Design and Representation of the Virtual Campus as a Place

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Abstract. Virtual worlds as places are networked environments that may look like the physical world as well as create a sense of place for a person to communicate, navigate, and do things. The virtual world, as a basis for creating a virtual learning environment, has the advantages of providing a familiar and rich environment that is inherently collaborative. The familiarity comes from the likeness of the virtual world to the physical world. The richness is possible through the design of the virtual world to have many of the characteristics of the physical world. The virtual world is inherently collaborative when awareness of other people in the world is included in the design. Virtual learning environments have used ideas from virtual worlds to varying degrees, including metaphorical references to a spatial world for navigational or organizational purposes. In this paper we present a framework for designing the virtual campus as a place that has the potential to provide as rich an environment for students studying in the virtual campus as the physical campus provides. The framework separates the design into three levels: the implementation level, the representation level, and the user interface level.

Keywords: virtual campus, design, virtual worlds, architecture

1. Overview of the Virtual Campus

The Virtual Campus in the Faculty of Architecture at the University of Sydney is used in undergraduate and graduate programs to complement the physical campus. In the virtual campus students can join a social and educational community as well as have access to learning materials, quizzes, student records, and other information. While many universities are developing online learning environments to allow flexible learning and access to materials from home, a few universities are moving towards the development of learning communities in addition to flexible access to learning materials. Our virtual campus lies in the second category: we are developing a combined learning community and online learning materials environment using a virtual world approach. We recognize that more and more students at universities are employed while pursuing a degree and their ability to spend a large amount of time on campus is diminishing. This has a negative effect on the students’ ability to participate in a learning community and promotes isolated learning. Providing a virtual campus to complement the physical campus can address the needs of students in participating in the learning community without having to be located in the physical campus. In this paper we highlight a framework for design that can facilitate and guide the development of the virtual campus concept.

Our virtual campus started as a virtual design studio (studioMOO) in which students established a collaborative project with students at other universities to share ideas, CAD drawings, and hold virtual meetings. We continue to support virtual design studios using a variety of software platforms (Maher et al 1999), including Teamwave (http://www.teamwave.com), ActiveWorlds (http://www.activeworlds.com), and desktop
conferencing facilities like Netmeeting (http://www.microsoft.com/netmeeting). While we use a variety of tools in the virtual design studio, we also realize the advantages of the original studioMOO environment providing a sense of persistent place and community in an online environment (Cicognani, 1998). We have studied the design aspects of the virtual campus as an object-oriented world, commenting on how a person communicates, navigates, and does things in a text-based virtual campus (Maher, Skow, and Cicognani, 1999). We have analyzed student participation in virtual seminars and have shown that student participation is higher in virtual discussions than in the equivalent face to face discussions (Maher and Simoff, 1999).

In reconsidering the design of our Virtual Campus, we have identified the following purposes for our virtual campus:

1. augment traditional lecture-based teaching with online learning materials
2. support project work that follows an intensive face-to-face learning program
3. provide distance learning with all interactivity and materials available online

A central aspect of our virtual campus is the development of a community of learners to allow collaborative learning rather than reinforce isolated learning. Our approach is to design the campus as a virtual place, with metaphorical reference to physical places. Rather than regard the virtual campus as an information resource, we design the campus as a place with access to both people and information. For this reason, we have developed a framework for designing a virtual campus that considers the metaphor of physical campus at the representation level, allowing the design activity to focus on those aspects of physicality and place to be considered separately to the implementation issues and the user interface.

There are numerous examples and developments in shared virtual places for educational purposes. The literature on the development of an online learning environment ranges from the design issues in a particular environment to the analysis of student participation in a specific learning environment. Samples of the studies that consider the learning environment as a virtual campus are:

- The formation of a learning community and the design of an environment that supports the needs of that community. For example, the TAPPEDIN project (Schlager and Schank, 1997; Schlager, Fusco, and Schank, 1998) is an extensive study of user needs in the design of a community environment to support teacher development.

- The development of an object-oriented approach to the implementation of virtual worlds. LambdaMOO is possibly the most widely used database, but others have been developed to address specific implementation issues. For example, Rowley (1997) describes InterMOO as an implementation of a distributed MOO database that is more robust, flexible and scalable.

