of increased interactivity with virtual environments and more engaging learning experiences relating to production of content as well as information access. For tutors, the process of learning and teaching in virtual environments will broaden possibilities for multimodal and exploratory learning.

While learning in virtual environments may be collaborative the role of the tutor in developing learning activities and experiences is no less important and as such the key challenges will have much in common with learning and teaching in physical environments. Which learning methods to adopt, which tools to use and how to assess these activities are central questions. But in addition questions that centre upon how to blend media with face-to-face interactions, how to support debriefing and reflection and in what ways collaboration can be best supported in-world will be central.

For the institutions the imperative of resolving the tension between control over systems and access to web-based systems will continue. In addition virtual world learning implies a need to revisit the structures of learning and the basic components of learning. Models that support flexible structures that allow for innovation to be diffused across teaching practices, and that support less of a gap between research outcomes and teaching

practices should be investigated. For example, time scales for learning may need to be longer, and there may be opportunities for cross-disciplinary learning. New approaches to assessment and accreditation may evolve through increased potential for cross-national boundary education, cross-sectoral course development (eg with industry) and international online learning classes.

For policy makers the implications of virtual worlds for learning are beginning to be felt, and groups such as the Virtual Policy Network⁴⁶ are bringing together government groups with academics and industrial partners to answer questions around intellectual property rights, cyber law and interoperability, as well as skills shortages and growing economic development. The message for policy makers then centres upon a need to engage with what is happening in the emerging commercial and educational activities in virtual worlds and to ensure that real-world laws and regulations are maintained.

For developers, the challenges are considerable due to the fast changing technology in the field and related fields of games development and interface design. Developers, and development companies, will need some support from government to achieve the potential envisaged, however the global nature of the emerging industry makes the sector an inherently competitive one, and collaboration with other companies is imperative. However, while the applications are evolving the need to test and evaluate the products and applications with user communities is essential, and developers need to work closely with users such as educational groups to ensure that applications are maximised and rolled out to the widest audiences. While the technologies are advancing apace, the need to maintain touching distance with user communities is even more vital.

In conclusion, a commitment towards participatory approaches at all levels of engagement seems a central requirement of future development, but we also need a commitment to ensure that the basic levels of education are maintained for future generations. The tension between participation, learner control, educational standards and quality assurance may provide a framework for ongoing work in this space, and accurate benchmarking metrics for evaluation and validation are still a primary objective.

4.2: Blending between virtual and real spaces and experiences

The visions of Stephenson, Gibson, and E.M. Forster in 'The Machine Stops', although substantially close to our modern interpretation of cyberspace as all-pervasive and engrossing are also substantially incorrect. For example, while Forster envisaged a world starved of social interaction in his dystopic image of the future, with everyone stuck in small rooms, the reality has been a dramatic move towards social interactions. In addition the capability of mixed reality to create seamless experiences between real and virtual spaces is notable in terms of rewriting our notions of space in quite radical ways. While learning has gone multimodal, the capacity to engage with spaces in more fluid ways in parallel provides a major driver for the 'virtual world revolution'.

The isolation dystopic model of cyberspace is reversed in the emergence of mixed reality games and worlds. The work of Blast Theory and the Mixed Reality Lab at the University of Nottingham ('Can you see me now?' (Benford et al., 2006) and 'Day of the Figurines' (Flintham, 2007)) are excellent UK examples of this approach, which seeks to blend real and virtual spaces. In 'Day of the Figurines', for example, real players are represented by 1,000 plastic dolls moved around a fictitious town, players move their dolls via SMS (short messaging services) texting, and are invited to respond to the deteriorating situation by making decisions. The relatively low tech approach to interactions, as players transform and are transformed by the virtual spaces, provides a model for how 'boundary objects' such as mobile phones can be used to traverse real and virtual spaces, and how metaphor can be used to create pervasive social interactions. The form of mixed reality experiences has potential for educational institutions due to relative low costs. Mixed reality games (or alternate reality games) allow users to cross the boundaries of virtual and physical spaces by using mobile devices, or sensors in the physical world. This trend is one that may have particular possibilities in learning and training contexts, as it allows for social engagement and collaboration, through role plays, low cost exercises and large numbers of participants.

