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Mere Mortals Creating Worlds: Low Threshold 3D Virtual Environments for Learning

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Abstract: The prevalence of computer games in popular culture and their demonstrable success at engaging players in complex activity requiring learning of new skills has generated wide interest in the potential of games and related 3D virtual environments for education. The process of design, developing, and deploying tailored virtual environments is typically expensive in terms of time and money, both of which are usually scarce in education. What educators need, especially in the initial period during which the educational affordances of virtual environments are being explored, is an approach that can support experimentation by educators with ideas for the application of virtual environments in support of pedagogy. Ideally such an approach would enable educators to test designs by rapidly developing and deploying virtual environments without requiring substantial technical support. Uptake of other technologies by educators has been encouraged by identifying tools that present relatively low barriers to use, 'low threshold applications' (LTA) (Gilbert, 2004). This paper will describe a project that has sought to develop tools and processes that support educators in working with 3D virtual environments in ways that encourage experimentation by facilitating easy development and adaptation of environments for particular pedagogical purposes. Examples of tools and environments that have been developed are described together with lessons learned in the course of the project.

Keywords: 3D Virtual Environment, Low Threshold Application, Educational Design

Introduction

RECENT DECADES HAVE seen changes in the characteristics of Australian higher education students. Between 1989 and 2002 the proportion of Australians aged between 20 and 24 enrolled in higher education increased from 10% to 19% (DEEWR, 2005) indicating participation by a wider segment of the population than previously. Many of those students have commitments, to family or work, that affect their ability to participate in conventional classes on campus.

A study published by Universities Australia (James, Bexley, Devlin, & Marginson, 2007) found that in 2006 the typical Australian university student was undertaking considerable paid employment during the semester. Among full-time undergraduate students, 70% were working an average of almost 15 hours per week, 15% were working more than 20 hours per week, and almost 5% reported working full-time. It is hardly surprising that many of these students do not attend all of their scheduled classes on campus. They need flexible educational opportunities that allow them to balance study, family and work commitments in ways that meet their individual needs.

One response by universities has been to adopt technologies, such as placing recorded lectures on the web, that offer on-campus students some of the flexibility more commonly

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associated with distance education models. A recent Australian study (Woo, et al., 2008) reported that recorded lectures appear to provide clear benefits for distance education students because they provide study support that is not otherwise available and an increased sense of belonging to the class. The data suggested that distance and on campus students used the recorded lectures in similar ways, listening to entire recordings more than once, but with some significant difference in purpose. Internal students reported using recordings to catch things they had missed in class, a use not generally applicable to external students who were more likely to use the recordings to set their own pace for working, compared to internal students for whom the pace is set by scheduled classes. Both groups used the recordings for revision. Access to recordings provided both groups with additional opportunities to interact with course content, and some students from both groups reported increased interaction with the lecturer and peers. However, there was concern among at least some lecturers that the availability of recordings had the potential to discourage attendance by internal students with a consequent reduction in interaction that promotes and supports learning.

Interaction and Distance Learning

The effects of initiatives, such as providing recorded lectures, on interactions of students with content, instructors and each other are of interest because of the widely held view that interaction is fundamental to the process of learning (Ertmer & Newby, 1993). Traditionally interaction in education has been managed by the teacher who was responsible for presenting the learner with an appropriate sequence of resources and experiences to support learning. Distance education, although available in various forms for a century or more, has often been considered as “second rate” because of its limitations in providing for pedagogic interaction (Koul, 2006). However, both the busy lifestyles of increasingly mobile learners in advanced economies and the requirement for mass higher education in emerging economies are adding to the attraction of moving education from a 20th century industrial model to a more flexible and cost effective 21st century information network model (Daniel, 2007).

Despite distance education having been historically disdained as inferior to conventional formats (Koul, 2006), research demonstrating “no significant difference” between distance education and regular classrooms (Russell, 1999; WCET, 2007) has encouraged its wider acceptance. A large meta-analytical study (Zhao, Lei, Yan, Lai, & Tan, 2005) found that, although overall there is no significant difference in outcomes achieved by students in face-to-face and distance education, there is considerable variability among comparative studies with some demonstrating significant differences in outcomes and some not. The study found several factors that may result in significant differences, not always in favour of face-to-face instruction, with the importance of interaction for learning being a central theme.

