Enabling Social Dimensions of Learning Through a Persistent, Unified, Massively Multi-User, and Self-Organizing Virtual Environment

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Abstract

Existing online learning experiences lack the social dimension that characterizes learning in the real world. This social dimension extends beyond the traditional classroom into the university's common areas where learners build knowledge and understanding through serendipitous and collaborative exchanges both within and across traditional subject area boundaries. A next generation Virtual Learning Environment (VLE) can address the limitations of current online systems by providing a richer social context for online learning. We describe the end-user properties of a highly-scalable self-organizing Croquet-based VLE that fosters dynamic group learning experiences and the development of communities of practice. This proposed VLE provides the capacity to merge the institutional infrastructure for academic computing, enterprise-level networks, Squeak/Croquet-based content authoring, and the educational principles of constructivist pedagogy.

1. Introduction

Existing online learning experiences lack the social dimension that characterizes learning in the real world. Although communications devices embedded in current learning management systems (discussion forums, email, bulletin boards) allow for administrative efficiencies, educator-learner communications beyond the classroom, and a limited degree of peer-to-peer interaction, these functionalities do not come close to providing a satisfying support system for a community-based, learner-centered "constructivist" pedagogy.

To date, the developers of commercial e-learning platforms have given us "transactional environments" for education – e.g. course management systems (CMSs) and learning management systems (LMSs) that are functionally suited and adapted to a world of online transactions. This transactional perspective on learning derives from a traditional, behaviorist approach to education that reinforces the self-contained nature of the individual learner. Cramped and limited, the learning management system's transactional approach cannot begin to address the crucial goals of higher education, particularly as those goals move away from basic knowledge acquisition to a more complex, contextualized understanding of knowledge construction.

The behaviorist approach to learning has long been challenged by proponents of a so-called "constructivist" pedagogical tradition. To understand the key differences between a behaviorist and a constructivist approach, consider the very different way in which each tradition understands one of the hallmarks of computer-enhanced learning – e.g. "interactivity." Current learning management systems offer "interactivity" from the behaviorist perspective. The individual learner is largely "self-contained" and left to his or her own devices to work with web-based resources, meaning that "interaction" occurs almost exclusively between the learner and the learning resources.

By contrast, the constructivist model is far more concerned with the quality of interactions between and among learners as they communally explore and interpret learning resources. From the constructivist perspective, knowledge is always "constructed" in group conversation and within the context of an older, ongoing "conversation" known as a "community of practice." The community of practice is a group of people with a shared history that gives them, among other things, a shared identity, a repertoire of common practices, and a similar knowledge set. Constructivist learning domains will necessarily involve the learner in a rite of initiation as he or she enters the ongoing "conversation" within which the disciplinary knowledge of the community is constructed over time. This approach to learning becomes effective when learners feel the supportive presence of participating peers, mentors, and experts [1-5].

According to constructivist pedagogy, the educational aims of higher education may be divided into the categories of: 1) *Knowledge and skills acquisition*, including competence with tools and techniques; 2) *Socialization*, particularly induction into the canons of particular communities, disciplines or professions [6] and 3) *Development of intentional learning*, a form of learning in which learning itself is the goal and the individual becomes a self-organized learner, capable of critical thinking, reflective practice and active open-ended inquiry [7]. Of these three broad educational aims, current e-learning tools have managed to address only the first, most transactional goal, with any degree of success.

The text-based discussion tools embedded in current commercial learning/course management systems do help educators build some sense of social cohesiveness into the online learning environment yet they fall short of providing the necessary scaffolding for active, evolving, and self-organized learning within communities of practice. We borrow a phrase from science historian Donna Haraway [8] to describe the crucial ingredient missing from text-based "community-building" tools – namely, "situated knowledge."

Our effort to implement an immersive, learner-centered educational environment is based on the "constructivist" pedagogy outlined above. We assume that a key goal of education is to facilitate a learner's maturation from a passive recipient of information who is dependent on authorities to a responsible, self-organized learner capable of co-constructing knowledge in active, ongoing dialogue with peers. Significantly, the mature "intentional" learner is one who is aware that all knowledge is "situated," meaning that perspective (vision) is embodied and therefore always situational, partial, and mobile. Each of us views a common object of knowledge (learning resource) from within a particular body, location, and experiential standpoint. Since knowledge is arrived at through dialogue among these partial perspectives, "situated knowledges" will always have to do with communities (or affinities), not isolated individuals. "Situated knowledges," as Haraway cautions, "require that the object of knowledge be pictured as an actor or agent, not as a screen or a ground or a resource."