⁴⁶ For more information about the Virtual Policy Network, see: www.virtualpolicy.net

Another example of how hybrids and blends of virtual and real spaces are emerging is seen in the form of 'mash-ups', including large datasets such as Geographic Information Systems (GIS) and mirror worlds such as Google Earth, which give new texture to information retrieval methods, and allow for greater manipulation of data by users whilst creating tangible links between virtual and real space (Leigh & Brown, 2008). The mirroring of real spaces and overlaying data onto these representations is becoming a widespread metaphor, and has real teaching potential, due to augmenting datasets and helping learners to visualise concepts, but also for providing links through to related datasets such as document indexes. The approach could be very useful for the research community as well. There are numerous examples of this approach. One being pioneered by Boulos and Burden (2007) is using mash-ups with Google Earth and Second Life to allow real time mapping of data in Second Life. The application is being used to support life emergency room situations and for public health applications.

Building links between real and virtual spaces is an approach that is also being piloted at the Serious Games Institute in partnership with Cisco and Giunti Labs, who are developing location-based tracking systems to be used in mixed reality games, as well as working with Implemia on Second Life tie-ins to be used for monitoring and controlling building systems in the real world from the virtual world, an area of activity that may have educational applications, eg for school and university energy conservation⁴⁷ as well as applications for independent living in health.

A final instance of blending real and virtual spaces brings together augmented reality technologies and is being piloted currently in museum settings (eg White et al., 2007). The use of mobile phones for delivering augmented datasets is becoming more widespread. In addition the overlaying of information in virtual worlds may have potential for supporting history teaching on site and during field trips, extending the reach of learning to include living and virtual archaeology (eg Margounakis, 2008).

Together these and other 'convergent technologies' and mash-up applications are having a radical impact upon the way that learning, teaching and research are being undertaken and have the potential to transform education. It is envisaged that over the next five years we could see some radical changes to what we learn, how we learn and how learning is delivered to students in relation to virtual worlds and social software in particular.

⁴⁷ For more information see the Serious Games Institute's website at: www.seriousgames.org.uk

5.0: Conclusions

This report has aimed to begin the process of mapping the territory of virtual world applications with regard to educational uses. As can be seen, both from this report and from the author's previous work, the area is large in scale due to the number of virtual worlds, the numbers of users and the potential reach of the applications to so many disciplines and sectors. The review is by no means comprehensive and many virtual world applications are either under development or outside the scope of this review. The scale of the numbers of virtual world applications alone may be surprising to some new to the area, and may be daunting for researchers aiming to participate in the academic debate around the area. However it must be emphasised that though the virtual worlds are diverse in applications and while there are a good number of virtual worlds out there the number is significantly lower when we consider the virtual worlds that have relevance for learning and education, as reflected in the selection of the five case studies where educational activity is more pronounced.

The review has aimed therefore to scope the field and provide a starting point for others to follow. While there is currently little peer-reviewed information in the area, this is changing and several large studies are underway looking at how virtual worlds can support learning and training. We await the publications from these studies eagerly, and special issues from a number of leading educational journals including the *British Journal of Educational Technology* are in the process of compilation.

It is clear that the social worlds, training worlds and corporate worlds have the most relevance for education and training, however the use of multiplayer role play games may have real educational potential in the longer run, and we await findings from research to help frame activity there. We are also seeing the beginning of real applications for mirror worlds in the area of education and research, and anticipate new developments there over the next five years.

The case studies have shown a diversity of ways of using virtual worlds, including mentoring, constructing learning activities, exploratory trails and quests, role plays and rehearsals of skills, but the potential uses of serious virtual worlds extend beyond these. In addition, virtual worlds are beginning to offer a new infrastructure for supporting a range of cross-disciplinary collaborative research and learning opportunities, which are only beginning to emerge, opening up scope for collaborative research projects and the development of new tools.

The support of cross-disciplinary communities such as Piet Hut's networks in Qwaq Forums may change the locus around which research takes place. Virtual seminars and lectures, activities and experiences similarly have the potential to extend beyond our normal consideration of the infrastructure of learning, for example changing the usual times and duration of learning and placing an emphasis upon learning processes that are sustainable over longer periods. Learning communities supported in virtual worlds may have implications for pedagogic models employed, the contexts of learning, the different ways that learning contexts are represented and change learning profiles. However, it seems likely that many of the familiar metaphors of learning (such as the classroom and the lecture hall) will become embedded into new virtual learning practices and an exchange of traditional and virtual learning practices may result. Either way, it is important that educational institutions and staff are involved in the development and use of virtual worlds for learning, so that pedagogic and learning design approaches that reflect the teaching communities are embedded into virtual learning processes.