This is consistent with a socio-cognitive understanding, which is based on the work of researchers such as Vygotsky, Piaget and Bandura, and in which learning and teaching are social activities (Kim & Baylor, 2006). In this view social interaction is central to learning and development, and is an important influence on the design of systems to promote learning. “Interaction is an essential ingredient of any learning environment” (Woo & Reeves, 2007, p. 15).

Moore (1989) recognised three forms of interaction: learner with content, learner with instructor, and learner with learner. Interaction with content is clearly a requirement for learning that content. Interaction with an instructor is widely regarded as essential or highly desirable because of the contribution a skilled instructor can make to facilitating learning. Moore noted that interaction between learners had been used in face-to-face classes for reasons that often had little to do with learners' needs but was a recent addition in distance education, where it was facilitated by new technologies, especially the Internet. He advised that distance educators should plan carefully for an appropriate mix of interaction to facilitate learning. Anderson (2003) has argued that it is not necessary, and may even be detrimental, for learning experiences to include high interaction in all three forms. The most appropriate mix in any circumstance may be affected by characteristics of the learner, what is to be learned, and material constraints on design.

Although the "distance" in distance education was originally understood as a matter of geography, the need to provide for more flexible access to education makes it increasingly important to understand distance more broadly. As early as 1972 the theory of transactional distance identified the "distance" in distance education as a pedagogical concept addressing the psychological and communications space that separates learner and teacher rather than merely geographic separation (Moore, 1993). Even within the face-to-face classroom such separation exists and has been explored through concepts such as teacher immediacy, defined by Christophel (1990) as the "perceived physical and/or psychological closeness between people" (p. 325). It affects learning by influencing motivation through behaviours such as smiling, disclosure, and humour.

Moore (1993) described transactional distance as a function of dialogue (purposeful interaction toward understanding), structure (course design with more or less flexibility for individual learners), and learner autonomy (extent to which learner, rather than instructor, determines goals and activities). Autonomous learners can manage with low dialogue and little structure. Less autonomous learners tend to prefer more dialogue with variable preferences for structure. Moore argued that new technologies permit learner-learner interaction that can reduce transactional distance while simultaneously increasing learner autonomy. If this does occur then it should enhance interaction that supports learning at the same time as providing learners with flexibility that is necessary for balancing study with other commitments.

The three dimensions of learner interaction proposed by Moore (1989), with content, instructor and peers, have been proposed as the basis of an aid for thinking about the general design of interaction in learning environments (Albion, 2008; Albion & Ertmer, 2004). The possibilities for interaction can be represented as a three dimensional space (Figure 1) where each of the axes varies from low interaction to high, with the intersection being where all three are low. Using the diagram as an aid to thinking it is possible to describe the pedagogical possibilities in each of eight smaller cubes and to consider how the affordances of any available learning environment might be used to promote learning through appropriate interaction (Albion & Ertmer, 2004).

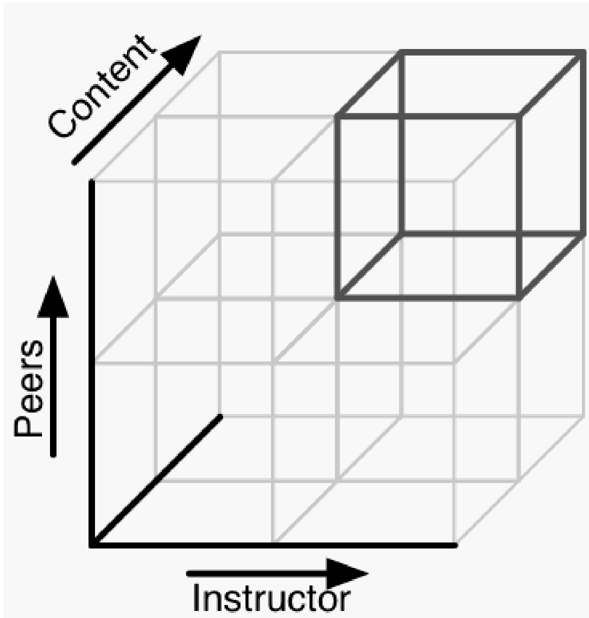

Figure 1: Instructional Interaction Space (Albion, 2008)

