A WEB 2.0/WEB3D HYBRID PLATFORM FOR ENGAGING STUDENTS IN E-LEARNING ENVIRONMENTS

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ABSTRACT

This paper explores the Web 2.0 ethos with respect to the application of pedagogy within 3D online virtual environments. 3D worlds can create a synthetic experience capturing the essence of *being* in a particular world or context. The AliveX3D platform adopts the Web 2.0 ethos and applies it to online 3D virtual environment forming a Web 2.0/Web3D hybrid that has wider usability than previous alternatives. This combined with the AliveX3D Scene Editor allows learning experiences, which are controlled by the learner, appear authentic and facilitate collaboration conversations to be developed simultaneously. This immersion enables learners to negotiate meaning based on their own personal cognitive, affective and kinaesthetic experiences rather than on the descriptions of others' experiences. We conclude by suggesting the choices embedded within the worlds allow the learning focus to shift away from isolated pre-designed interactions, to a situation that encourages the learner to control, manage and direct their own learning.

Keywords: **A WEB 2.0; WEB3D; hybrid platform; virtual environments.**

INTRODUCTION

The importance of embracing the next generation of web technologies is now paramount. More students than ever before are part of the latest generation of which the Internet, simulation and games are an essential part (Gottliebsen, 2007). These students are technology savvy or digital natives (Prensky, 2001). Educational materials deemed acceptable in the past now fail to engage students who are more attuned to the high quality 3D entertainment software, e.g. computer games. These students demand more from their educational experiences than flat pages of content, un-interactive videos and text based communication software.Web3D makes immersive 3D environments accessible to students and teachers, by seamlessly integrating with freely available web-browsing software. Immersive 3D environments provide unique, hitherto impossible, opportunities to change the nature of learning and teaching experiences, especially for distance education students. Such environments positively affect many of today's educational issues including student engagement, immersion and authentic professionalism. Computer simulations and games provide educators with a means of supplying action based, discovery experiences to students. The medium produces high, sustained levels of engagement and a deeper understanding of subject matter (Prensky, 2003).

In addition, students are able to do expensive and inconceivable activities virtually (Winn, 1993; Avgoustinov, 2000) and have an identity in the environment which provides them with rules, allusions and other concepts and objects that make them feel a part of the world (Schuemie, van der Straaten, Krijn & van der Mast, 2004).

Furthermore, effective learning environments help students to think and act like practitioners (Herrington, Oliver, & Reeves, 2002). Role-playing is a valuable exercise for students to practice the skills involved in their chosen profession (Bender. 2005). In addition, virtual environments can closely approximate a work place that may otherwise be inaccessible to students while they are studying. This provides a level of knowledge about how people interact, dress, use profession specific terminology and daily routines not available elsewhere (Oblinger, 2006).

In addition, immersive 3D environments provide distance students with:

- **interactivity with content and processes enhanced by simulations and role plays (Oblinger, 2004);**
- **opportunities to be interactive with individuals or groups of individuals while immersed within another activity (Rosenbloom, 2004); and**
- **the capacity for students to build their own activity and experiences; to take control of their own learning (Meiguins et al., 2004).**

Unfortunately for under-funded tertiary teaching institutions, professional quality 3D games and simulations are immensely expensive to create (Liarokapis, 2004; Perdomo, 2005). An easy to use, inexpensive system to develop Web3D environments is essential for this technology to move into mainstream learning and teaching practice in universities (Long & Anschuetz, 2002; Ressler, 2002; John, Brodlie, & Bello, 2003; Arendash, 2004).

Furthermore, the long history of technology use in education shows an inclination to use it in the same traditional manner as old technologies (Cuban, 1986; Means & Olson, 1994) even with new media (Galarneau, 2004). This tendency neither produces change nor improves education. It is imperative that old pedagogies and curricula are updated and modified to make the best use of the new technology. Implementation of new technologies in universities has its inherent problems and even more so the execution of games, simulations and virtual realities which have traditionally been the domain of technical experts.

What is clear from previous research is that for a successful paradigm shift towards enhancing e-Learning with new technology, teachers need to be shown how to access and make use of the required resources. The resulting applications must be convenient and provide rewards and recognitions for their use (Rogers, 2000).

To address these issues the Advanced Learning and Immersive Virtual Environments (ALIVE) project at the University of Southern Queensland, Australia (http://www.alivex3d.org), aims to reduce educators' fears of such technologies by exemplifying Web3D applications in contexts to individual's disciplines through:

- **dissemination of examples of existing successful Web3D games, simulations and virtual realities in e-Learning technologies along with information about their affordances and constraints;**
- **provision of training, professional development and mentoring in the basics of creating Web3D applications;**
- **exploration and development of exemplar teaching models for the use of Web3D applications in educational content; and**
- **exploration and development of insights into how these approaches can be supported and developed at an organisational level.**

Moreover, the ALIVE team is dedicated to the Web 2.0 ethos centering on the idea of a collective intelligence which evolved from hyper-linking, web services, platform-independent software, re-usable and re-mixable content and, above all, user participation.

Most importantly, the applications being developed are highly focused on cost-effectiveness, sustainability and scalability which are the keys to their adoption in educational institutions.

In this paper, we introduce the AliveX3D platform for developing Web3D applications that:

- **conform to international standards and thus have the advantages of interoperability, web-services and cross-platform, inter-application file and data transfer;**
- **provide high-quality graphics rendering using the cross platform rendering engine OpenGL in addition to applying game industry rendering algorithms to enable faster updates and response times;**
- **provide *easy to use* editors to produce high-quality graphical environments by making the 3D modeling and animation process of existing 3D world editors transparent to the user;**
- **operate in stand-alone mode to allow educators and students to use the editor and view content without an internet connection and on CDROM if desired (a functionality not provided by the before mentioned environments);**
- **provide low bandwidth multi-user communication when collaborating online;**
- **allow the integration of 2D and 3D content in their more traditional settings as opposed to inappropriately rendering 2D content inside 3D environments, and;**
- **remove the focus from virtual social communities where the user is solely represented by a 3D humanoid and where more appropriate replace the users' avatar with some other 3D representation (if at all).**

We begin with an examination of the AliveX3D platform as a hybrid online environment and the suite of tools which apply Web 2.0 concepts to the collaborative development and use of Web3D technologies.