While the use of immersive world applications is clearly maturing in areas such as business and health training, there are still significant challenges that remain such as a need for common standards and the validation of assessment and evaluation techniques. This presents the community of learners, tutors, institutional management, policy makers and developers with interesting challenges when considering how to respond to the future of learning. For example, if content in the future becomes more generated by learners than tutors this will of course have an impact upon the role of the tutor, as we have seen in online learning. However, it is through engagement with the new tools that tutors can begin to see how their skills should be best employed.

A debate between developers, educators and designers is needed to ensure that these challenges are met positively, and to ensure quality in all areas of academic and educational practice. These collaborations have

already begun in the research community and will, it is hoped, continue to underpin development in the area of serious virtual worlds. Although virtual worlds have been around for over 20 years, it is only really in the last five years that the real potential for virtual worlds has been recognised, and the next 20 years could bring about a virtual world revolution that has the capability to radical shift how we learn. To ensure that this revolution is successful at engaging students and supporting the development of higher order thinking skills it is vital that we work together as a community and integrate our plans so that the learners of the future have an educational system that gives them an enriched learning experience, does not suppress creativity and helps to create a cohesive community that works together for the greater good.

To ensure that this happens, we need to monitor closely what the exact implications will be of virtual self-organised communities, we need to refocus our educational practices upon the key aims and objectives of our society and we need to find ways to promote excellence in cross-disciplinary research and methodologies. We would also benefit from shorter timescales for peer-review to reflect the fast changes in our society. While virtual worlds may suggest a new infrastructure for cross-disciplinary encounters, the traditional quality levels need to be maintained: validation, assessment and accreditation are still an integral aspect of this and the need to raise standards of education rather than dumb them down should be a priority at a time when more educational tools are available. We need to work together to ensure that tutors have everything they need to maintain high standards and support them in the more creative process of choreographing learning experiences that they will need to help create for our learners.

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Appendix A: Experts Consulted for the Review

Due to all the research limitations of such a new field, in particular with respect to a dearth of relevant peer-reviewed materials, the author has where necessary consulted the leading specialists in the field. By way of acknowledgement of their inputs, many thanks to the following subject matter experts who were consulted during the process of producing this report. This report has been reviewed by Heather Williamson (JISC, UK), Dave Taylor (Imperial College, London, UK), Martin Oliver (Institute of Education, London, UK), Tish Shute (Consultant, US) and George Veletsianos (University of Minnesota, US).

Expert	Organisation
Kevin Ayres	IBM, UK
David Burden	Daden Ltd, UK
Diane Carr	Institute of Education, University of London, UK
Dick Davies	Ambient Performance, UK
Ron Edwards	Ambient Performance, UK
Tom Fournier	Active Worlds, Inc., US
Russell Francis	University of Oxford, UK
Bernard Frischer	University of Virginia, US
Michael Gardner	University of Essex, UK
Oliver Goh	Implenia, Switzerland
Chuck Hamilton	IBM, US
Bernard Horan	Sun Microsystems, UK
Andrew Hudson-Smith	University College London, UK
Piet Hut	Princeton University, US
Seema Iyer	Sun Microsystems, US
Leigh Jackson	Department of Business, Enterprise & Regulatory Reform, UK
Aleks Krotoski	University of Surrey, UK
Fotis Liarokapis	University of Coventry, UK
Martin Oliver	Institute of Education, University of London, UK
Jude Ower	Digital 2.0, UK
Andy Powell	Eduserv, UK
Genaro Rebolledo-Mendez	Serious Games Institute, University of Coventry, UK
Ren Reynolds	Consultant, UK
Roo Reynolds	IBM, UK
Michelle Roper	Federation of American Scientists, US
Maggi Savin-Baden	University of Coventry, UK
Tish Shute	Consultant, US
Soulla Stylianou	Daden Ltd, UK
Dave Taylor	Imperial College, London, UK
Paul Turner	Walk in Web, UK
George Veletsianos	University of Minnesota, US
David Wortley	Serious Games Institute, University of Coventry, UK