Shin (2002) proposed transactional presence as a way of viewing the issue of transactional distance from an alternative perspective, drawing on concepts such as social presence (Gunawardena & Zittle, 1997). Transactional presence is “the degree to which a distance student perceives the availability of, and connectedness with, other parties involved in a given distance education setting” (Shin, 2002, p. 121) and both encourages and is derived from interaction in the learning environment. Tu (2000) found that optimum levels of social presence, fostered by appropriate course design and instructor behaviour, led to increased online interaction. Similarly, another study (Weaver & Albion, 2005) reported a significant relationship between levels of perceived social presence and motivation to participate in online course discussions, a common form of interaction in distance education.

These findings point to ways in which facilitators of distance education courses might use computer-mediated communication to increase transactional presence and/or decrease transactional distance as a means of promoting the interaction required for learning. However, the benefits will depend upon the specific communications tools used. The most common forms of online communication depend upon written dialogue, which works well for some learners (Lin, Cranton, & Bridglall, 2005) but lacks many of the cues associated with face-to-face communication. Some learners find the reliance on text limiting and experience online courses as “a form of disembodied presence” (Mason, 1995, as cited in Shin, 2002). Because learning is holistic, and involves emotional and physical interactions as well as the cognitive, the lack of contextual clues and opportunity for informal interaction is a significant loss for some learners (Lin, et al., 2005).

Research about online learning has identified perceived lack of authenticity and presence as issues (Land & Bayne, 2006). Many educators and learners find text-based online learning environments disembodied and less real than conventional face-to-face classes. Adding audio and video content using recorded material (Woo, et al., 2008) or applications that support direct interaction among learners and instructors may enhance the sense of presence and reduce transactional distance (Little, Passmore, & Schullo, 2006).

Games and MUVEs in Education

Enhancing online learning environments by expanding the options for communication beyond text seems logical as an approach to reducing transactional distance and increasing the interaction that supports learning. To be effective, such adaptations need to meet the needs of both teachers and learners. Given the popularity of computer games among the generation currently leaving school and entering higher education, it seems reasonable to suppose that environments that share some characteristics of such games might be more appealing to learners than more traditional approaches (Prensky, 2001b). Even where such environments are not explicitly designed for learning, there is evidence that players are learning sophisticated skills through their deep engagement (Brown, 2006).

Multi-user virtual environments (MUVEs) or 3D virtual worlds have characteristics similar to popular games but without the explicit goals of games. Because they represent users with avatars, they have the potential to reduce the sense of disembodiment experienced by some learners in text-based environments. Communication in early versions of such systems was limited to text but current versions support voice conversations and the presentation of media streams from outside the MUVE. Studies have found that such 3D spaces can enhance social presence (Hauber, Regenbrecht, Hills, Cockburn, & Billinghurst, 2005; Salinäs, 2005) in ways that would be expected to reduce transactional distance and promote learning.

MUVEs possess qualities that offer potential to address some of the challenges posed by the growing demand for distance education or at least some features of distance education in regular higher education. These qualities include appeal to learners familiar with computer games, learning through engagement in authentic activities, and enhanced presence promoting interaction. The challenge is how to realise that potential by discovering approaches to the application of MUVEs that work well for learning and disseminating those practices as widely as possible.

Design of educational games and simulations typically requires knowledge and skills across the domains of both educational design and games design (Agostinho, Meek, & Herrington, 2005; Chambers & Stacey, 2005). It seems likely that design and implementation of 3D virtual worlds for educational use will require a comparable combination of capabilities. Because it is rare to find individuals capable of both educational design and the technical tasks required to implement their designs, teams that bring together the necessary skills commonly undertake such development but often increase the complexity, time and resources required. Traditional software development processes typically begin by specifying the design and include periodic pilot testing during development but with limited opportunities for changes to the design once it is specified. More recent approaches, such as *agile programming* (Hunt, 2006), adopt a cycle of frequent testing that provides opportunities for designs to be adjusted during development and are better suited for the exploration of new educational technologies.