Development of a VLE that can "re-embody" the online learning experience will provide educators with what Haraway refers to as an "apparatus of bodily production" [8]. Within such a scaffolding, the objects of knowledge –learning resources such as simulations, clip models (*sensu* Van Dam), and the like – become active, meaning-generating parts of a learning landscape populated by learners and educators who are readily identifiable, locatable, mobile, and responsible for their perspective on the objects of knowledge around them, objects that are themselves pictured and active in this environment.

We do not propose the creation and delivery of a virtual museum of fixed knowledge artifacts. Instead, we seek to promote a technological approach that provides educators and learners with a living, dynamic virtual space for creativity and constructivist exploration and experimentation (*sensu* Kay and Pappert). To this end, we are presently designing and implementing the architecture for a dynamic *knowledge ecology* that evolves over time owing to the facility with which educators and learners are able to add and modify content within shared virtual spaces [9]. The goals of the project are to develop, implement, deploy, and evaluate a large-scale Squeak/Croquet-based distributed collaborative environment for the education and research communities. The design of this system involves a grid computing architecture to provide a distributed object repository matched with a tier of decentralized servers to manage real-time interactions. The goal is to promote a self-organizing, interdisciplinary knowledge sharing system that ensures accountability and trust relations among users through a system of identification, authentication, and authorization.

In what follows, we describe how the application of such technologies can establish a system that itself models the values that many educators wish to impart to their learners by 1) illustrating the power of collaborative creation through the continual co-construction of dynamic knowledge spaces; 2) by establishing a crucial social foundation for the distributed development of rich educational resources, and 3) enabling academic communities of practice that can effectively leverage the use of post web-browser educational technologies.

2. The Problem

One may think of the university campus as a broader social space containing classrooms where learners interact with their peers in the creation of knowledge. It is clear that learning is not confined to the classroom but also takes place in the university common areas where learners enjoy a less structured but equally valuable opportunity to interact with peers, draw connections across individual disciplines, and experience serendipitous encounters that transform their thinking.

Our current efforts to develop a Squeak/Croquet-based distributed collaborative VLE are motivated by a perceived insufficiency of current online learning systems and the need for a richer learning context, one that reflects the situated nature of knowledge and provides increased opportunities for serendipitous learning encounters. The failure of content/course management systems to capture the richness of the social dynamic on campus has led to various attempts at solving the problem by creating social spaces within text-based "environments." Educators have adapted multi-user dungeons (MUDs) and their object-oriented variants (MOOs) for educational purposes [10]. However, the text-based nature of the MUD/MOO does not favor every learning style. It requires that its participants have fast fingers and strong imaginations as they attempt to conjure up realms of shared existence that have no locatable presence.

Significantly, many online learners are familiar with the conventions of an alternative online social environment, one that is not text-based but instead predominately visual – e.g. the immersive, interactive online game environment. Respected educational reformers have only recently recognized the educational potential of these highly social and immersive gaming environments [11] and many are beginning to argue that such a common online space complete with a set of tools for authoring knowledge objects that may be visibly altered and manipulated would provide participants with a far more intuitive social environment than the kind provided by text-based MUD/MOO alternatives [12].

3. Barriers

To be sure, a transformative online context for teaching and learning that leverages the online entertainment industry's rich visualization and interactive technologies could not have been feasible until now, for a number of practical reasons, including 1) the costs associated with the development of rich 3D or other content; 2) the problem of distributing rich 3D simulations to the end-user's computer; and 3) the heavy burden that advanced media place on institutional network resources.

Implementation of even the most rudimentary 3D content remains a very costly proposition, largely prohibiting the use of 3D environments in non-commercial applications. A typical 3D game that delivers 100 hours of rich and interactive game play may cost between $5-20 million US Dollars (USD) to produce. Even with the use of open source 3D engines, development of a well-constructed and content-rich environment to run within an engine often takes 18-24 months to create (at a cost of $2-10M USD).

In an effort to reduce the costs of implementation, some educators have turned to licensing the use of a given commercial online entertainment application so that they can leverage the feature set of its graphics engine, modifying one or more levels in support of a specific set of educational goals – a practice referred to as "game level modification" or "MOD-ing." However, given this approach's reliance on existing features developed for a commercial entertainment product, the educator's MOD cannot be readily re-purposed or extended for other educational applications or for use by other educators. Furthermore, the game engines available for licensing seldom support the kind of application switching necessary to a modern learner-oriented computing environment, making it difficult to integrate things such as web browser access within the game-based learning environment.