Appendix B: Glossary of Terms

Term	Definition
Artificial intelligence	Artificial intelligence (or AI) was first used by John McCarthy in 1956 to describe the science and engineering behind intelligent systems. The term today applies to the design and study of intelligent agents which are systems that perceive the environment and interact intelligently within it. Artificial intelligence is used to support chat bots in virtual worlds allowing machine-driven avatars to interact with human-driven avatars.
Avatars	Avatars are visual representations of the user or learner in-world. The visual representations are usually (but not always) human in form; they can also be animal representation (such as furies in Second Life) or penguins in Club Penguin. Avatars allow users of the virtual worlds to control movement and activities in-world and help users to identify more closely with the virtual representations.
Bots	Bots are applications developed in-world. Chat bots are machine-driven avatars that may provide information and conduct tours around the virtual world. These are driven by algorithms that are increasing in sophistication.
Exploratory learning	Exploratory learning, as defined by the author in the context of the exploratory learning model, relates to experiential learning, and extends from this to include virtual experiences as valid forms of learning supported within open-ended learning environments but filtering back into abstract conceptualisation and testing (see de Freitas & Neumann, 2008 for full explanation).
Griefing	Griefing occurs in-world and includes such actions as restricting the movements of other avatars, disrupting in-world events through nudity and denial of service attacks.
Lifelogging	Lifelogging is the activity that allows users to log aspects of their lives through images, videos or text entries using social software tools such as Twitter.com or Facebook.
Massively Multiplayer Online Role play Games (MMORGs)	Massively Multiplayer Online Role play Games (MMORGs) such as Everquest and Guild Wars have very large user numbers and provide immersive role playing for gamers. The 3D environments utilise collaboration in-world and often centre upon quests.
Mirror worlds	Mirror worlds are worlds or 2D/3D visualisations that mirror the physical world. Google Earth is the most well known of these worlds; other examples include Digital Earth.
Mixed reality	Mixed reality is the ability to use different media forms to bring together digital information with real-life physical experiences. Increasingly the blend between real and virtual spaces is becoming possible through use of multimedia tools, sensors in the environment and physical experiences. In terms of games, the term Alternate Reality Games (ARGs) has been coined and in virtual worlds the use of mash-ups between different applications can be considered to be part of creating mixed reality experiences.
Multimodal learning	Multimodal learning uses different media modes to support learning practices. There is some evidence from studies in e-learning that using more than one mode of learning can be more effective due to how humans learn, eg through five senses.
Multi-Object Orientated Multi-User Dimensions/Dungeons (MOOs)	Multi-Object Orientated MUDs (MOOs) are MUDs with objects that can be used.
Multi-User Dimensions/Dungeons (MUDs)	Multi-User Dimensions/Dungeons (MUDs) are text-based non-graphical virtual worlds.

Term	Definition
Problem-based learning	Problem-based learning is a learner-centred and problem-centred approach to learning which focuses upon collaborative approaches. The approach fits well with exploratory learning and virtual environments due to its collaborative and social emphasis.
Self-organised community	A self-organised community may be an online virtual community that organises its own structure, laws and regulations.
Serious games	Serious games are games for non-leisure purposes. Games may be PC-based, console-based or used on mobile devices. Mixed reality games (or ARGs as above) blend computer and physical world gaming activities.
Social worlds	Social worlds are virtual world applications where activities primarily focus upon social interactions and interchanges, such as chat, in-world meetings and attending events. Examples of these include Second Life and Active Worlds.
Software Development Kits (SDKs)	Software Development Kits (SDKs) are development kits that are relatively simple to use, allowing non-developers to change code and system functionality. In general, these are used by technically savvy users or hackers, but the SDKs are becoming more and more easy to use allowing more people from outside the development community to engage with developing systems, and modding (or altering) them.
Uncanny Valley theory	The Uncanny Valley theory was put forward by Masahiro Mori in 1970, who proposed that robots should not look too realistic. The theory has since been applied to avatars but has not been proven.
Virtual worlds	A virtual (immersive world or metaverse) is an interactive environment (often in 3D or animated graphics), which can be used by many users at the same time. Virtual worlds have also been termed immersive worlds, immersive virtual worlds, MMOGs and simulated worlds, among other terms. Such widely different use of terminology can be confusing for users and novices. In addition, as functionality can be very different, terms such as social worlds and mirror worlds are also coming into common parlance. Another term, 'serious virtual worlds', has been coined to distinguish between the use of virtual worlds for leisure and non-leisure purposes.
Voice Over Internet Protocol	Voice over Internet Protocol (or VOIP) refers to systems such as Skype or in-world audio channels that allow voice files to be transferred over the internet via internet protocols.