The adoption of new technologies in schools has been examined from an ecological perspective (Zhao & Frank, 2003) and compared to the progress of an invading species entering a stable ecosystem. The key factor in adoption of new technologies was their compatibility with the aims of teachers and data from several schools suggested that the process was one that entailed co-evolution of teacher practices with the application of the technology.

The evolutionary metaphor suggests a way forward with the application of 3D virtual worlds in education. There are numerous different software systems on which MUVEs may be built. They offer different possibilities and restrictions, which are changing rapidly as the systems develop. Although there seems to be good reason to expect that MUVEs might be used productively for learning and teaching, it is not clear what the most productive uses might be. Hence, rather than a unitary development effort directed toward a single planned outcome there might be value in promoting an experimental approach with numerous alternatives being tried to see what works best under given conditions. In effect, this would be an evolutionary approach to development in which the most successful of numerous variations would emerge as the preferred solutions for particular educational niches, much as species evolve through mutation to occupy ecological niches. For such a process to work it would be necessary to develop a mechanism that would provide for the generation of small variations (mutations) in educational MUVEs at low cost.

Gilbert (2004) identified two threshold factors likely to limit the uptake of new technologies in education. The first was the lack of development resources to tailor applications for specific purposes. The second was anticipated reluctance of faculty members to make what they perceived as major changes to their instructional practices. He argued that they would be more receptive to smaller changes that would also require fewer resources for implementation. Out of this thinking grew the idea of a Low-Threshold Application (LTA) which is a "teaching-learning application of information technology that is reliable, accessible, easy to learn, non-intimidating, and incrementally, inexpensive" (Gilbert, 2004, p. 49). Compared to more complex technological innovations, the likelihood that an LTA will be adopted is increased because it is seen as non-challenging and requiring minimal extra work and carries little or no additional cost.

The Web3D Project

The threshold factors identified by Gilbert (2004) apply to the development and application of 3D virtual worlds for educational use. Hence, a route to generating the experimental variations needed as a base for evolution of successful 3D virtual worlds for education would be to develop LTAs that would empower content experts to incrementally adapt and implement learning experiences in virtual spaces. The project described in this paper was funded by the Australian Learning and Teaching Council (ALTC) to explore the development of tools, equivalent to LTAs, that could support content experts in the development of 3D virtual environments demonstrating good design in both educational and technical domains. Aspects of the project and the earlier ALIVE project with which it has been associated have been described elsewhere (de Byl, 2009). In the context of this project, Web3D is used to describe techniques that embed 3D content within web pages, a process that has potential to simplify access to the material and improve the presentation of certain elements as compared to more specialised 3D virtual environments such as Second Life™.

The planned outcomes of the project were a suite of exemplars of Web3D applications for education, Web3D development tools and resources suitable for non-technical users, guidelines for application of Web3D in education, and an online community of practice for educators applying Web3D techniques. The project schedule was to begin by working with early adopters on exemplars and use their experience and the tools developed in the first phase to support a second round of adopters. Development of the first group of exemplars proved to be more challenging than anticipated and the project did not progress as rapidly as originally planned. Nevertheless, some of the goals have been achieved and more will be accomplished before the project is completed late in 2009.

Exemplars developed to date vary from 3D models of objects such as a skeleton or the solar system presented in a web page, through ALIVE Classmate, which provides an online space that a teacher can use for presentation and discussion with distant students, to 3D interactive games. The learning designs are diverse but the underlying technology used in the exemplars is the same and the development tools and building blocks can be re-used in different contexts.

The *interactive skeleton* (Figure 2) presents a 3D model of a skeleton in a window within a web page in a way that enables the learner to use the mouse and keyboard to rotate and zoom the 3D model for closer examination of the various elements of the skeleton from different angles. Optional labelling of the parts of the skeleton is provided for. Although this is a relatively simple exemplar of 3D use for education, it illustrates the usefulness of the Web3D approach for extending content beyond a flat image presented in the page. Rather than offer the learner a single viewpoint, Web3D allows the object to be viewed from different angles and distances. Presenting the 3D model in the context of a regular web page simplifies both materials development and access. Moreover, the software used to develop the objects allows text in the web page to be configured as hyperlinks that can direct the 3D model to rotate and zoom to highlight associated elements such as specific bones or joints. These features permit close alignment between descriptive text and the interactive 3D model, enhancing the learning experience. The techniques used to build and present the skeleton in a web page can be applied to any object that can be developed into a 3D model and can be extended, as in a solar system model, to include simple animation such as the rotation and revolution of the planets and their satellites. In addition to presentation in a web page, the 3D models can be embedded into documents created in Microsoft Office applications such as PowerPoint, permitting direct display of the interactive 3D model in the context of a presentation.

