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by Penny de Byl

The process of implementing new technologies in university settings has inherent problems, not the least of which is the tendency of educators to use technology, even new media technology, to recreate traditional pedagogical structures (Cuban 1986; Means and Olson 1994; Galarneau 2004). Adoption of new technology may also be hindered, in spite of pedagogical possibilities, by faculty members' lack of experience with it. This is even more true in the case of games, simulations, and virtual reality environments since these have generally been the domain of technical experts (de Byl 2009). However, as students demand more from their educational experiences than flat pages of content, uninteractive videos, and text-based communication software, instructors must begin to move into these complex technologies.

The Advanced Learning and Immersive Virtual Environment (ALIVE) project was launched to address these issues by providing technologically novice educators with the ability to create immersive virtual learning environments. In this paper, I discuss the difficulties educators encounter in creating Web3D content, describe the challenges the research team faced in implementing the project, and highlight the manner in which the ALIVE suite of tools, currently in beta testing, will address these issues.

Web3D

The pedagogical power of three-dimensional learning environments resides in their ability to immerse learners in a synthetic, purpose-built virtual environment where they can explore content-rich worlds and collaborate around participatory learning activities (Bartle 2004). Within these environments, students use avatars to represent themselves or adopt a surrogate persona. The learner participates with other learners in synchronous or asynchronous discussions, investigations, and experimentations while also involved in a range of other learning activities, including simulations, role-playing activities, problem solving, formal instruction, self-assessment, and peer assessment (McArdle, Monahan, and Bertolotto 2006).

Web3D makes immersive three-dimensional environments accessible to students and universities because Web3D elements and tools can be integrated seamlessly into freely available Web-browsing software. Immersive three-dimensional environments provide unique pedagogical opportunities, particularly for distance learners to

- engage with enhanced content and processes through simulations and role playing (Oblinger 2004);
- interact with individuals or groups of individuals while immersed in another activity (Rosenbloom 2004); and
- build their own activities and experiences, thereby taking control of their own learning (Meiguins et al. 2004).

These environments can offer authentic experiences for users, placing them in a sensually rich situation not afforded by other learning environments. Virtual worlds allow students to hear, see, and interact with simulated real-world scenarios in which learners can arrive at genuine understandings. Only an actual real-world experience could offer more complete experiences. For example, the 3D game *Pulse* immerses the student in a medical emergency room situation complete with the visual and auditory cues expected in a hospital (Johnston and Whatley 2005). The student experiences the background chatter of nurses, the clinical talk of other doctors, and the use of medical equipment and then sees how the patients respond to treatment.

The variety of input delivers a level of authenticity that provides the student with a preview of the real-world environment.

Unfortunately, professional-quality games and simulations are immensely expensive to create. In order for this technology to move into mainstream learning and teaching practices, educators must have access to easy-to-use, inexpensive systems for developing Web3D environments. The ALIVE project is intended to provide instructors in higher education with access to the flexibility and portability of Web3D technologies for a full range of uses (de Byl and Taylor 2007):

special needs education, where Web3D has the potential to offer physically or cognitively disabled students a wider range of experiences (Kayo et al. 2007; Bertini, Bimbi, and Sbattella 2004).

- 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 teaching and learning in real-life situations by displaying virtual projected objects into the real world, for example, by creating an openly available virtual version of an ancient ruin through composite virtual models and video footage of the existing site;
- distance and e-learning, where teachers can interact and collaborate with students using simple, accessible Web3D tools, a Web browser, and an Internet connection;
- vocational training, in which instructors can provide students with authentic experiences in domains and environments not typically accessible to them during their studies; and

These technologies have the potential to reduce dramatically the cost, distance, danger, or impracticality of some real-world teaching and learning situations. The three-dimensional representation of topics, locations, or models allows instructors to present students with more viewpoints, perspectives, and interactions than are possible using two-dimensional representations.

Web3D Development Difficulties for Novices

The idea of creating effective and engaging e-learning environments for technically perceptive and innovative educators is alluring. However, the reality is that creating professional applications, including three-dimensional games and simulations, requires the skills and knowledge of a specialist (de Byl 2009). Such design activities are often beyond the technical skills of most students and educators. As a result, despite the unique pedagogical benefits these environments can deliver, including learner self-motivation, learner commitment, and self-directed learning opportunities (Martinez 2003), Web3D environments are out of the reach of most educators.