Appendix C: List of Virtual Worlds

	Virtual world application	Description	URL
1	Active Worlds	Active Worlds hosts a universe of over 1,000 3D virtual worlds. Active Worlds' most popular world is AlphaWorld. Access to the worlds is free and facilities there include shopping, chat and playing online games.	www.activeworlds.com Last accessed 15 April 2008.
2	Active Worlds Educational Universe	Active Worlds Educational Universe is an entire Active Worlds universe allocated for educational activities. The aim is to make the Active Worlds technology available to educational institutions for a lower cost.	www.activeworlds.com/edu/awedu.asp Last accessed 15 April 2008.
3	Atari's Virtual World	This planned world will not be a virtual world like Sony's Playstation Home (see 29), but will allow users to craft their own experiences. They will be able to control their own development tools and create simple and complex games.	www.mcvuk.com/interviews/9/Ataris-Online-Revolution Last accessed 15 April 2008.
4	Areae – Metaplaces	This planned virtual world will include development tools that will allow users to create their own worlds and games easily and very quickly.	www.areae.net Last accessed 15 April 2008.
5	citypixel.com	Citypixel is an animation-based virtual world. Users can lease flats, play games and chat with neighbours. It is more of a social world and is free to join. There are currently 26,541 city residents in-world.	www.citypixel.com Last accessed 15 April 2008.
6	Club Penguin	Part of the Walt Disney Company, Club Penguin was set up in 2005. It is a virtual world aimed at children, and is used for playing games, interacting together and playing.	www.clubpenguin.com Last accessed 15 April 2008.
7	The Croquet Project	Croquet is an open source software development community supporting the creation of virtual worlds. Based upon Squeak architecture, it is used to support resource sharing, collaboration and communications between its users.	www.opencroquet.org Last accessed 15 April 2008.
8	Cybertown – Civilization for the Virtual Age	Cybertown is a private futuristic 3D virtual world. The social world supports personal chat and free email. Citizens can shop online, play games and interact with others. Role playing games are integrated with live events.	www.cybertown.com Last accessed 15 April 2008.
9	Cyworld	Cyworld is a South Korean social online community. It encourages a buddy system, exchange and storage of photographs, and has bulletin boards. The social world commands around 20 million unique visitors each month. As many as 90% of South Koreans aged in their 20s are registered users of the world.	www.cyworld.com Last accessed 15 April 2008.
10	Entropia Universe	Mindark's Entropia Universe is a continuation of Project Entropia. It allows for money made in-world to be easily converted back into real money. The social world also allows for businesses and entertainment. It is free to download and doesn't use subscription charges.	www.entropiauniverse.com Last accessed 15 April 2008.
11	Forterra Systems' OLIVE	Forterra's Online Interactive Virtual Environment 1.0 platform has been used for training purposes. It is a private world, and can be accessed through licensing payment structures. It has been used for military, medical and professional purposes.	www.forterrainc.com Last accessed 15 April 2008.
12	Gaia Online	Gaia is a social world for teens. Here users play games, create their own space and profiles, chat and explore. Around 300,000 members log into Gaia each day. There are shops and online forums and videos to watch.	www.gaiaonline.com Last accessed 15 April 2008.

