

# LEARNING CONSTRUCTION IN VIRTUAL WORLDS

Learning construction in virtual worlds

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## Abstract

Virtual Reality Modeling Language (VRML) is a tool for creating and distributing virtual worlds on the Internet. It can be used to create a 3D virtual environment by computer-rendered simulation of an interactive scene with links to other virtual worlds or 2D information. It allows information to be organized spatially and related by location and proximity. This paper summarizes the concepts and potentials of VRML applications in the construction industry. The design and development of virtual worlds of building construction is discussed. User's interaction with the virtual worlds to explore and understand concepts in construction is illustrated.

Keywords: Virtual Reality Modeling Language, VRML, multimedia, hypermedia, 3D modeling, construction technology, computer-aided learning, CAL

## 1 Introduction

Education can be viewed as a knowledge transfer process from two different perspectives:

- Instruction: information provider (professors, tutors, and computer-mediated systems) takes an active role in presenting information to learners.
- Learning: learner takes an active role in retrieving information from external sources; analyzing and structuring the information to develop his own knowledge.



A channel of communication is required to enable information to be represented and transferred from providers to learners. A variety of channels are currently used: books, lecture notes, videos, slides, and World Wide Web (WWW) etc.

Traditional classroom situation is an instructional process, which is teacher-centred. The process is dictated by the teacher who determines the way that information is transferred to the students. The counterpart to instructional process is an exploratory learning process, which based on student's initiation and control to dig out information relevant to his needs and interests. Library is a basic knowledge source to support the learning process.

## **2 WWW and computer-aided learning**

Development in computer-aided instruction and learning are to improve the information transfer process. A computer-aided learning system has three basic components: learner, knowledge core, and delivery system. The development of Internet and WWW establishes a standard for the delivery system. From an instructor's point of view, WWW is a new way to deliver instruction. From a learner's point of view, WWW is a huge database for him to explore. WWW is a new medium for education, a new opportunity for learners to discuss, share and collaborate. How to represent knowledge content on the WWW to achieve learning objectives is an important area of research.

Learning is a process of active engagement with experience. Learning is sustained by mental stimulation, and encouraged by proper environment. WWW provides the basic tools to develop an exploratory interactive learning environment. Interactivity refers to activity performed by a learner in response and in relation to the learning environment. Use of appropriate media and technologies enhance the interaction between the learner and the environment. In traditional settings, learners are confined to basic "static" interaction with materials delivered through one-way media in the form of printed text, images, audio, and video. With the advent of new media and technologies, dynamic interaction is now possible and affordable. It brings the learner closer to the act of discovery, e.g. examining objects in exploration of virtual worlds. In addition to course material and contextual information, the selection and use of appropriate media and technologies becomes an essential factor for establishing and maintaining interactive learning environment.

With new technologies comes the challenge for creating new, interactive learning environments which facilitates learning and promote open and constructive dissemination of knowledge. It is perhaps the turning point for new paradigms to emerge.

Hypertext was the first tool to enhance interactivity on the WWW. It broke down the traditional linear nature of the written word by encouraging readers to find their own paths through large amounts of information with embedded links. With the advent of digital technologies, hypermedia emerged to include text, images, audio, video, and animation as information nodes.

### **3 Virtual reality**

In construction industry, three-dimensional (3D) information is essential. In traditional communication media, 3D information is represented in a two-dimensional (2D) format such as drawings and photographs. Sometimes, physical models are constructed using cardboard so as to examine the form, shape, or spatial relationship between various elements. With the advancement in computing technology, computer generated 3D models can now be built instead of physical models.

Virtual reality (VR) is a computer-generated simulation of a 3D environment, in which the user is able to both view and manipulate the contents of that environment. Usually it is associated with an immersed experience that requires special-purpose hardware such as head-mounted display and data gloves. VR is a computer system used to create an artificial world in which the user has the impression of being in that world and with the ability to navigate through the world and manipulate objects in the world. Current technologies are not only able to provide a visual experience, but also with 3D sound, touch and force, for users to explore. The CIB established TG 24 to study and document the existing Virtual Reality efforts in construction. The applications of Virtual Reality studied include those in Building Design; Facilities Management; Real Estate; and Promotional Sales.