Specialized, easy-to-use authoring tools are needed to lower the effort threshold necessary to create such applications (Fuchs 2004). Instructors will need adequate technical infrastructure, training, and WYSIWYG editors to implement three-dimensional media in e-learning. Moreover, applying the standards that institutions typically apply to educational content, these environments must be sustainable, interoperable, and scalable (de Byl 2009). While the two-dimensional Web is, to some extent, adhering to this standard, three-dimensional applications and content are far from meeting it.

ALIVE Web3D Technologies

To address this gap in Web3D authoring tools for educators, the ALIVE research and development laboratory at the University of South Queensland, Australia is attempting to increase educator and researcher knowledge about the usability, usefulness, and effectiveness of three-dimensional immersive Web-based environments (Exhibit 1). The lab is also working to develop easy-to-use e-learning tools built upon game engine technology. These tools are designed for the higher education sector, which is populated by diverse groups of students and educators who are becoming increasingly familiar with emerging interactive

three-dimensional technologies.

The aim of the ALIVE project is twofold: First, researchers are examining how Web3D technologies can be made more usable for technical novices, offering educators advice on available technologies and tutorials on Web3D implementation and providing Web3D technology developers with usability requirements to make the technology more widely accessible. Second, the project aims to raise awareness of the power of Web3D for e-learning.

Established in late 2005, ALIVE began with an ethos of sustainability, interoperability, and scalability, examining three-dimensional tools across differing operating systems. The team adopted X3D, the ISO-standard programming language for three-dimensional applications because of its flexibility, openness, and interoperability. Unfortunately, we encountered many compatibility and quality issues across platforms and found ourselves expending a great deal of effort on low-level programming. This task was quite expensive in terms of the cost of labor, and we became consumed with technical issues that kept us from achieving our original goal of creating easy-to-use Web3D authoring tools for e-learning.

Having decided that the end was more important than the means, we had to compromise with regard to interoperability and openness and find a suite of development tools that "just worked." This adjustment enabled us to move forward with creating and researching proof-of-concept educational tools. We are now working toward building a community of users to test our technology, which is built on Microsoft technology, including DirectX, ActiveX, and Internet Explorer, while adhering to the X3D standard as closely as possible.

The ALIVE suite of tools is fundamentally different from other existing tools for the creation of three-dimensional immersive content and environments on the Internet. Through the use of DXStudio, a three-dimensional game creation and editing application, we are building rapid development tools that allow educators to create their own purpose-built three-dimensional environments that can be seamlessly integrated with two-dimensional course materials (Exhibit 2). This means creating e-learning content via easy-to-use interfaces that remove the need for specialists in three-dimensional modeling and programming. Our ALIVE suite of integrated tools ranges from fully customizable and programmable content for the technology-savvy teacher to prefabricated, plug-and-play, immersive virtual teaching and learning environments; together, these tools give educators the freedom to customize 3D virtual worlds for their own use.

One such tool we are working on in beta release is the ALIVE DXEditor 3D scene editor, which features a WYSIWYG interface (Figure 1). The editor's functionality has been structured to take advantage of the online environment, reducing download time by relying on an online library of three-dimensional objects that users can use to build or augment their three-dimensional scenes. Users download objects only when they want them in a scene. This keeps the download size of the editor relatively small since users do not have to download the entire library. The library is also expandable.The ALIVE team, as well as others who wish to contribute to the project, can add objects to the library and make them available to all without requiring users to download version updates in order to access these new objects. The editor simply connects to the Web server, queries the library for available objects, and presents the list to the user.

In addition, the editor offers interactive versions of traditional classroom learning and teaching tools, such as whiteboards, slide projectors, and streaming video. These tools could easily be included in a variety of virtual settings, placing educators and students together along with the tools to steer their interaction in productive directions in authentic reproductions of real-world situations that may not be accessible in the traditional classroom. Using mimio Interactive, an electronic device that turns any surface into an electronic whiteboard, the lecturer writes on a real-world whiteboard, and the lesson is mimicked in an online virtual classroom. This set-up can be used for teaching simultaneously in the real-world and virtual settings or the instructor may be alone in a real-world classroom presenting to students logged into the virtual world.