- The use of an object-oriented representation in 3D virtual worlds. Net Effect (Das, et. al. 1997) uses an object database that provides an infrastructure for developing, supporting, and managing large, media rich, 3D virtual worlds, for use by several thousands users: children between the ages of 7 and 11 years. ActiveWorlds (http://www.activeworlds.com/) uses an object oriented approach to a 3D building environment for professional and educational communities through the development of a universe with several worlds, each world has a different purpose and community.

Our experience in using, developing, and modifying the virtual campus is the basis for our research in the design of virtual places from the perspective of architectural design. We have developed a model of design for virtual places that can be the basis for understanding
existing virtual learning environments as well as provide a framework for designing new virtual places.

2. Design and Representation of the Virtual Campus

The design of the Virtual Campus is originally based on the virtual world concept. Virtual worlds are networked environments that look like the physical world, and create a sense of place for the person navigating and doing things. The design of the Virtual Campus is influenced by the similarity between the physical world and the possibilities for leveraging this similarity in the virtual campus. The experience of others developing a virtual place for education demonstrates the different ways in which the conceptual metaphor of place can be used:

- Diversity University (http://www.du.org) organizes places according to rooms, buildings and outdoor space in a neighborhood-like environment. Navigation is facilitated by a map of the campus and a person moves from one place to another with directional commands like east or west.

- TAPPEDIN (http://www.tappedin.sri.com) organizes places in a high rise building by a consistent use of floors, wings, rooms, lobbies, etc. Navigation is similar to moving around a physical building using stairs and elevators and directional commands like up, down, in and out.

- Virtual U (http://www.vu.vlei.com/) uses the idea of buildings to organize information and materials and uses an image of the part of the campus you are in to orient the user.

- The Virtual Campus at the University of Sydney (http://www.arch.usyd.edu.au:7778) organizes places according to the function of specific rooms. Navigation is done by choosing among alternative rooms’ functions, in increasing specificity.

We propose that there are benefits in the consistent use of the conceptual metaphor of a physical place. Students can rely on their interaction with the physical world as a basis for figuring out how to navigate and interact with the place and other students. Our experience in the physical world is the basis for our understanding concepts that are not physical (Lakoff and Johnson, 1999). A framework for design that relates the design of virtual places to the design of physical places has the potential to provide a more consistent use of our experience in the physical world while highlighting the aspects of the virtual campus that go beyond the physical campus.

We present the design of the Virtual Campus at three levels: the implementation level, the representation level, and the interface level.

1. The focus of the implementation level is the language environment in terms such as the database, persistence, speed, and organization of the “content” of the virtual campus. We consider the object-oriented implementation because it most closely maps onto the object components we present in the representation level.

2. The focus of the representation level is on the components and hierarchies of the virtual campus and their consistent use of a specific metaphor.

3. The focus of the user interface level is on the facilities provided to the user for effective use of the virtual campus.

For each level, we describe the considerations, the design that we have developed before we had this framework, and propose how we are currently redesigning the virtual campus to provide a better environment for an educational community.
2.1 The implementation level

Our Virtual Campus is implemented as an object-oriented database, based on the LambdaMOO core (see Benedikt and Ciskowski, 1995). The database is accessed visually through dynamically created Web pages as well as through a telnet connection for simple interaction and advanced programming. External tools are maintained as stand alone tools, loosely integrated with the Virtual Campus. The major external tool in the current implementation of the Virtual Campus is WebCT (http://www.webct.com).

When considering the design at the implementation level, the requirements to be considered include:

- The number and location of the users
- The location of the objects in the database
- The advantages of central or distributed database or files
- The bandwidth available to the users
- The mapping from the representation level to the implementation level
- Interoperability with other virtual campus environments

In our virtual campus, we have up to 800 students (the number of students enrolled in the Faculty of Architecture), although only 300 students are active right now and of those only 20-40 students are connected at one time. For now the students are located in the Sydney area, but not necessarily on a fast connection. We use a central database on our Unix web server. We have a direct mapping from the representation level to the implementation level: a new room or learning space is implemented by creating anew object in the database. We have benefited from the interoperability of the lambdaMOO database for installing features from other MOO educational sites.