A WEB 2.0 – WEB3D HYBRID

Web 2.0 ethos centres on the idea of a collective intelligence. To date, Web 2.0 applications have focused on the more traditional method of delivering content in a 2D format through web-browsers.

Typical Web 2.0 applications include word-processors (Figure:1), spreadsheets (Figure:2), personal computer desktop emulators (Figure: 3) and project management software (Figure: 4).

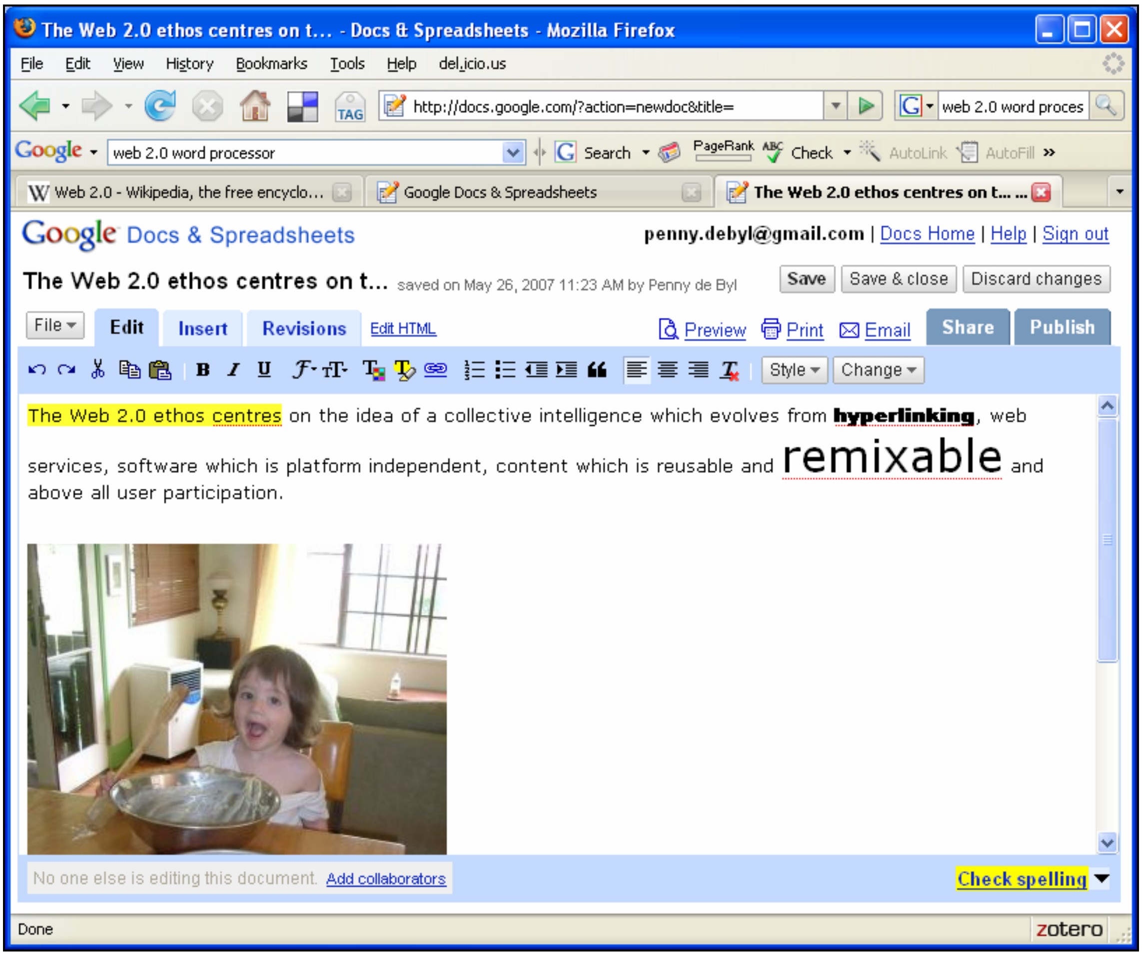


Figure: 1

Google Docs **is an advanced online word processor allowing the user to store all documents on the Google server. The documents are then available from any desktop computer with an internet connection and web-browser. The online documents can be shared with others for collaborative work.**