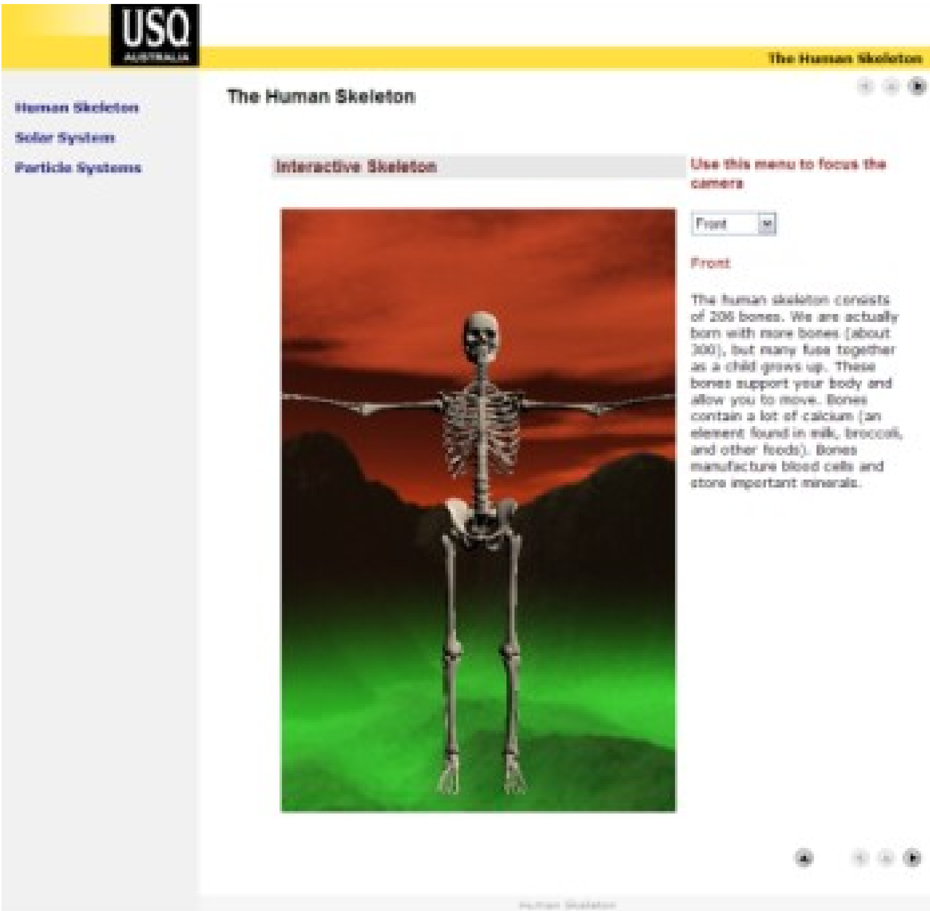

Figure 2: Interactive 3D Skeleton

ALIVE Classmate (Figure 3) was developed to demonstrate the potential of Web3D applications for enhancing interactions between distant participants in an educational event by extending communication beyond simple text. An avatar (humanoid figure) is used to represent each participant and can be personalised for each user. Facilities are provided for communicating using voice (VoIP) or text chat as preferred and screens can be installed to support presentation of slide shows, streaming video, and a multi-user whiteboard. With appropriate preparation and some practice it is possible to achieve interactions that are much richer than asynchronous discussion boards using no more than a web browser with an installed plugin. The illustration (Figure 3) has been captured from a video demonstration that can be viewed on YouTube (http://www.youtube.com/watch?v=LV8G3e_Pk1Q). ALIVE Classmate allows for private 3D virtual worlds to be initiated and customized by an individual educator with participants connected using a peer-to-peer connection rather than a central server infrastructure as is required for alternatives such as Second Life™. Although the demonstration configuration of ALIVE Classmate is most obviously suited to conventional pedagogies such as lectures, the environment can be configured to support a variety of learning activities limited only by the creativity of the users.