The object-oriented database provides the basis for all aspects of the Virtual Campus:

- the implementation of the infrastructure of the places such as classrooms and offices,
- the implementation of the things in the place such as slide projectors, seminar recorders and people, and
- the implementation of the administration of the place such as the objects for information about registration of people and programming changes,
- the implementation of the interaction with other environments such as the web browser and WebCT.

We use a hierarchical object classification, consistent with the basic LambdaMOO database. The root object defines the basic characteristics of all objects in the Virtual Campus. The first level of object types includes person, room, exit, thing, and administration. A generic person is the basis for creating students and academic staff in the Virtual Campus. By creating a reactive object for each person, a student can customize his object representation to personalize himself and to have it behave as the individual wants. A generic room is the basis for the representation of classrooms, offices, elevators, etc. The exit is an object for connecting rooms that allow people and things to leave and enter. A generic thing is the object from which the object instances of furniture, whiteboards, slide projectors, notes, etc. derive their basic properties and verbs. The actions that can be performed on a thing include take, get, put, erase, etc. The administrative objects are there for programming purposes and generally are not relevant to the students.

We have not focussed on the implementation level in our design, giving more attention to the representation level. In reorganising the object classes, we plan to develop a closer mapping from the representation level to the implementation level. The implementation level can be developed in a process similar to the database modelling process, by defining the requirements, the data model, and then developing an entity-relation model of the world to be implemented.
2.2 The representation level

The representation of our Virtual Campus is based on the conceptual metaphor of physical places, or more specifically, building design. The infrastructure of the Virtual Campus is comprised of rooms and things. The room is a generic term for any kind of self contained space, so a room could also be interpreted as a hallway or an elevator, as well as a classroom. We started our virtual campus by creating room objects, placing “thing” objects in them such as desks and chairs, and then augmenting their functionality for effectively holding seminars and meetings, or working privately in a virtual office. This followed similar approaches in developing the lambdaMOO database for educational purposes (such as Diversity University (http://www.du.org:8888), BioMOO http://bioinfo.weizmann.ac.il:8888/), TAPPEDIN (http://www.tappedin.org:8000) and others. Many ideas and objects were shared among the developers.

With a framework for design that has separate considerations for the implementation and representation levels, we are now focussing on the design and development of the representation level. We have adopted the metaphor of the physical place and are considering how this metaphor provides both a consistent base for defining new representations, a starting point for a new design, and the potential to go beyond the metaphor and develop new functions and behaviors that are possible only in virtual places. We have identified two approaches to establishing the metaphor of the physical place:

- The building blocks of physical place defined in terms of function, behavior, and structure.
- The immersive environment of the 3D world in terms of ambience, function, and navigation.

When designing a representation of the virtual campus, we consider the following:

- The selection of the metaphor, for example: a campus, a building, or a specific place in history (or the future).
- The explicit representation of the characteristics of the place, for example: function, behavior, structure; activities and contents; or form and function.
- The importance of using a single metaphor or multiple conceptual metaphors, examples of different metaphors is the physical campus metaphor, the desktop metaphor, and the information superhighway metaphor.

In designing the building blocks of the virtual campus, we start with a prototype representation of the associated physical place and adapt it. To characterize the physical and virtual building blocks, we use the concept of a design prototype (Gero, 1990), a representation of the aggregation and components of a design domain according to function (or intended purpose), behavior (response to its environment), and structure (materials and form). We have developed a design prototype representation of rooms, creating a list of prototypical rooms that were then implemented to facilitate the creation of new rooms for different functions. Such prototypical rooms include classrooms, offices, hallways, libraries, studios, and elevators. Making these prototypes explicit allows the representation to be more than a label for the same type of room. The differences in the prototypical rooms are briefly described below.

- Classroom – a place for lectures, seminars, and access to slides, notes, and bulletin boards.
- Conference room – a place for larger groups to attend and discuss presentations.
- Office – a personal working place for individuals.
- Meeting room - a place for small meetings and discussions with presentation and recording equipment.
- Studio - a place for designing and working on projects.
An example of the comparison of the physical and virtual prototype representation of a classroom is shown in Table 1.