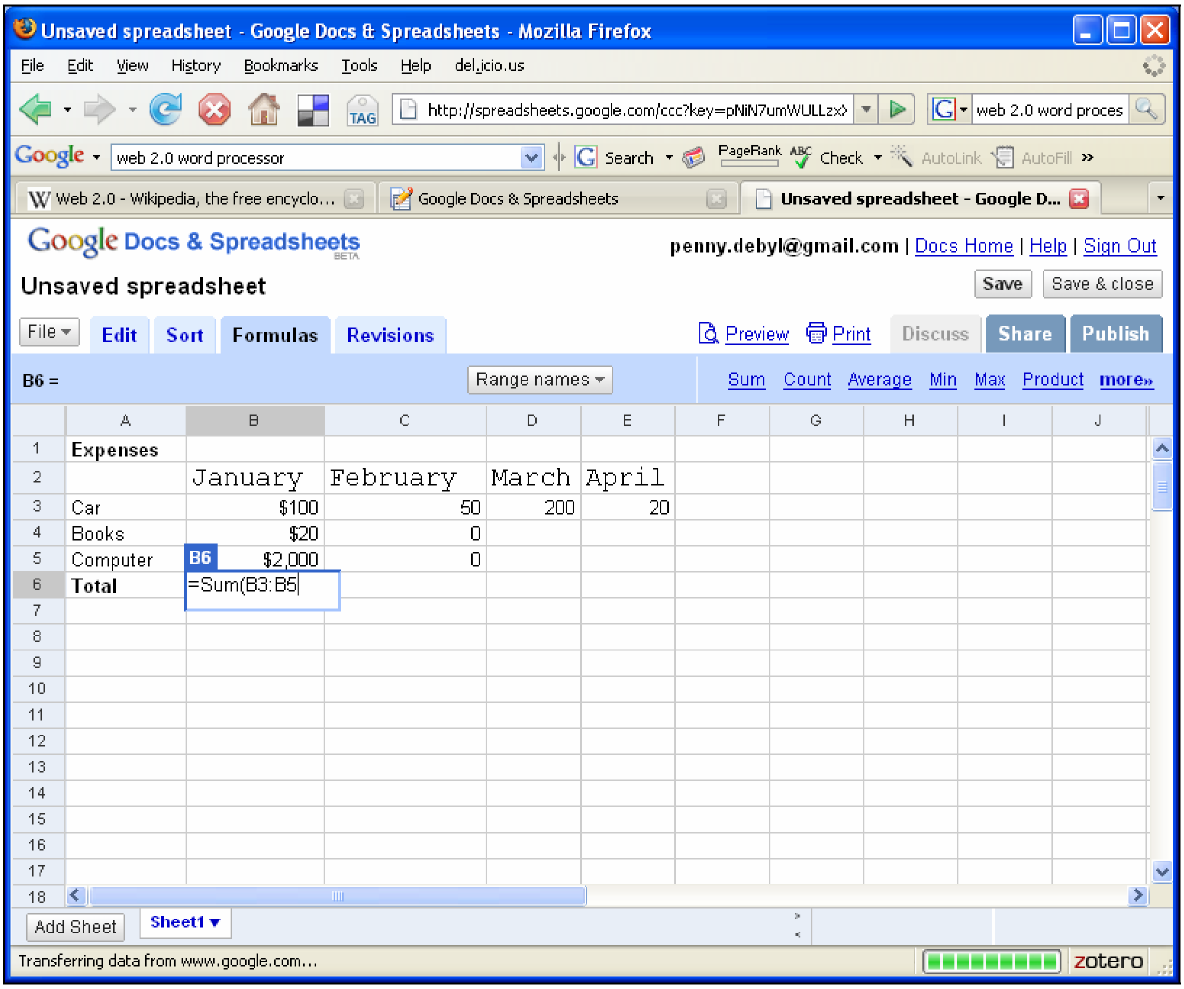


Figure: 2

Google's online spreadsheet affords the same advantages of the *Google Docs* applications (see Figure: 1) and gives the users all the functionality of a standard spreadsheet.

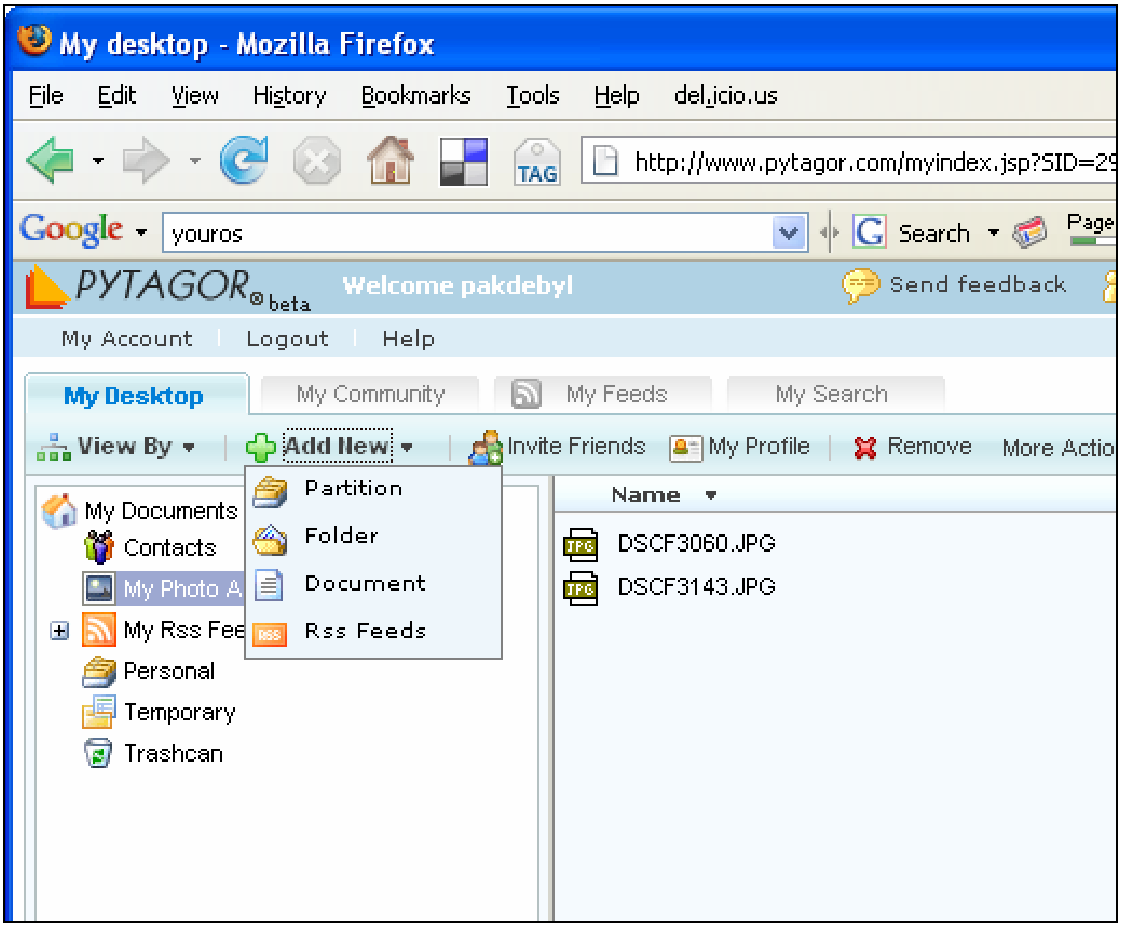


Figure: 3
The *Pytagor Online Desktop* where users can store files, personal information and RSS feeds for private use or sharing with invited friends.