For many years, slow processor speeds and rudimentary graphics processor capabilities made it difficult to deliver content-rich 3D environments with high polygon counts to large numbers of users. Distribution of a content-rich MOD based on a commercial gaming engine and its installation on the computers of all the end-users proved almost insurmountable for academic institutions.

As a result of the high implementation costs associated with their development, visually immersive online social spaces have for the most part remained the purview of the online gaming world, where rapid movement is prized over the creative alteration and manipulation of knowledge objects [13].

Probably the single most intransigent barrier to the successful implementation of immersive 3D learning spaces is the least technological in nature. It is the perception that 3D belongs to the world of online gaming, and therefore to the world of what are generally regarded as trivial and violent pursuits. We argue that the learning potential in creating 3D social environments will become more apparent now that the barriers to the production of high-quality 3D learning spaces are beginning to crumble. It will take educators, not commercial game designers, to recognize and exploit the learning potential of such an environment, where an educator can display a 3D simulation of two molecules bonding and learners may interact with one another as they watch the bonding process unfold. Moreover, it will be educators, and not commercial game designers, who will concern themselves with developing the open logical models and API's for the kind of automated access tools and interpreters which will make it possible for the visually impaired to participate in such a vision-centric online community.

The ubiquitous deployment of high-connectivity WANs at educational institutions, the recent advances in desktop processing capabilities, middleware services, and grid computing have all converged to provide the proper conditions for the development and implementation of VLEs capable of fostering dynamic group learning experiences and the development of communities of practice.

4. Properties of a Virtual Learning Environment

A persistent, unified, secure, massively multi-user, and self-organizing VLE is one in which users and network-deliverable resources are displayed as mobile avatars and objects, respectively, within a very large, contiguous online space. Within the shared context of such a common space, authenticated members of a university's multi-disciplinary enterprise could gain access to learning objects and other network-deliverable services (including integrated online communication features such as voice/video, email, and chat/instant messaging).

Moreover, the massively multi-user nature of such an interactive environment will provide a way of extending social dimensions of learning into the virtual arena. Like-minded colleagues with an affinity for a particular subject matter could gather at the location within the VLE of those learning resources that are most relevant to their interests. Since the real-time communications tools familiar to most users (chat and instant messaging) would be fully integrated into this multi-user environment, members could easily forge new professional/personal connections or maintain established ties with those assembled around relevant learning resources. This virtual environment, then, would offer its users a chance to form affinity-based "communities of practice" that are directly related to their personal academic goals.

4.1 Persistent and Self-Organizing

Persistence of resources and situations within a VLE may best be explained through analogy with current so-called "weblog" technologies. Weblog software enables individuals and groups of individuals to maintain a continually updated web site that grows over time with the accumulation of writing and images. Thus, the weblog both persists over time and evolves over time.

Similarly, the technologies behind an effective VLE should likewise provide an easy, non-technical way for users and groups of users to continually update the environment by instantaneously publishing its constituent resources. Such resources would be immediately visible and available to all other members of the shared space though a process of authenticated publication to the space. All such resources should be stored in a federated repository so that they may be reused or modified by others. Through these features, the proper conditions will be set for the VLE to persist, evolve, and become organized over time.

4.2 Unified and Secure

Learning communities are enabled, according to pedagogues Laplate and Weisneri [14], when members are able to: 1) locate or be directed to relevant people and stored information, including easy access to federated databases and digital repositories; 2) locate and be informed of likeminded members; and 3) feel certain that communications between members are secure and that all participants are accredited members.

An effective VLE should be designed to deliver the unifying social context and secure framework for locating credible information linked to identifiable sources, whether those sources are peers, teachers, or federated databases. The integration of all these authenticated resources is the power of such a persistent, unifying, and secure community space. The VLE should also be attuned to the particular institutional needs and concerns that surround the question of online identity management.

The creation and maintenance of verified scholarly communities of collaborative learning and practice require that all participants acknowledge one another's identity and thus the situated quality of knowledge. By leveraging Internet2 middleware initiatives such as Shibboleth, a Croquet-based VLE architecture could make use of existing institutional Identification, Authentication and Authorization (IAA) infrastructures to create an arena of discourse where communications between members are secure and where all participants are accredited members (Laplate and Weisneri, 2000).

With the unifying community context of a socially-enabled VLE, institutions will gain the capacity to exploit the power of those less structured and interdisciplinary learning events that make up the fabric of traditional campus life and extend them to the online realm. Such real-world encounters already take place in the campus commons area. They are self-organized and transcend course-bound instruction because they arise out of impromptu debate with peers who represent a broad range of disciplines and perspectives. They are arguably the most valuable opportunities for learning that a university can afford learners.