<table>
<thead>
<tr>
<th>Physical Classroom</th>
<th>Virtual Classroom</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Function</strong></td>
<td></td>
</tr>
<tr>
<td>Presentation of learning materials</td>
<td>Access to learning materials</td>
</tr>
<tr>
<td>Privacy during class times</td>
<td>Direct access to a specific subject</td>
</tr>
<tr>
<td>Discussion environment</td>
<td>Meeting place</td>
</tr>
<tr>
<td>Blocks outside activities and noise</td>
<td>Monitored discussion environment</td>
</tr>
<tr>
<td></td>
<td>Blocks outside activities and discussions</td>
</tr>
<tr>
<td></td>
<td>Access to other students in a particular subject</td>
</tr>
<tr>
<td></td>
<td>Access to personal performance in a specific subject</td>
</tr>
<tr>
<td></td>
<td>Link to tools needed to complete assignments</td>
</tr>
<tr>
<td><strong>Behavior</strong></td>
<td></td>
</tr>
<tr>
<td>Warm in winter; cool in summer</td>
<td>make room quiet to interruptions</td>
</tr>
<tr>
<td>Different levels of lighting</td>
<td>start and stop a session</td>
</tr>
<tr>
<td>Acoustics to project lecturer’s voice</td>
<td>moderate a discussion</td>
</tr>
<tr>
<td></td>
<td>Entrance/exit</td>
</tr>
<tr>
<td></td>
<td>2D image of the layout</td>
</tr>
<tr>
<td><strong>Structure</strong></td>
<td></td>
</tr>
<tr>
<td>floor shape and size</td>
<td>3D model of the room</td>
</tr>
<tr>
<td>wall height</td>
<td>Contents such as chairs, blackboards, slide projectors, etc.</td>
</tr>
<tr>
<td>materials of walls, floor, ceiling</td>
<td></td>
</tr>
<tr>
<td>door location</td>
<td></td>
</tr>
<tr>
<td>organization and number of chairs</td>
<td></td>
</tr>
<tr>
<td>blackboards, slide projectors, etc</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. A simplified prototype representation of physical and virtual classrooms

When developing the representation of the prototypes in a virtual campus, we have been more concerned with the function and behavior of the various parts of the campus, rather than with the structure. It is not clear what the metaphor of structure in the physical campus is in the design of the virtual campus. This is considered further in our design of a 3D immersive environment for the virtual campus.

The 3D immersive environment can have the following purposes: navigation, ambience, access to tools and facilities.

Navigation: navigation in and out of rooms may be easier with a 2D image of the floor plan. Navigation around a complex set of buildings and rooms may be facilitated with a 3D environment for example, Figure 2 shows the variety of ways that 2D and 3D representations are used for navigation in TAPPED IN.

![Figure 2. 2D and 3D Representations for navigation in TAPPED IN](http://www.tappedin.sri.com).
Ambience: understanding what a person can do in a virtual place can be conveyed by creating a visualization of the objects in the physical world that serve similar purposes. Figure 3 shows how Virtual U uses a 3D representation that provides ambience for the student.

![Figure 3](http://www.vu.vlei.com)

Access to tools and facilities: identifying the activities and objects that are available to a student or teacher can be presented in 3D. As we redesign our Virtual Campus, we are considering the role of the 3D representation in providing access to activities and facilities. We are developing the representation so that the objects that provide the activity or facility (for example, the office or the slide projector) include the 3D model as part of its definition. We have considered the virtual office for a student as a 3D immersive environment by starting with a physical office and extending the concept for a virtual office. Once inside an office, navigation is not an important issue, so we focus on the ambience and access to tools and facilities for learning.

Figure 4 shows a design of an office by a graduate student for his own use. The office has different areas for different uses. Rather than reproduce the visualization of a physical office, he has developed a design that highlights the differences possible in a virtual place. His design places the various thing-like tools along the wall of the office and indicates separate areas for entering, working, and meeting others. Rather than include a desk, the office has only a chair and storage places. There is very little furniture since the function of furniture is a virtual office is not as important as creating a sense of place for the people in the office. Since the walls do not need to be solid to provide privacy, he has designed walls as frames for holding things.
2.3 The interface level

With a design framework that emphasizes the distinction between the implementation, representation, and the user interface, we can consider various ways of creating an effective interface. Our initial design is heavily influenced by the text-based virtual world we selected for implementation. Currently the interface to our Virtual Campus uses a split browser window with is icons and hyperlinks in an html frame and text commands in a telnet frame. These two types of clients, the web browser and the telnet window, are standard and therefore accessible to anyone. The web aware interface provides automatic formatting and icon access to the same information available in the original telnet window interface. The Web aware interface currently provides less functionality than the telnet window interface since it has limited facilities for creating new objects and interacting with objects as icons.