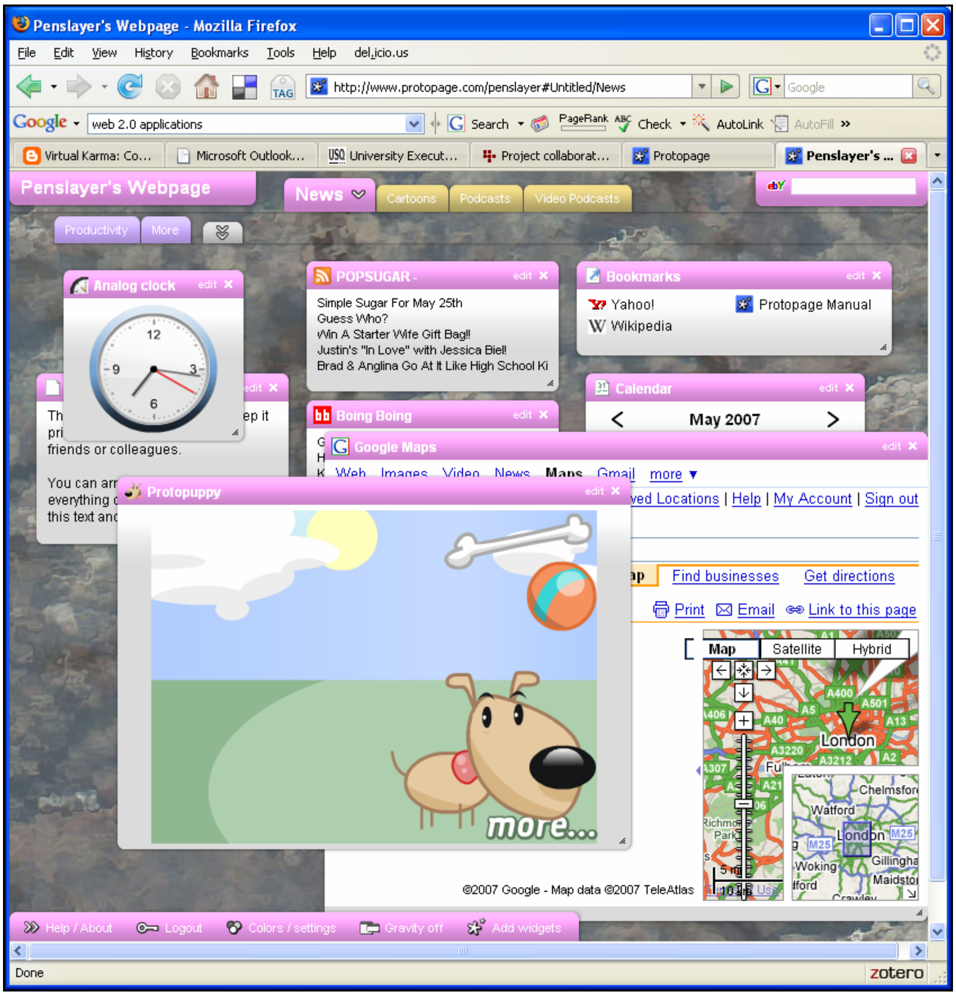


Figure: 4

Protopage **is an online desktop for the user to organise files and online applications. The attraction of this type of desktop is that it can be called up by the user from any computer and the contents can easily be shared.**

Educators who seek to nurture a collaborative ethos of engaged learning in their students are turning to Web 2.0 applications to provide a richer learning experience as the medium moves away from one in which information is transmitted and consumed, into a podium for content which is created, shared, mixed, re-engineered and redistributed (Cubric, 2007; Allay, Lawrence & Gamble, 2007; Thompson, 2007). The traditional approach to structuring e-Learning platforms is moving from cumbersome and expensive structured holistic applications to a set of loosely joined Web 2.0 applications such as blogs, wikis and other social software. Although Russell (2005) argues that online technologies reduce the capacity for students and teachers to form the affective relationships that are paramount to the interpersonal processes present in face-to-face teaching, students are increasingly choosing not to attend on-campus activities (Dolnicar, 2005) while students studying at a distance have little choice in how they interact and collaborate with their teachers and peers. As such, the onus falls on the educator to provide the most effective e-Learning platform and educational experiences to address all the domains of learning.

While educators are coming to grips with the new Web 2.0 technologies with the majority of Web 2.0 e-Learning activities focused on blogs and wikis, the net generation is moving ahead.

Thus the focus of the ALIVE project is to bring the power of 3D gaming and simulation technologies to e-Learning platforms and educational experiences moving beyond the current holistic approach in the re-creation of real classrooms in online 3D social community environments. Platforms such as Second Life and Active Worlds are being experimented with as pedagogical tools even though they have not been developed explicitly for this purpose.

In such environments, much of the effort to date has focused on the distribution of existing learning materials (text, course notes and lecture slides) coupled with tools for communication while learning (Clark & Maher, 2005) including virtual clones of whiteboards, slide-projectors and other classroom teaching apparatus.

These environments are not as well developed as their 2D e-Learning counterparts, do not utilize the power of online virtual reality to its greatest potential and do not facilitate learner-centered collaborative experiences. To this end, the AliveX3D platform adopts the Web 2.0 ethos in a move towards interoperable and reusable 3D learning objects forming a Web 2.0 - Web3D hybrid focused on 1) re-use of data sources; 2) cost-effective scalability; 3) user controlled data; and 4) collective intelligence with respect to the e-Learning possibilities.

Re-use of Data Sources

The AliveX3D platform is being developed in co-operation with the Web3D consortium (http://www.web3d.org). The motivation behind this collaboration is to further develop and apply the real-time ISO standard for 3D data exchange, X3D. X3D standardisation enables AliveX3D applications to have functionality not yet realised in other 3D multi-user environments including:

- **the conformance of web semantics and metadata which is seriously lacking in many e-learning applications (Palmer, Naeve & Nilsson, 2001) and supports search engine and intelligent software agent support;**
- **web services which provide programming interfaces over the Internet which enable e-Learning applications to interface with remote applications such as institutional administrative systems (e.g. *PeopleSoft*);**
- **cross-platform, inter-application file and data transfer which allows educators to import 3D models from other applications (e.g. CAD, GIS) and export 3D objects created in X3D compliant editors;**
- **enabling creators to add meta-data to every object in the 3D environment allowing for search engine penetration beyond the upper level scene description; and**
- **the addition of information about system dynamics stored with the scene geometry, for example blood flow viscosity and velocity can be encoded within anatomical model.**

Cost Effective Scalability

The interoperable and open source nature of X3D and the associated Web3D consortium ensures the AliveX3D platform is scalable through the many efforts of a community of practice including industry, programmers, educators and students all contributing shareable and reusable content. In addition, the ALIVE team is creating an online repository of X3D high quality models from which the community can import and export. The 3D environments created in AliveX3D can also be as small or as large as required. Naturally larger environments will require more resources and longer download times. However this can be re-scaled as a set of smaller environments distributed on multiple web servers world-wide connected together with hyperlinks in the same way the World Wide Web is currently structured.