There are other ways of implementing VR without special gear to cut down the cost and to distribute and share virtual worlds on Internet.

### **4 VRML and construction**

VRML is an abbreviation for Virtual Reality Modeling Language. The VRML Consortium is a nonprofit corporation founded in 1996 to provide a forum for the creation of open standards for VRML specifications. It established an open standard for creating and distributing 3D multimedia and shared virtual worlds on the Internet. VRML is a scene description language that describes the geometry and behaviour of a 3D scene. It is a 3D graphics standard, representing a platform-independent multimedia file format for delivering interactive virtual worlds. The user just needs a VRML browser, similar to WWW browsers, to visit and navigate VRML worlds. Using VRML, 3D models, video, graphics, audio and text presentations can be integrated into a single virtual world, which makes communication easier and more powerful.

Virtual worlds can range from simple objects to very complex scenes. Background colours, textures, lights, sound, movie, and animations can be used to enrich the virtual worlds. Sensors and scripts are used to define user interaction and objects' behaviours. User can fly through, walk through, examine, and explore in virtual worlds. User can interact with objects or even another user in virtual worlds.

Traditional textbooks of building construction make use of drawings to illustrate the concepts. Training in understanding drawings enable students to visualize the concepts in a 3D manner. To get a better understanding of the concepts, students need to relate them back to the real world situation by referring to physical samples and site visits.

Construction drawings describe each building by floor plans and sections. Each floor plan shows interconnected rooms, position of doors, windows, and staircases. Symbols are used to define whether a door opens inward or outward and whether a staircase goes up or down. VRML directly reflects this hierarchical decomposition with separate elements for rooms, floors, walls, and ceilings. Additional attributes define the appearance such as colour of the walls and ceilings. Room fittings such as tables and chairs can be described by reference to external 3D models.

There are two essential elements in VRML to enrich virtual worlds and to add behaviours to objects: anchors and sensors. Anchors are used to create hypermedia links that represent a logical, spatial, or hierarchical relationship. Anchors allow user to interactively recall and view linked information by selecting objects of interest during navigation. Linked information can be another WWW page or another virtual world. A rich data structure that allows for extensive cross-referencing can be created. Sensors are nodes in the virtual world that react to users' actions such as touch or drag an object. Objects' behaviours can be activated according to the user's interaction with the sensors.

For example, user entering a virtual room sees the floor, walls, ceiling, windows and doors. User can move around in the room to explore. Selecting the door can bring up another virtual world showing detail elements of the door. Selecting the elements may start an animation that shows the assembly sequence of the door. It may also bring up another web page showing construction detail drawings, specifications, and costs. For building elements that are not easily observable such as air conditioning systems, exploration in the virtual world makes the user easier to understand the components and their relationships. A virtual air conditioning system includes chillers, fan coil units, ducts and pipes connecting components in a 3D space. Selecting each component may show a more detail model of the component.

## **5 VRML applications in construction**

The construction industry can use VRML to explore exact representations of architectural drawings and models during the design stage. Design team members can communicate with 3D models in addition to drawings. The virtual building representation can be augmented by linking to its various components, the original drawings showing construction details, photographs of the real site, and so on. The interactive 3D models can therefore be used for data management purposes. Information about the building can be presented and communicated with maximum efficiency. Figure 1 is an example showing a virtual world of concrete floating floor augmented with drawing and text. The real estate industry can show flats in VRML on the Internet to clients, allowing people to get a feel for physical space. Suppliers can have 3D catalogs of their product on the Internet for demonstration. Assembly of complex parts is better communicated through 3D interaction. Figure 2 shows a sample design of office furniture. In education, virtual worlds can be use to illustrate the construction details and processes. User can select the angle of view and can interact with objects at his own pace.