Figure 3: ALIVE Classmate

The remaining exemplars in the initial set offer a learning experience more akin to interactive games. A *behavioural management simulation* (Figure 4) was developed for use in a psychology class where students learn to manage a group session. The student using the simulation plays the role of facilitator and is required to manage interaction in the simulated group to provide members with equal talking time, suppress aggressive activity, and encourage 'shy' participants to interact. The facilitator is presented with a variety of options that may be selected to initiate an interaction or respond to an utterance from a simulated group member and is able to judge progress toward achievement of the goal of equal talk time using the display that appears above the heads of the simulated participants. XML files that can be edited in a standard text editor are used to store the data used to drive the simulation by specifying the characteristics of simulated group members, the options available to them and the facilitator, and the consequential behaviours of group members. This approach supports customization of the content of the simulation by the faculty member responsible for the course in which it is used. Compared to alternatives, such as role-play, the use of simulation offers flexibility for learners with schedules that inhibit synchronous participation.

Figure 4: Behavioural Management Simulation

Exoplanet (Figure 5), a second exemplar in the series with game qualities, was developed to assist students of astronomy to learn how to identify inhabitable planets. The underlying scenario assumes that Earth cannot sustain human life into the future and that the player is responsible for identifying another planet that humanity could colonise. To achieve the goal the player must examine the characteristics of a number of planets (mass, distance from sun, atmosphere, etc.) and determine their suitability for human habitation. Data for the simulation are drawn from NASA databases for authenticity. Play begins with a view of a starfield in which summary characteristics of a system are revealed on rollover. Thereafter it is possible to zoom in to a view of the solar system showing orbital paths (Figure 5) and then down to the planetary surface to inspect it more closely.

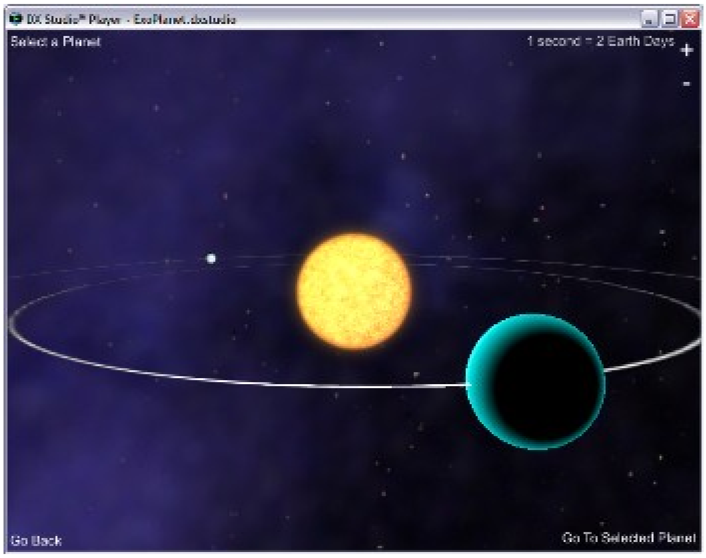

Figure 5: Exoplanet

Escape Alive (Figure 6), the third exemplar in this series, was developed to aid the Workplace Health and Safety section in training employees in procedures for safe evacuation from a burning building. Players navigate their way through a 3D representation of an office building to find their way to evacuation points. Success depends upon following appropriate protocols including closing doors, activating alarms, crawling under smoke, and using a fire extinguisher to create safe passage in a hallway. As the fire spreads and smoke intensifies over time, visibility deteriorates and the player's health declines. Escape depends upon acting coolly and quickly to avoid wasting time and the risk of becoming trapped.