User-Controlled Data

Creating a reasonably real, online environment becomes possible when users are given the power to collaborate, create and edit content. Koster (2002) argues that virtual environments (in this case online gaming worlds) need to follow a "Lego" methodology and give the users a set of building blocks by which to construct the world.
This type of atomistic construction is most exciting when users can build in a collaborative environment (Ondrejka, 2003).

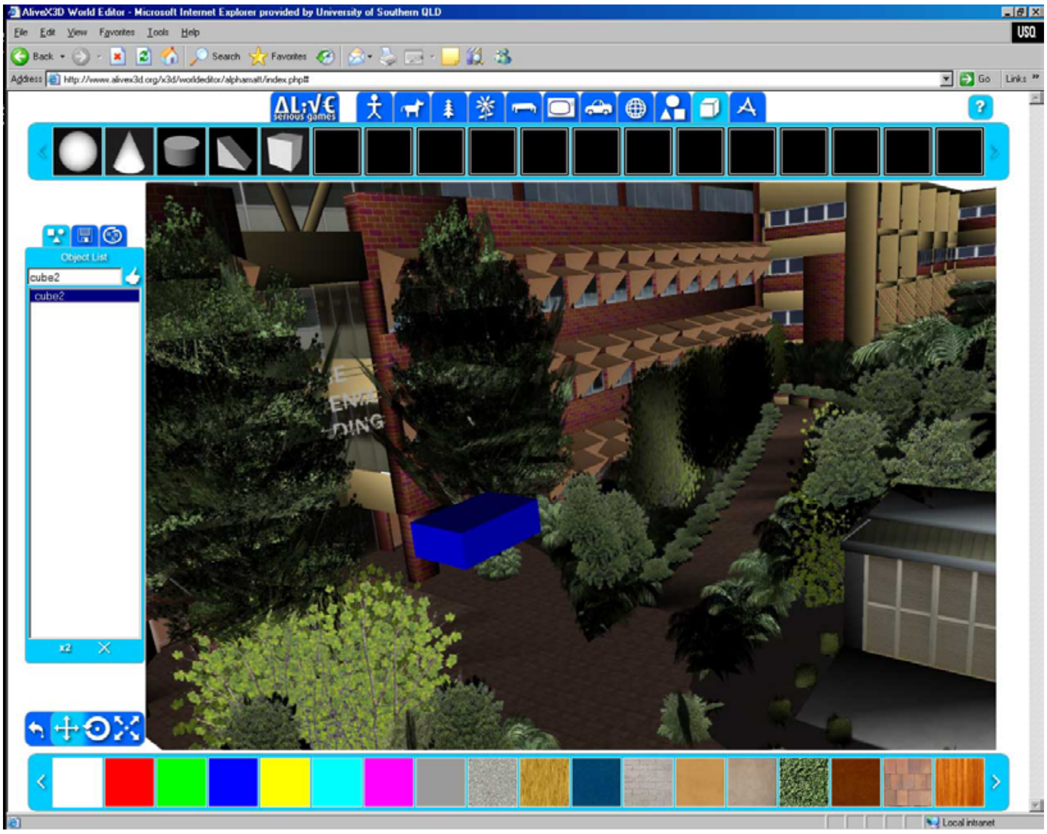


Figure: 5
The simple interface for the AliveX3D editor

Consequently, the flagship of the AliveX3D platform is the Scene Editor which includes a library of pre-fabricated 3D objects from which users can build 3D multi-user environments.

This will provide the opportunity to create an e-Learning space unique to an educator and their course. In addition, students can collaborate to edit the same online space and thus contribute to its layout.

The Scene Editor (see Figure: 5) follows the model of scalability and interoperability by allowing users to mix and match 3D objects both within the editor and exported for use in other compliant products. The editor is currently in beta release and interested readers can trial the application by visiting http://www.alivex3d.org

Collective Intelligence

Merely managing an online community such as those afforded by *Second Life, Active Worlds* does not constitute an environment of collective intelligence as is the nature of Web 2.0 applications.

The interoperable and collaborative online 3D editing functionality of AliveX3D will enable collective intelligence to develop in e-Learning environments moderated by educators.

Constructivist theory also applies whereby students in the 3D environment can experience an immersive multi-user first-person world and meaningful communication can be achieved through negotiation of the structure of the content as it is being created (Winn, 1993).

While knowledge construction within the world can arise from first-person experiences, the experiences are validated and corrected through the moderation of other people sharing and interacting with the environment.

COMPARATIVE ANALYSIS

Table: 1 provides an overview of the functionality of current popular online 3D providers with the AliveX3D platform. Of the providers examined, AliveX3D and Open Croquet are the only open non-proprietary applications. This benefits educators as they have complete control over their content and the applications are relatively inexpensive to install and use (as there are no licensing fees).

AliveX3D as an e-Learning platform is more extensible than proprietary technologies such as those behind the collaborative 3D environments *Second Life* and *Active Worlds.*

The AliveX3D platform enables a development environment which belongs to its users where the technology can be hosted on a single institution's web servers. This removes any implications of constrained server environments and governance over the content by the platform provider as is the case with *Second Life.* AliveX3D is also unique in that it can operate with or without an Internet connection and as a stand-alone or embedded webpage application.

In addition to the functionality differences, the AliveX3D platform has been tested for performance relative to minimum computer specifications and network requirements.

The data favors the AliveX3D solution as a low bandwidth e-Learning platform without compromising quality.

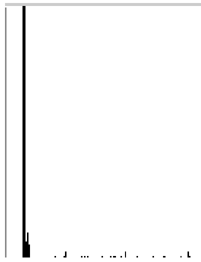
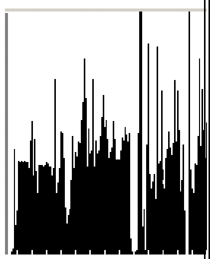
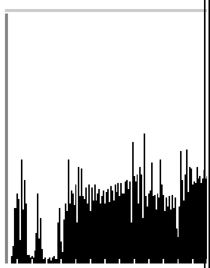
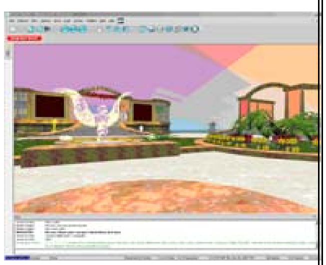
The results shown in Table: 2 illustrate the bandwidth usage and technical specifications of several online 3D platforms. This data was collected over three minutes of online usage of each application from startup.