	Virtual world application	Description	URL
13	Google Earth	Google Earth is a mirror world. It combines powerful Google searching functionality with satellite images, including maps and 3D visualisations of buildings and cities. Searchable via postcode, the resource is being used for a range of purposes from finding directions to research and education.	http://earth.google.com Last accessed 15 April 2008.
14	Habbo	Habbo is a social networking site for teens. It was launched as Habbo Hotel in 2000 in Finland and since then has become popular internationally. It is animated rather than 3D and includes chat rooms and discussion forums. Each user is a 'habbo' and can customise their avatar. With six million unique users per month (in 2007), 70% of Habbos are 13–16 years old.	www.habbo.com Last accessed 15 April 2008.
15	Hipihi	Currently in beta testing, Hipihi is a Chinese virtual social 3D world created by its residents. Graphically it is very attractive and in terms of functionality is closest to Second Life. The user demographic is slightly more female than male. Subscription to Hipihi will be free but services in-world may be charged.	www.hipihi.com/index_english.html Last accessed 15 April 2008.
16	IMVU	Palo Alto-based IMVU offers 3D chat, customisable avatars and a 3D environment. In beta testing, this more social-orientated software has a free sign up and 3D messaging. The world also includes virtual currency and the opportunity to create and sell products.	www.imvu.com Last accessed 15 April 2008.
17	Lego Universe	Lego Universe is still under development. It will be a massively multiplayer game and is being developed by NetDevil.	http://universe.lego.com Last accessed 15 April 2008.
18	NASA World Wind	Originally released in 2004 by NASA, World Wind (1.4) is a free, open source mirror world. The geobrowser overlays NASA satellite imagery, aerial photos and publicly available GIS data onto a 3D model of the Earth. It allows users to zoom in from satellite pictures.	http://worldwind.arc.nasa.gov Last accessed 15 April 2008.
19	Media Machines	Under development, Media Machines is a social world which uses 3D visuals to support social networks, avatar creation and personalised content.	www.vivaty.com Last accessed 15 April 2008.
20	Media Grid: Immersive Education	Immersive education is a Media Grid initiative which combines 3D graphics, games and simulation technology, voice chat and rich digital media for supporting collaborative learning online. Made available to university students the world is now being piloted with school children and corporate training. It aims to create a more immersive experience in support of learning objectives and curriculum, using a computational grid development platform designed for networked applications that use digital media.	http://immersivededucation.org Last accessed 15 April 2008.
21	Microsoft Virtual Earth	The Microsoft Virtual Earth platform integrates geospatial data, maps and images to present a mirror world for users. It works as a geobrowser, and has been used by cities such as Miami to integrate data from GIS, thereby creating layers to help navigate through information and consumer services. Used as a mapping tool, for design and to aid awareness about natural disasters, the mirror world can be used for mash-ups with other applications.	www.microsoft.com/virtualearth Last accessed 15 April 2008.
22	moove online	With 780,000 users worldwide, moove online is another social world community based upon avatars and social interactions. The system is accessible via the 3D client Roomancer, released in 2001.	www.moove.com Last accessed 15 April 2008.

	Virtual world application	Description	URL
23	Multiverse	Multiverse is a technology platform for creating high quality MMORGs, non-game virtual worlds. Recently they announced the capacity for using 2D flash-based versions of virtual worlds with their platform, allowing users to view the world on the web as a 2D world and using the 3D world viewer as a 3D world.	www.multiverse.net Last accessed 16 April 2008.
24	The musiclounge / vSide	Billed as the 3D Facebook, this online 3D style social space for teens has been created by Doppelganger. Online parties and the use of cartoon-like avatars and forums are designed in a stylish way to attract teens.	www.themusiclounge.com Last accessed 16 April 2008.
25	Nicktropolis	Nicktropolis is a large online community for children. The emphasis in this world is on use of games. The look is animated and the functions include swapping stuff, socialising with friends, watching videos online and playing games. The community has around seven million registered users and is free to join.	www.nick.com/nicktropolis Last accessed 16 April 2008.
26	Ogoglio	Ogoglio is an open source virtual world application used for creating other virtual world applications. The project is under development but aims to provide the usual functionality of a virtual world.	www.ogoglio.com Last accessed 16 April 2008.
27	Open Source Metaverse Project	The Open Source Metaverse project provides an open source platform similar to Second Life and There.com. The serve engine can be installed locally so users can create their own metaverse (analogous with the Apache web server for web content). It is modular, flexible and extensible.	http://metaverse.sourceforge.net Last accessed 15 April 2008.
28	Open Simulator	The OpenSimulator project is a virtual worlds server for creating 3D virtual environments. It has been described as a reverse engineered Second Life, and allows users to run their own Second Life island on their own PC without opening up firewalls. It can be run as a standalone application or as a collaborative world like Second Life. It is written in C# and is modular, allowing developers to extend functionality via plug-in modules. The next step is to allow users to move objects between OpenSim and Second Life.	http://opensimulator.org/wiki Last accessed 16 April 2008.
29	PlayStation Home	Under development, Playstation Home will be a community-based service for Playstation users. It allows users to create their own avatars for their console (3) and have apartment space, and in the future users will be able to create their own content. The launch is scheduled for Autumn 2008.	http://en.wikipedia.org/wiki/PlayStation_Home Last accessed 16 April 2008.
30	Project Wonderland	Under development, Project Wonderland, based upon Sun Microsystem's Darkstar technology, is a virtual worlds toolkit for creating collaborative experiences. The application allows for document sharing and games. The project is open source, and in demos reveals particularly strengths with supporting virtual meetings and voice chat.	https://lg3d-wonderland.dev.java.net Last accessed 16 April 2008.
31	Protosphere	Protosphere is a virtual world under development. Produced by Protonmedia for business uses, the platform will offer the usual functionality of avatars, social networking and a 3D interface.	www.protonmedia.com Last accessed 16 April 2008.
32	Qwaq Forums	Qwaq forums is a quick solution for creating virtual meeting places, based upon Croquet (Squeak). It is aimed at supporting virtual collaborative solutions for enterprises. It offers document sharing, programme management and virtual operations centres, as well as corporate training capabilities.	www.qwaq.com Last accessed 16 April 2008.