Since learning communities are enabled when members have easy access to federated databases and digital repositories, effective socially-enabled VLEs should also be designed to improve the ability of participants to locate relevant people and stored learning resources. Current course/learning management systems offer a course-as-silo model that conceptually as well as literally reinforces the disjointedness of the educational experiences they provide. Learners are left to their own devices to do the challenging work of synthesis and cross-disciplinary integration. For their part, educators face a similar dilemma as they design their online courses, given the way in which online content is increasingly being constructed and stored as chunks of information, or learning “objects” disengaged from a larger, and more meaningful context.

In an effort to encourage resource sharing in the design of online courses, academic institutions and their members have initiated numerous attempts to leverage the power of large-scale information systems and establish repositories of federated learning resources. Likewise, an effective VLE will provide a single and shared interface that will readily subsume an academic institution’s content management system along with all federated repositories as components of the simulation. As a result, educators would be able to take full advantage of one or more course or learning management systems’ administrative efficiencies within the VLE while being able to readily locate and retrieve stored resources from federated multimedia repositories for use within the VLE simulation space.

By creating a VLE such as the one described here, creative and communications intelligence can be moved from a network core to its periphery, enabling users to construct simulations in the VLE by using and recombining components designed for other simulations. This vastly reduces the costs of innovation and promotes the emergence of new pedagogical approaches. Virality of such a system occurs through its incremental adoption when the benefit of using it increases as members use and contribute to it.

5. User Experience

The user’s view of the VLE would be rendered dynamically according to the user’s point of reference within the space – i.e. the user has the ability to move freely through a vast and continuous environment using keyboard and mouse according to common computer gaming conventions.

Extending Croquet with institutional authentication infrastructures makes it possible for authenticated groups of users to access and work within a scalable array of virtual worlds that are accessible through a common virtual framework (see [9]).

Authorized users would be allowed to construct and modify objects within a particular locale of the VLE. Depending on a user’s level of authorization for a given locale, the client application may be used to bring up a simple editor that enables users to define objects within the VLE that point to user specified local or network resource data. Objects may either be created outside of the client application and then loaded into the system or chosen from a series of server-defined presets and instantiated at specified locations within the VLE. Objects may also be published to the larger community depending on the user’s identity and associated level of authorization for a particular region of the VLE. When a user modifies objects within a locale, the client software passes object coordinates, an object identifier, and any required assets to the local interactivity server that then promotes that information to a server, or servers, containing information about the world content (Worldbase servers). There, the information is stored, replicated and cached and then eventually passed back outward to all clients. The client will utilize a local cache of data derived from the Worldbase servers, interactivity servers, and other clients (see [9]).

Using the same client-based editing capabilities, authorized users will also be able to personalize the VLE with custom objects that are available only to them or their designees upon login to the system. The data necessary for clients to render the local environment and objects contained therein is updated dynamically as the user moves about within the VLE. Educational resources, learning objects, and other representations of network-deliverable services appear as objects within the space.

The VLE will initially be embodied as a massive simulated environment that will serve as the unifying context for all resources that are delivered through the system. The environment will initially be seeded with objects that point to a defined and existing set of web-deliverable educational resources. This set of objects will be supplemented and modified by over time by users of the system.

The VLE can effectively overlay all web-based methods of information delivery since such resources can be accessed via a built-in browser that is capable of displaying interactive web-based resources within a scene. This makes it possible for the system to define a backwards-compatible framework for currently deployed learning management systems, content management systems, and all other Internet-deliverable information resources.

Objects within the environment would constitute a “user interface proxy” that points to data held on servers – acting as hypermedia objects that point to other network-deliverable resources. Such objects could even point to a resource that is used to load an alternate scene loaded from a server (see Figure 1).

Through the client-generated VLE, objects within and beyond the current locale would be identified and located through the use of web-based directories and through web-based searches of database entries. Once a target object is identified through a text-based search, users would be provided with the ability to select a link and be transported to the corresponding object within the environment. During the load time of a selected resource, the users viewpoint would be moved in a continuous manner through the space. During transit, users would be exposed to cues about the overall knowledge structure, the situation and relationships of the target resource, and the existence of other users interacting within the same knowledge space. A specific web-page resource could be requested by users when they enter a URL into the interface or when an object in the VLE is selected. Such pages would appear in a window that either pre-exists or appears within the simulation.