In each case, the application was connected in multi-user mode and tested while the user's avatar continuously moved about the environment and sent chat messages.

Table: 1
An Analysis of AliveX3D Functionality with other Online 3D Providers. Grey areas indicate the existence of a specific functionality in the platform.

	Alive X3D	**Sec ond Life**	**Active Worlds**	**Open Croquet**
Interoperable and Re-mixable Content				
- Imports a variety of 3D Model Formats	■	■	■	■
- Worlds exportable to other applications	■			
- Aligns with ISO standards	■ X3D			■ VRML9 7
Operating Mode				
- Stand Alone (No Internet Connection)	■			■
- Multiuser Application (Internet Connection)	■	■	■	■
- Web-browser plugin (No Internet Required)	■			
- Web-browser plugin (Internet Required)	■			
Integration of 2D and 3D content				
- Text placed on 3D Objects	■	■	■	■
- 2D Text Displayed Flat on Screen.	■	■	■	■
- Hyperlinked with External Text	■			
- Metadata stored with 3D Objects	■			■
Scalability				
- Peer to Peer Network Connections				■
- Many clients one server	■	■	■	■
- Distributed Client/Server Network	■			■
Data Storage				
- on providers server	■	■	■	
- on developers own server	■			■

Table: 2.
AliveX3D Technical Specifications compared with other 3D Online Platforms

	OS	Minimum Hardware Specs	Internet Connection	Initial Download * (Mb)	Upload (Kb)	Download (Kb)	Bandwidth Usage Over 3 minute interval from start of application (Max 189Kb/s)**	Visual Scene Quality
ALIVEX3D	Win	Pentium II 300mhz 64MB RAM, OpenGL video card with at least 8MB	None (Stand-Alone Mode) 56K Dialup (Multi-user)	5	81	1		
CROQUET	Win Mac Linux	Pentium IV, nVidia GeForce 2 Graphics Card or better	None (Stand-Alone Mode) 56K Dialup (Multi-user)	72	47650	14620		
SECOND LIFE	Win Mac	800MHz Pentium III 256MB RAM, Mac OS X 10.3.9, 1 GHz G4, 512MB + nVidia GeForce 2, GeForce 4mx or ATI Radeon 8500, 9250	Cable/ DSL	Win – 32 Mac - 65	1190	10160		
ACTIVE WORLDS	Win	Pentium II CPU 300mhz or equivalent 64MB RAM, D3D video card with at least 8MB	56K Dialup	5.8	449	8830		

*** Download Size of Latest STable: Release available on the 28th June, 2007.**
**** Tests run on a Intel Xeon CPU 3.20GHz, 4GB RAM, High-Speed Internet10.0Mbp**

As AliveX3D applications can be segmented into smaller self contained environments, unlike *Second Life*, AliveX3D applications experience a peak of download when the application starts. This peak would also be experienced if the user were to move to another AliveX3D world.

This effect is shown in the graph for *Active Worlds* (Table: 2) where the network activity peaks towards the end of the session when the user teleports to another 3D location. This contrasts with *Second Life's* constant bandwidth usage. Although AliveX3D is capable of the same chat and positioning functions as *Second Life*, it can be noted in the results in Table: 2, AliveX3D achieves this with very little extra network load.

ALIVEX3D E-LEARNING APPLICATIONS

The ALIVE team has actively experimented over the years with number of e-Learning alternatives building expertise and knowledge of weaknesses in the way existing 3D worlds are built. The most significant weakness is the presentation of textual information, such as equations, formulas, definitions and general information (Bell & Fogler, 1995). To prevent such inadequacies in delivery of 2D content, the AliveX3D platform can embed 3D worlds inside 2D content when the conversion of the existing 2D content into 3D affords no real pedagogical benefit. E-Learning materials developed with AliveX3D are therefore unique in their integration of 2D content with 3D games, simulations and visualizations. Through the use of a web-browser plug-in and a range of *easy to use* tools, text based and other two dimensional content can be seamlessly entwined with immersive 3D real-time collaborative projects. Several applications of AliveX3D will now be examined to demonstrate the expanded functionality.

Plug & Play 2D/3D e-Learning Content Creation

Inserting a pre-fabricated 3D multi-user classroom into online course material through the click of a button or tick of a checkbox in a word processor can be as technical as the educator needs to get (if they wish). This will result in e-Learning materials with live collaboration functions as well as traditional 2D content.

Figure: 6.
A multi-user 3D chat room embedded within course content online.

The advantage is that students and teachers will all simultaneously know who is viewing the material and be able to interact with them in either real or other time. Underpinning the principle of simplicity of the scene editor is the understanding that content created needs no expertise in 3D modeling or virtual environments. In the example shown in Figure: 6, people viewing the introductory material for the course can chat synchronously with each other at the same time. Distance, on-campus students and teachers can meet and greet in the same environment.

Sophisticated Real Time 3D Simulations and Games

Although the AliveX3D platform concentrates on simple creation and deployment of virtual 3D worlds, educators and students can create and program X3D objects at any technical level. Detailed models can be created in high-level editors (e.g., CAD, GIS, Maya) or from 3D scans and imported into the plug-in to give users access to 3D data not examinable in 2D. For example, Figure: 7 demonstrates the plug-in showing a scaled and animated model of the solar system which the viewer can zoom in and out and freely rotated.