Figure 6: Escape Alive

Project Outcomes to Date

The exemplars described above represent progress toward achieving the primary project goal of developing a suite of Web3D exemplars for education. The development process resulted in the creation of a variety of 3D elements, such as building parts, furniture, and common objects, which are reusable, with or without some cosmetic changes, in other 3D virtual spaces. These objects provide the foundation for a library of objects that may be used by academics to build their own environments, thus reducing both the effort and technical capability required for developing customised 3D spaces for use in teaching. The programmers working on the project also developed a simplified editor for shaping a 3D virtual space and placing and adjusting objects within it. Although the editor and other tools are not yet at the stage where they can be easily used by non-technical academics, the combination of the editor and the growing library of objects lend hope that the project goal of making it possible for non-technical academics to design and develop their own 3D spaces may be achievable, at least to the degree permitted by technology that is still immature and in rapid flux.

Underlying the project was the desire to provide more engaging interactive learning experiences, especially for those students learning at a distance. In terms of the *instructional interaction space* (Albion, 2008), most of the exemplars described above represent enhanced interaction with content, in the form of a model or simulation, but with little or no interaction with instructor or peers. The sole exception to that is the *ALIVE Classmate* application, which permits interaction on all three dimensions, albeit with traditional transmissive pedagogies as the obvious, but not necessary, default. There is work remaining to explore the remaining sectors of the possible interaction space.

Lessons Learned

The process of developing and testing the exemplars has produced lessons that are guiding work in the remainder of the project and may be of wider relevance to others seeking to take advantage of these emerging technologies.

The technical challenges faced by the project were more significant than had been anticipated. Although there are many software tools available for creating 3D objects, they require technical skills beyond those possessed by most teaching academics. Such tools require considerable time for practice to develop the relevant skills, especially for high quality objects that require the use of professional tools such as Maya or 3D Studio. Fortunately, several of the exemplars had common elements required in the virtual environments and it was possible to reuse elements, with or without minor customisation. If academics without specialised technical skills are to be able to arrange their own 3D spaces for learning and teaching they will need to have ready access to collections of 'building blocks' from which the spaces can be assembled. Fundamental to achieving this will be adherence to standards that permit easy sharing and reuse of objects and the establishment of libraries of such objects that can be made available through a broad community of practice. The project has made a start by establishing the Web3D Exchange (http://web3dexchange.org/) but much work remains to be done on developing standards and the community of users.

Relatively few academics have much experience of playing computer games. Consequently they find it challenging to conceptualise the design of games to support learning even in discipline areas where they are acknowledged experts (Prensky, 2001a). This is likely to be true, even when they have well deserved reputations as effective educators. Moreover, one of the major challenges of designing educational games is that "whenever you add an instructional designer, they suck the fun out" (Prensky, 2004, p. 1). From the opposite perspective, game developers are generally not well versed in formal understanding of learning design although well-designed games support players in learning how to succeed by successive approximations. Successful development of educational games requires bringing together varied expertise across at least the domains of content, learning design, game design, graphics and programming. Recruiting team members with one or more of the necessary skill sets and facilitating communication among them is essential for success and represented a significant challenge to the progress of the Web3D project. The original project leader had strong background in games design and programming and assembled a small team of programmers. The content experts lacked background in games design and mostly had little formal background in learning design. The team members with background in education had limited experience of games and the specific content to be included. Working together on the project initially presented challenges in communication across the different fields of expertise but offered each group the opportunity to learn from the other perspectives.

Conclusion

There are powerful reasons to explore the educational possibilities of 3D virtual environments. They include an increase in the number of higher education students completing at least parts of their courses by distance education, the fundamental importance of interaction for learning, and the widely observed power of games and game-like 3D virtual environments to engage users, especially young people, in interactive experiences. If any benefits are to be made available as widely as possible, it will be important to develop processes that empower non-technical users (mere mortals) to create virtual worlds tailored to the needs of their own classes. Such are the influences that contributed to the genesis of the Web3D project described in this paper and led to the adoption of an approach based on the notion of low-threshold applications (Gilbert, 2004).

To date the project has encountered more challenges than anticipated in making the creation of virtual worlds easily achievable by non-technical users. At least in part these challenges have been related to the relative immaturity of the technologies being explored. Some progress has been made toward creating exemplars, resources and tools that can be applied by non-technical users and it is anticipated that, as the technologies mature, hardware and software with the necessary power and ease of use will become more widely available. As that happens we expect that the lessons learned by pioneering users will be applied by many more mere mortals as they create virtual worlds to support learning and teaching.

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