The interface is shown in Figure 4 for the classroom for the Hypermedia course. The components of the interface are marked as red numbers.

1. The display area. This is a multifunction window used to display the point-and-click interface to the room. In this window you can navigate between rooms, inspect objects, read notes, etc, by clicking on the links. Different rooms have different objects, depending on their function; for example you usually find whiteboards and bookshelves in classrooms. This window is also used to display some of the tools, for example the slide projector screen, or as a display for other tools, for example, the who tool.

2. The icon area. This window contains icons that allow you to access a number of tools in the Virtual Campus. If you click on one of the icons, the display area will switch to display that tool. The icons shown, from top to bottom are the room view, the slide projector, the whiteboard, the book, the who tool, the mail tool, and the help manual.

3. The text area. This is basically a telnet client providing a chat-like window with a command driven interface to the object-oriented database of the Virtual Campus. Here
you see text feedback from your actions, text descriptions of the behavior of other people and objects, and the conversation taking place in this room.

4. The text entry area. This is where you can enter commands, and talk to other people.

Figure 4. Current interface to the Virtual Campus

One of the features of the Virtual Campus is the link to separate applications. We currently link to the WebCT (http://www.webct.com) environment. The link is accessed through the “book” icon, which opens a new browser window for the student directly to the learning materials associated with the classroom he is in. Though WebCT is a stand-alone tool, implemented separately to the Virtual Campus, information about the student and the course are passed between the applications. This link preserves the continuity between the virtual learning place and the online learning materials. The interface for the Virtual Campus need not be changed as new tools are added; we can add another icon to the tool bar as a link.

Figure 5 shows the corresponding course materials interface for the Hypermedia course. The various components of the course materials and tools we are using are:

- Information pages: these are web pages which provide information about the use of the campus and the objectives, unit value, and assessment.
- Calendar: the calendar is used to post public notices about lectures, seminars, meetings, and for individuals to post private notices for organizing their own time. Notices can have links to reading material.
- Bulletin Board: a tool for carrying on discussions and questions about the course material.
- Course Content: a nested graph of course notes and reading material.
- Submissions: a tool for uploading student files for assessment.
- Online Quizzes: a tools for completing and grading quizzes
- Student Tools: a separate page of tools to assist the student in tracking their own performance and keeping track of where they are in the course content.

![Image](http://www.webct.com)

Figure 5. The interface to the course materials in WebCT (http://www.webct.com)

There is a capability to view the room as a VRML file, where the 3D model is stored in the object-oriented database. We are currently integrating the 3D immersive environment that provides a direct mapping from the representation of the virtual campus to the interface. The limitations of the 3D immersive environment include the lack of 3D representations of activities and functions that have no equivalent in the physical world, and the difficulty in understanding a 3D world that is presented on a flat screen on top of a desk. In Figure 6 we show the integration of the 3D environment using VRML in place of the text-and-icon web page shown in Figure 4. This implementation does not support interactivity within the 3D environment. We are currently considering the alternatives for maintaining the object-oriented implementation of the room prototypes while implementing the 3D environment. The main difficulty is that 3D models have an explicit representation of the walls and other “solid” parts of a room, where our object-oriented representation of the room includes the function and behavior of the container or “space” part of a room.
3. Conclusions

The Virtual Campus described in this paper focuses on providing a place for students to learn and develop as part of a learning community. The design of the Virtual Campus combines aspects of virtual worlds and the sense of place they create with the flexible learning tools available to present and manage learning materials. The design of the virtual campus is presented in three levels: the implementation level, the representation level, and the interface level. The use of an underlying object oriented database for the implementation level has facilitated the incremental growth of the Virtual Campus. The consideration of the representation level and the conceptual metaphor of building design provide an intuitive environment with the ability to expand beyond the concept of the physical campus. The interface level directly addresses the ease of use of the Virtual Campus. Currently, we are redesigning the Virtual Campus with a focus on the representation level, defining the function, behavior and structure of each type of place the campus includes, and defining a 3D model to represent the structure of each place.

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References


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