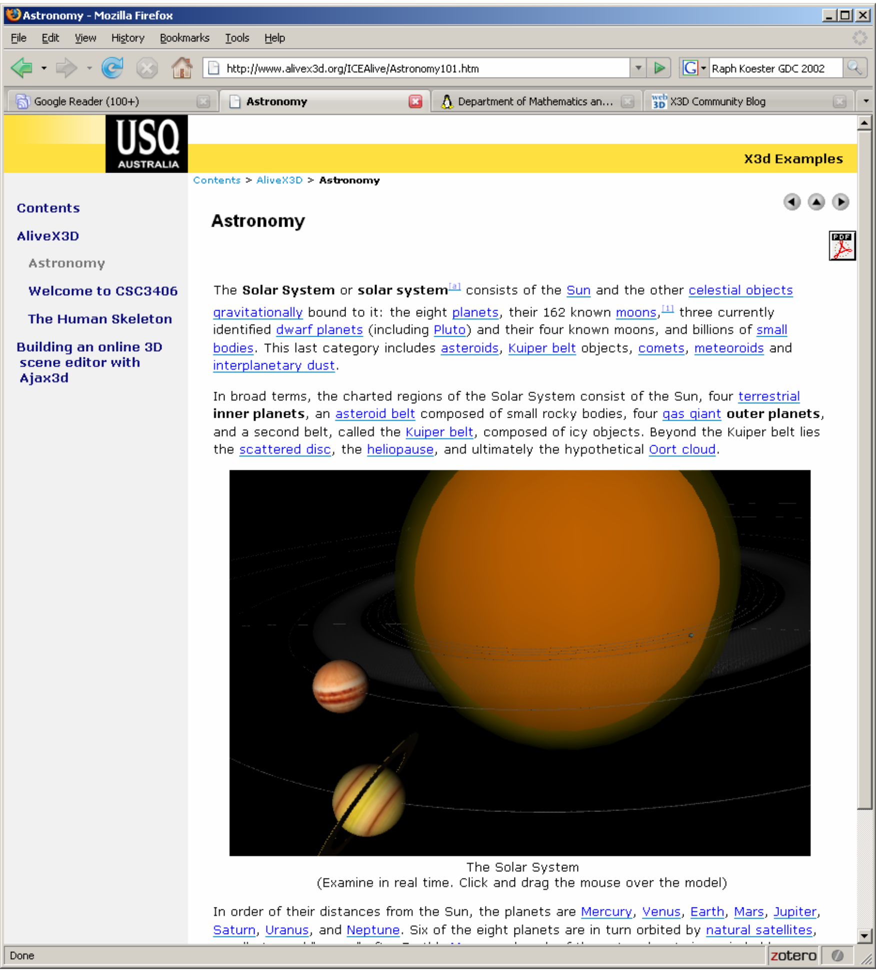


Figure: 7
A 3D replica of the solar system imported into AliveX3D and embedded into 2D course content (text sourced from Wikipedia).

Dollylinks: Hyperlinking into Embedded 3D

A wholly unique feature of AliveX3D functionality is the ability to create hyperlinks from 2D text which *dolly*[1] the camera in the 3D scene towards an area of interest. This creates a truly 2D/3D integration where the reader of the webpage content can control the location of the camera by clicking on *dollylinks* of interest. For example in Figure: 8, the page content describes the bones in the human skeleton. The bone names in the text are *dollylinked* to their 3D representations in the 3D window. The camera is not set to follow any particular sequence of animations but simply calculates a smooth navigational path to animate its movement from one *dollylinked* object to another all based on the current camera location and the *dollylink* clicked by the reader. The free nature of the 3D navigation within the 3D window, means that the reader can directly interact with the 3D object at any time by using the mouse within the plugin. Unfortunately it is difficult to show the exact nature of this functionality within a paper, suffice it to say, the concept is a truly powerful way of integrating mixed media and is a functionality not afforded by any other form of plugin, including Flash.

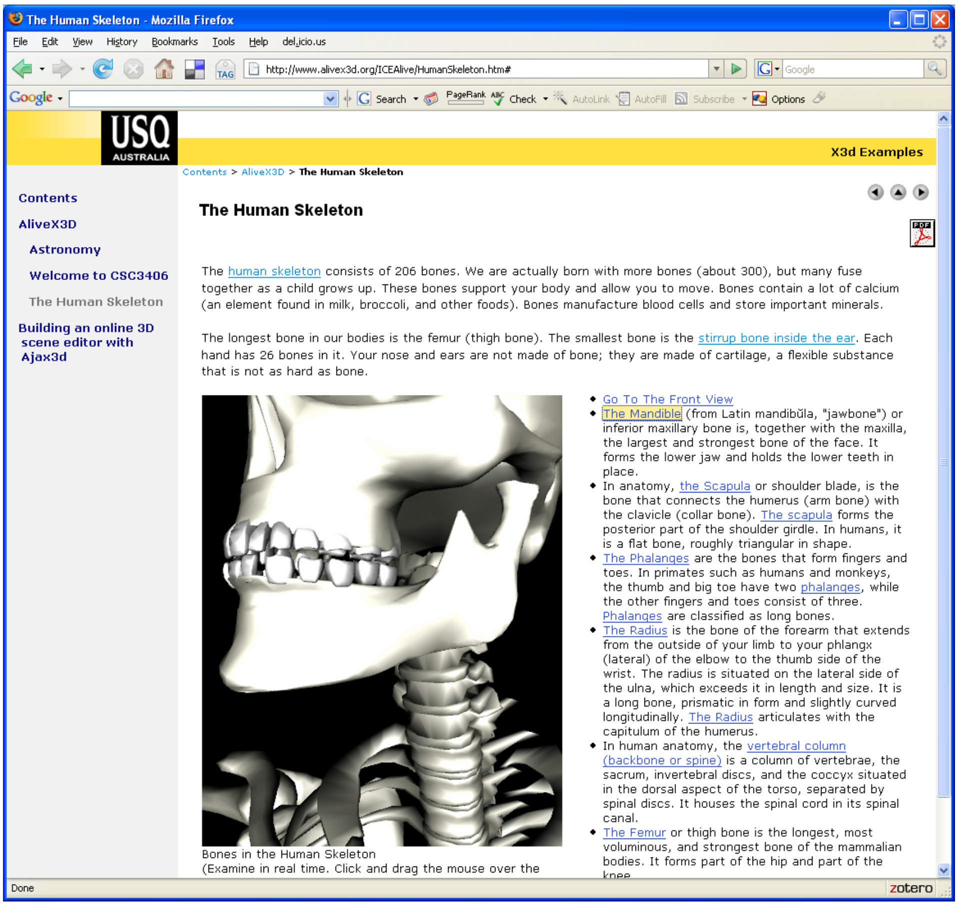


Figure: 8
Dollylinks from webpage text can control the movement of the camera in the 3D window. The camera can be ordered to move and focus in on the area of interest.