	Virtual world application	Description	URL
33	Second Life	Second Life is a 3D virtual world launched in 2003. The emphasis here is on creating your own avatars and content, but the Linden dollar is the main currency. With over 13 million residents, Second Life is one of the more popular virtual worlds, possibly because the barrier to joining the community is so low in terms of PC specification and its free membership. See case study.	www.secondlife.com Last accessed 16 April 2008.
34	Teen Second Life	Also developed by Linden Lab, based in San Francisco, Teen Second Life is aimed at teenagers aged 13–17 and supports similar functionality to Second Life.	http://teen.secondlife.com Last accessed 16 April 2008.
35	There.com	Also offering free membership, there.com provides text chat, instant messaging and customisable avatars. Again it is a social world and 'therebucks' are the virtual currency used. The technology is the basis of the Forterra platform.	www.there.com Last accessed 16 April 2008.
36	Tixeo	Tixeo is a live 3D meeting tool aimed at enterprise. The products include 3D meeting and 3D workstation. Available to demo for free.	www.tixeo.com Last accessed 16 April 2008.
37	Uni-verse	Still under development, Uni-verse is a European open source internet platform for 3D interactions for home, public and personal use. Verse is the foundation of the platform, and is a network protocol for 3D data. By sharing data, it allows many applications to act together as a large system.	www.uni-verse.org Last accessed 16 April 2008.
38	Unype	Unype is a location-based social application platform. It is a mirror world, and acts as a mash-up between Google Maps, Google Earth and social software, including Twitter, Facebook and Ning.	www.unype.com Last accessed 16 April 2008.
39	Kaneva	In beta testing, Kaneva combines social networking with a virtual world. A social world, Kaneva allows for avatar customisation, social chat and sharing of interactive content.	www.kaneva.com Last accessed 16 April 2008.
40	Whyville	Whyville is a social world for children. It has its own newspaper, senators, beach, museum and economy. It has millions of registered users and supports game-playing.	www.whyville.net Last accessed 16 April 2008.

List collated by the author using online web searches and the informative resource at <http://leducation.wikispaces.com>

Appendix D: Useful Resources

The following links to useful resources can be used to gain more information about individual virtual worlds and provide excellent resources for researchers.

Educational resources for Second Life. Last accessed on 17 April 2008 at:

www.simteach.com/wiki/index.php?title=Second_Life_Education_Wiki

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www.mmogchart.com

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www.seriousgames.org.uk

Terra Nova: is an informative blog that focuses upon virtual worlds. Last accessed on 18 April 2008 at:

<http://terranova.blogs.com>

Virtual Worlds News. Last accessed on 18 April 2008 at:

www.virtualworldsnews.com

Virtual Worlds Review: an overview of what is happening in virtual worlds. Last accessed on 18 April 2008 at:

www.virtualworldsreview.com

Web3D Consortium: provides information about open standards for virtual worlds. Last accessed on 3 October 2008 at:

www.web3d.org

Appendix E: Related UK-based Research Projects

This section outlines some of the JISC- and other funded research projects that relate to serious virtual worlds. For a comprehensive list of virtual world research activity and usage in the UK see Kirriemuir, 2008.

Design of Learning Spaces in 3D Virtual Environments (DELVE)

This project evaluates a range of 3D virtual learning spaces, immersive and non-immersive, realistic and non-realistic, with students, in order to propose models for a variety of pedagogical requirements. The project involves activities based at the Open University and the University of Nottingham. It will make use of the two universities' Second Life islands and ongoing research initiatives in 3D virtual environments.

www.jisc.ac.uk/whatwedo/programmes/elearning_ltig/delve

M0delling Of SecondLife Environments (MOOSE)