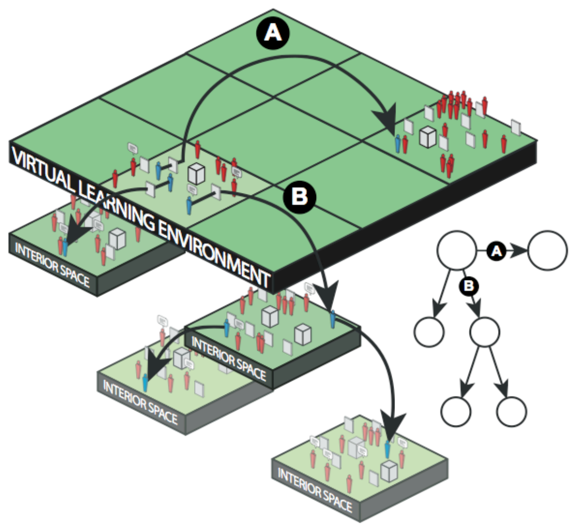

Figure 1: To allow for the efficiencies of taxonomically organized information when appropriate, an object within a locale may represent an access point to another locale at the same taxonomic level of the space (A), or to a subordinate taxon (an "interior space") (B). Thus, objects may, from a users perspective, contain spaces within them or they may act as gateways to remote locations within the shared VLE or to spaces contained within objects.

Depending on their institutional identity and to the rights afforded to those identities, users would have the ability to create objects, move/modify objects, or modify the metadata associated with objects in the space. This mechanism of distributed authorship of the environment makes it possible for the knowledge structures of the VLE to represent collective intent and become optimized over time. Through this mechanism, objects come to be organized in regions that reflect disciplinary relationships as perceived by authorized expert users. Since each such object occupies a discrete location within the VLE, all users perceive and maintain a sense of the informational relationships of a user-derived disciplinary "knowledge space." As such knowledge resources are established and refined within locales of the VLE, users within those locales are able to visualize the relationships among the knowledge resources and other users through the power of *ad hoc* user communities.

The cumulative effect of such a distributed and collaborative process of VLE creation is that the local knowledge structures and social organizations within locales of the VLE become optimized over time reflecting best practices as determined by disciplinary content experts and participants in the 'community of practice'. Quality of the knowledge resources and their structure is controlled through the verifiable authorship of each and every object or object modification. Since authorship of all modifications is known and attributable to the true institutional identity of the author, social pressures that are tied to institutional identity and regulate behaviors within real-world academic institutions are made to operate within the VLE. Thus, the system is designed to provide educators with a flexible and collaborative framework for online-content creation, organization, and delivery.

6. Impacts

Both execution of the deliverables within this framework and the deliverables themselves will serve to integrate research and education. The execution will involve the work efforts and participation of learners in a wide range of educational disciplines including those in the educational sciences, curriculum development, and pedagogy. Through implementation of this framework, institutions will have the opportunity to observe and assess the merits of constructivist pedagogy and the role an enhanced social context plays in improving online learning outcomes.

6.1 Educational Assessment

Users within this distributed knowledge space will be visible to one another and their patterns of movement can yield data that may be tracked and assessed by other authorized users, including faculty, who will be able to monitor learner performance and improve learning outcomes. We will therefore design and implement methods by which user interactions and behaviors within the common VLE can be tracked and reported and will develop a set of tools for tracking and reporting activities within the learning space. This will make it possible for researchers and educators to assemble data about how users interact with each other and with knowledge structures within the VLE. Researchers will be able to use these tools to track interactions, decisions, collaborations, and communications and store them in a single, personalized location for evaluation. In this way, information for evaluation and feedback can be reported against defined and accessible learning objectives. Exploring this area of research will be central to building effective virtual learning systems for education and training.

7. Challenges

Success of this initiative is reliant on the development of a useful open/open source framework and implementation, the initiation of a community of developers to build and enhance those implementations, and the formation of a community of institutions, educators, and learners that adopts the applications. By enabling such communities to thrive and form ad-hoc networks of educators and learners, we will have set the starting conditions for large-scale transformative change in teaching and learning.

8. Conclusion

The time is now right for educational institutions to incorporate the power of 3D visualization technologies into the online academic arena. Recent advances in academic computing, including the ubiquitous deployment of high-connectivity WANs, have finally made it feasible for educators to shape the new media in transformative ways. A persistent, unified, massively multi-user and self-organizing virtual environment for learning that leverages the rich collaborative capabilities of open source technologies such as Croquet is what is needed to take e-learning to the next plateau, enabling online "interactivity" in a constructivist sense – e.g. "interactivity" that is synonymous with vital, self-organizing communities of practice.

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