The three-dimensional worlds created with the ALIVE 3D Scene Editor can also be loaded into ALIVE

Classmate, which allows educators and students to meet in a three-dimensional online world and interact not only via a whiteboard or video link but also via text chat and voice with a voice over Internet protocol (VoIP) link (Exhibit 3). ALIVE Classmate allows for private virtual microworlds that are fully customizable and controlled by the educator in charge. Unlike Second Life or Activeworlds, which are large, persistent, continuous online worlds requiring dedicated server hardware to maintain, ALIVE Classmate allows the educator to create a short-term virtual environment on a desktop computer and invites students to participate using a peer-to-peer connection.

ALIVE Web3D e-Learning Exemplars

The combination of technologies and tools in the ALIVE suite allows for a variety of e-learning scenarios across many academic domains.

Embedded Environments: Merging 2D and 3D Learning

ALIVE environments can be embedded into most Microsoft products (Exhibit 4). The DXStudio player's plug-and-play functionality means that by clicking a button in any Microsoft Office application, educators can embed environments created with the ALIVE Editor into existing course materials created in any of those applications. The resulting materials blend live collaboration functions with traditional two-dimensional content.

This option opens up a multitude of learning and teaching opportunities. Not only do the three-dimensional scenes appear within the document, page, or slide so that users can access them without leaving the application, but they are also live, interactive three-dimensional worlds through which the viewer can manipulate and navigate. Even more powerfully, the environment can be configured to allow users in the environment to interact synchronously with others.

Compatibility with popular Microsoft applications also allows two-dimensional content to be embedded in three-dimensional scenes and simulations, giving educators the tools to overcome some of the weaknesses that have often characterized three-dimensional renderings of textual information, such as equations, formulas, definitions, and general information (Bell and Fogler 1995). Empirical studies have shown that two-dimensional information retrieval is faster and that students much prefer viewing two-dimensional information in two-dimensional displays than in three-dimensional formats (Smallman et al. 2001).

Dollylinks: Hyperlinking into Embedded 3D

Another feature of ALIVE is the ability to create hyperlinks from two-dimensional text that move and orient, or "dolly," the camera in a three-dimensional scene around an area of interest. Using this feature, a reader of two-dimensional Web page content can click on "dollylinks" that direct the camera to specific locations to illustrate the two-dimensional content. This feature creates a truly 2D/3D integration. For example, in a hybrid application for a class on human anatomy, page content describing the bones in the human skeleton may be hyperlinked to three-dimensional model of a skeleton. The bone names in the text are dollylinked to their three-dimensional representations (Exhibit 5). When a user clicks on a particular dollylink, the camera moves to a close-up of that particular bone. The camera does not follow a predetermined path; rather, when the user clicks a particular link, the program calculates a smooth navigational path from its current location to the requested location. The free nature of the navigation means the reader can interact directly with the three-dimensional object at any time by using the mouse within the environment.

Conclusion

The importance of embracing the next generation of Web technologies is paramount. While some academics have already perceived the potential usefulness of immersive three-dimensional environments for instruction, few universities have made the jump to experimenting with their design and mainstreaming the use of these environments. This failure is a result of the effort, skill, and technical know-how typically required to design these environments. The ALIVE team has attempted to remedy this problem by providing an easy-to-use tool that allows educators to create three-dimensional simulations and learning objects and easily embed them within their teaching and learning materials.
To this end, the ALIVE team has attempted to

- allay teachers' anxieties regarding these technologies by demonstrating the use of Web3D applications within the context of individual disciplines;
- disseminate examples of Web3D games, simulations, and virtual reality programs that have been successfully used for e-learning along with information about these programs' affordances and constraints; and
- provide easy-to-use tools that remove the technical obstacles to three-dimensional technology in the classroom so that the educator can concentrate on teaching.

In order for three-dimensional technologies to flourish within educational institutions, the technology needs to be affordable, scalable, sustainable, and interoperable. It is hoped that through ALIVE tools, our Web site, and interaction with the Web3D Consortium, we can create a community of practice that encompasses educators, developers, and artists willing to contribute pedagogical content, prefabricated environments, and high quality models that can be made available to everyone.
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