PEDAGOGICAL MOTIVATIONS

Pedagogical motivations are many, but three are key to understanding the applicability of AliveX3D to higher education learning and teaching. The first is

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[1] The cinematic term for the movement of the camera towards or away from a subject.

associated with a student's control of their own learning. Garcia and Oin (2007) in a study of student technological competencies and perceptions of effective teaching concluded *"all students share common values regarding pedagogical practices and educators in all media need to do more to expose students to novel approaches and provide them with opportunities to take responsibility for learning activities"* (p.1). The second focuses on authentic learning activities and spaces. Shaffer (2005) suggests that rather than constructing a curriculum based on the ways of knowing of a discipline we should imagine curricula in which students learn to think as doctors, lawyers, architects, engineers, journalists.

Finally, the third key is associated with learning conversations and collaborative learning. Sharples (2005) brings all three components together when he says that the "*most successful learning comes when the learner is in control of the activity, able to test ideas by performing experiments, to ask questions, collaborate with other people, seek out new knowledge, and plan new actions"*(p. 3). These three drivers of learning (control, authenticity and collaborative conversation) can now be simultaneously implemented within a Web3D environment through the proposed Alive3DX innovations.

Web3D can support a suite of pedagogical experiences that are unique within current e-Learning technologies. The worlds created in immersive 3D virtual reality environments are distinctively structured. The world creates a synthetic experience that captures the essence of *being* in a particular world or context, and replaces the traditional computer interface which sits between a learner and their computer-based educational material (Winn, 1993).

This immersion enables learners to negotiate meaning based on their own personal cognitive, affective and kinaesthetic experiences rather than on the descriptions of others' experiences. It assumes learners will construct knowledge through non-symbolic, non-reflective, first-person psychological activity that occurs when they interact directly with worlds. Choices embedded within the worlds allow the learning focus to shift away from isolated pre-designed interactions, to a situation that encourages the learner to control, manage and direct their own learning. Once immersed within a world, learners can communicate, investigate and experiment either individually or in the company of other learners, to transcend geographical and temporal boundaries. Such conversations can be synchronous or asynchronous, anonymous or identified and are believed to provide community support as well as social learning opportunities and relationships.

It is reported in other types of education games that the presence of a low risk non-threatening environments encourages participation and risk taking (Dickey, 2005).

Thus, the pedagogical power of Web3D is its ability to allow the learners to immerse themselves in a synthetic, purpose built virtual environment where they can act or collaborate as either themselves or as a surrogate persona (avatar). The learner can participate with other learners in discussion (synchronous or asynchronous), investigation or experimentation while involved in a range of other learning activities including simulations, role playing, problem solving, formal instruction, self-assessment and peer assessment (McArdle, Monahan & Bertolotto, 2006).

The accessibility to Web3D by higher education teachers afforded by AliveX3D will allow them to use the flexibility and portability of Web3D technologies for (Chittaro & Ranon, 2007):

- formal education where interactive systems allow students to create their own content, experiment and collaborate while under the supervision of teachers;
- informal education where examples of augmented reality can enhance the teaching and learning of real-life systems;
- distance and e-Learning where teachers can interact and collaborate with students using simple and accessible Web3D tools, a web browser and Internet connection;
- vocational training in which authentic experiences can be given to students in domains and environments not accessible to them during their studies;
- special needs education which offers physically or cognitively disabled students a wider range of experiences with respect to traditional lessons;
- dramatically reducing the cost, distance, danger or impracticality of some real world teaching and learning situations;
- three dimensional representation of topics offering more viewpoints, perspectives and interactions compared with two dimensional representations; and
- establishment of correct mental models and deeper understanding of situations.

FUTURE DIRECTIONS

The fundamental principal underlying the AliveX3D platform is *simplicity*. This addresses the main issues that hampers institution wide acceptance of such technology; cost, time and maintenance (Jones, 2004; Jones & Kalinowski, 2004).

As is shown herein, AliveX3D is unique among existing e-Learning and immersive virtual environments on and off the Internet. Its following of Web 2.0 philosophy and alignment with the Web3D consortium standards places it at the forefront of usable, scalable and sustainable e-Learning technologies. AliveX3D moves beyond the capabilities of existing environments to focus on the education needs within the higher education sector. It will overcome the shortfall of these online virtual environments by:

- conforming to XML and X3D standards and thus having the previously listed advantages;
- providing high-quality graphics rendering using the cross platform rendering engine OpenGL in addition to applying existing game industry rendering algorithms to enable faster updates and response times;
- providing *easy to use* editors which will produce high-quality graphical environments by making the 3D modeling and animation process of existing 3D world editors transparent to the user;
- operating in stand-alone mode which will allow educators and students to use the editor and view content without an internet connection and on CDROM if desired (a functionality not provided by the before mentioned environments);
- providing low bandwidth multi-user communication when collaborating online unlike *Active Worlds* and *Second Life* which require large amounts of bandwidth as they push the environment continuously out to the users causing them to momentarily stall and break the immersive experience;
- operating within http protocol port settings which means institutions wanting to integrate the plug-in with their course content will not require permission from their ICT services to lower firewalls and reconFigure: networks;
- allowing the integration of 2D and 3D content in their more traditional settings as opposed to inappropriately rendering 2D content inside 3D environments;

- supporting and producing interoperable content under the X3D standard;
- supporting the ability to compose a single X3D scene out of assets located on external web servers via hyperlinks;
- removing the focus from social communities where the user is solely represented by a 3D humanoid and where more appropriate replacing the users avatar with some other 3D representation (if at all); and,
- providing secure, invitation only online virtual worlds which are not open to the public but restricted to class members (when required) through existing web server authentications.

The development of the AliveX3D platform will continue. The next stage will investigate the best methodologies for deployment of Web3D in e-Learning context at an institutional level. The aim of this future work will be to produce exemplars, tools and strategies to immerse Web3D technologies within curricula, empower educators to use Web3D technologies in curricula, enhance student engagement through authentic learning activities; and create an Australian community of practice for Web3D e-Learning to annex the international Web3D consortium.

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