MOOSE investigates the scaffolding and processes needed to enable groups of students in Higher Education to establish their socialisation and engagement for more productive information and knowledge exchange and learning through the medium of online 3D Multi-User Virtual Environments (MUEs) using Second Life. The MOOSE project develops and integrates eight Second Life activities ('SL-tivities') into two undergraduate distance-taught courses: Archaeological Theory at the University of Leicester and Data, Computing and Information at the Open University. Empirical data on students' learning is collected and analysed using cognitive mapping to create unique 'maps' of individuals and groups and their change in views, feelings and experiences over time.

www.le.ac.uk/beyonddistance/moose

MUEs, Moodle and Microblogging (M3) project

The School of Modern Languages at the University of Southampton is exploring the potential of integrating Second Life and Twitter with an existing Moodle course. Twitter bridges the 'in-world' (SL) environment, with the 'outside world' of Moodle. This project focuses on the use of three technologies: Second Life, Moodle and Twitter. The project has three iterations: the first explores Twitter, Moodle and Second Life with a group of MA students, the second uses a group of pre-arrival students in an online course, and the final, third phase will take place with learners in external institutions and/or through the Emerge community outside the Modern Languages context.

www.elanguages.ac.uk/secondlife

MyPlan

The JISC-funded MyPlan is developing, deploying and evaluating new techniques and tools that allow personalised planning of lifelong learning. As part of the project user studies have been undertaken with college learners and mature students to identify how Second Life can be used most effectively to support lifelong learning.

www.lkl.ac.uk/research/myplan

OpenHabitat

The JISC-funded Open Habitat project is a collaboration between the University of Oxford, Leeds Metropolitan University, King's College London, the University of Essex and Dave Cormier, based at the University of Prince Edward Island. It takes an innovative approach to encouraging creative online collaboration in MUVes – the online 3D spaces in which each user is represented by an 'avatar' or 3D character. The project aims to generate solutions to the challenges of teaching, learning and collaboration in MUVes. These solutions will be primarily in the form of guidelines, models and exemplars.

www.openhabitat.org

Pattern Language Network for Web 2.0 Learning (Planet)

The aim of the project is to develop a community and associated systems to support HE practitioners, who are increasingly using new web technologies to capture and share their examples of good practice. Teachers in higher education are increasingly using participative and collaborative technologies, such as blogs, wikis, social networks and virtual worlds. The project works with teaching practitioners using and developing new techniques in these areas (including a number of major virtual worlds projects), together with their associated learner communities, to develop this framework.

<http://patternlanguagenetwork.org>

PREVIEW project

The JISC-funded Problem-Based Learning (PBL) project is lead by St George Hospital and the University of Coventry as part of the Users and Innovation strand. Problem-Based Learning has become a central learning approach in many curricula, but the collaborative style of learning is threatened by the movement towards more self-directed and distance learning. This project will investigate, implement and evaluate a user-focused approach to developing scenarios and materials, linking the emerging technologies of virtual worlds with interactive PBL online, to create immersive collaborative tutorials. The project team will create (i) specific PBL environments within Second Life, (ii) PBL scenarios, and (iii) strategies, guidance materials and good practice guides, all of which will be evaluated under the guidance of users, and made available to the higher education community.

www.elu.sgul.ac.uk/preview

Second Health

Second Health was a project created by the National Physics Laboratory for Imperial College London (ICL) to communicate a vision for healthcare in the future and to provide public awareness on healthcare issues. The outcomes of the project were three videos, which illustrate the way a medical situation could be addressed within a healthcare system of the future. The production of the (machinima) videos utilised a team of doctors, health professionals, video producers, writers, animators, designers and virtual world builders, both in the US and in the UK.

<http://secondhealth.wordpress.com>

Second Life Science City

The Advantage West Midlands-funded Second Life Science City is a virtual world demonstrator and events programme to engage West Midlands businesses in the use and exploration of the commercial and social networking potential of immersive virtual environments such as Second Life. It is a collaborative project funded by Advantage West Midlands and supported by a range of regional and national partners such as Daden Ltd, Ambient Performance, Enable Enterprises, Digital 2.0, CSWP, Faro Ltd and NPL.

Project objectives are to:

- Create new business opportunities which exploit the commercial potential of virtual worlds
- Identify and champion regional pioneers and innovators to develop market awareness
- Build a regional cluster of virtual world application developers and end users to create a critical mass
- Establish the West Midlands as a global leader in this emerging application area
- Strengthen the region's strategic developments in serious games
- Differentiate Birmingham Science City from other Science City projects

www.seriousgamesinstitute.co.uk/research/projects

Serious Virtual Worlds: a scoping study

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