## 6 Learning in virtual worlds

Virtual worlds provide a basis for exploratory learning and can be used as an educational tool for promoting non-linear thought. It also allows the users to have some degree of control over the learning environment and to adapt materials to their own learning style. Another learning approach is to have students creating their own virtual worlds. Students can gain hands on experience in a simulated construction process. Since components are reusable, virtual worlds can easily be built by selecting appropriate objects from standard libraries. Figure 3 and 4 show some objects from standard library for building construction. Students can organize, structure, and associate objects in the virtual worlds in their own way. Their virtual worlds reflect their understanding of the concepts and knowledge in construction.

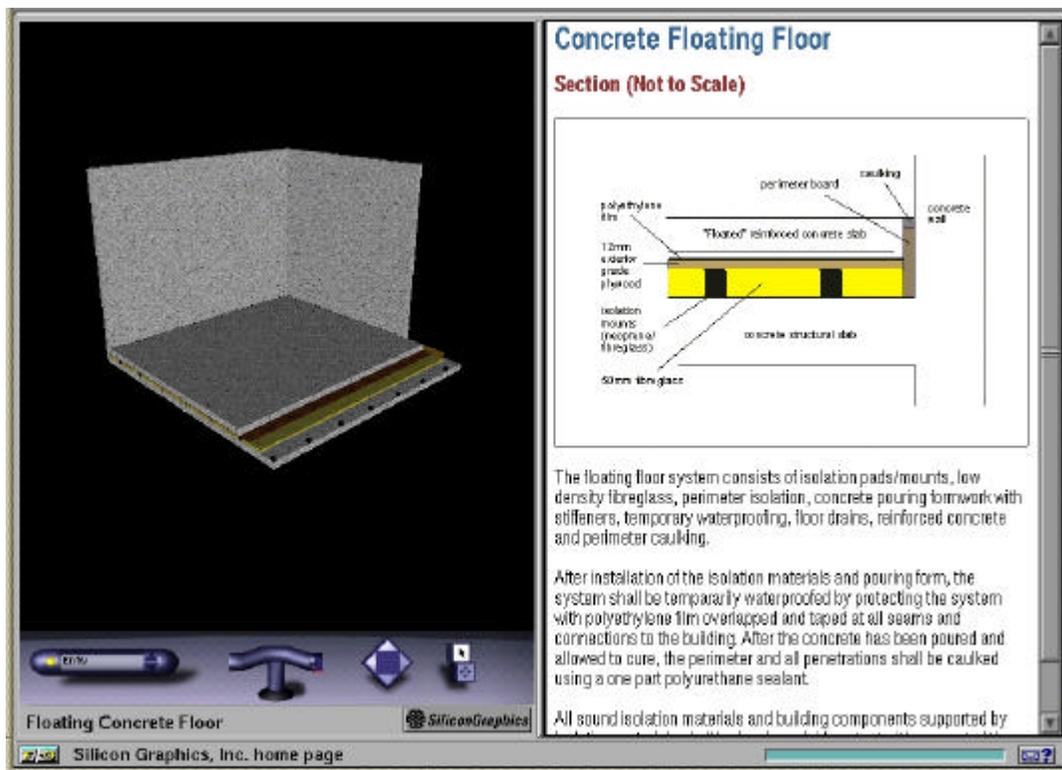


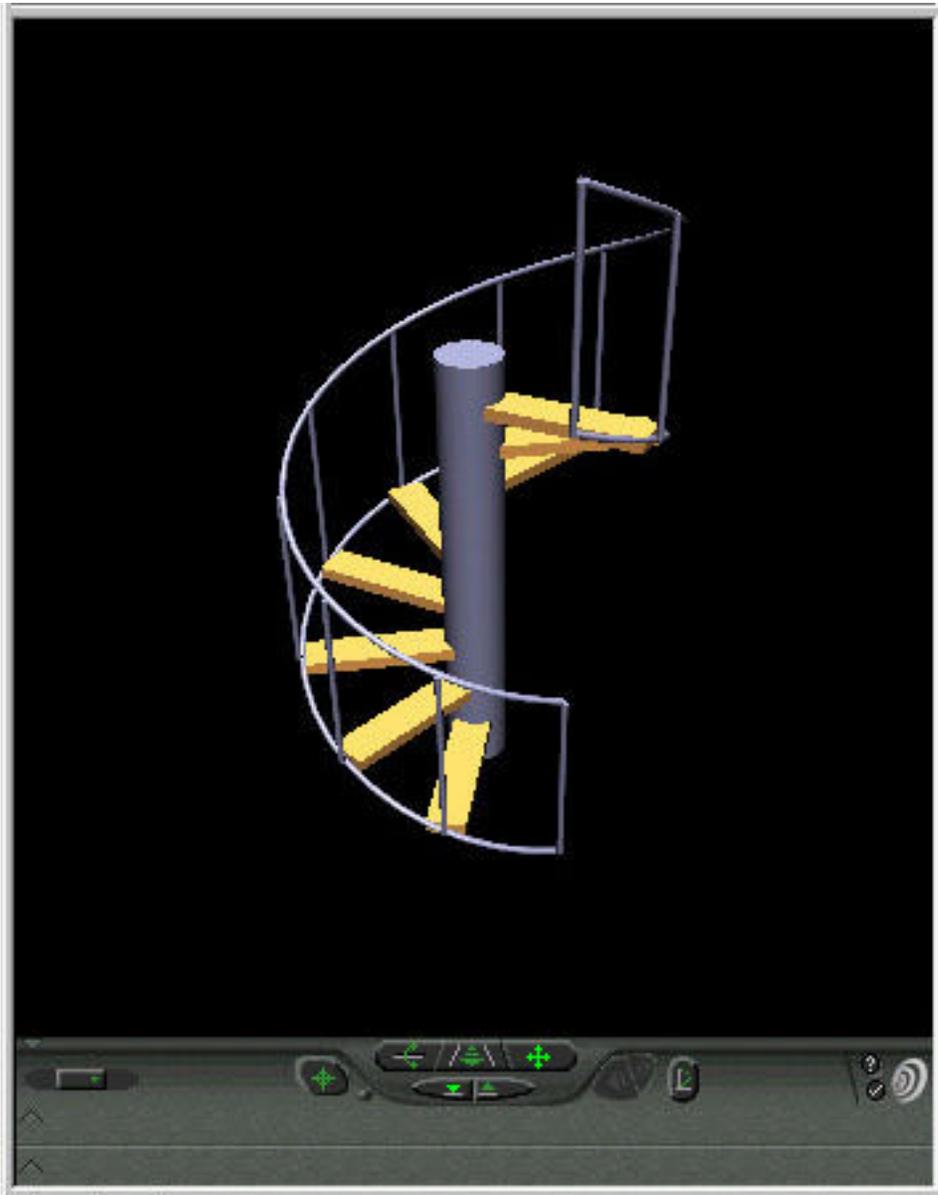
Fig. 1: Virtual world of concrete floating floor augmented with drawing and text



**Fig. 2: Sample design of office furniture**



Fig. 3: Standard component: oak door



**Fig. 4: Standard components: spiral stair**

## **7 Future development**

Today's virtual worlds on the web are still largely exploratory in nature. Many authors, range from universities to businesses to individuals, are still learning VRML as a new medium. Current VRML standard still lacks some important features of interactive 3D world, such as shared object behaviours and cause-and-effect relationships. The VRML standard is continuing to evolve to include more complex notions, such as objects that change over time. This will allow even more compelling applications to be created.

The creation of a distributed multi-user virtual world is another research area. When a user enters a virtual world, there is actually an embodiment of the user in the world, known as an avatar. So different users, represented as different avatars, can interact with each other in virtual worlds at the same time to form a virtual community to share, discuss, and collaborate. The potential of such an interactive learning environment is still waiting to be explored.

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