

Internet-Based Interactive Construction Management Learning System

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Abstract

The Del E. Webb School of Construction is currently involved in a three-year project aimed at enhancing the construction management education. The primary undertaking of this project—in its second year—is to incorporate practical content in the construction curricula thus bridging the gap between the classroom and the construction site. Enhancements are being accomplished by developing 1) an Internet-based Interactive Construction Management Learning System (ICMLS) and 2) an advising and mentorship program that will enhance practitioner-involvement. The Interactive Learning System uses interactive and adaptive learning environments to train students in the areas of construction methods, equipment and processes. This system is being developed using multimedia; Internet based computing; Virtual Reality Modeling Language (VRML); databases; and discrete-event simulation. This paper will provide an update on the design, development and implementation of ICMLS. Lessons learned and tools utilized that may be helpful in other branches of engineering and non-engineering fields will be described. The project team envisions that the successful completion of this project will lead to a number of benefits including: 1) improved recruitment, retention, and program completion for the construction management program; 2) “job-ready” graduates that can be successfully employed in the construction industry; and 3) enhanced practitioner involvement and construction industry input.

Introduction and Background

Preparing students for the challenges of managing large construction projects is an important responsibility and a difficult task¹⁵. The instruction methods used in the majority of construction engineering and management curricula rely, for the most part, on traditional methods such as exposing students to applied science courses. These traditional teaching methods, however, are often not fully adequate in providing students with all the skills necessary to solve the real world problems

that are encountered in the construction industry². Furthermore, complex engineering knowledge is also not conveyed effectively. This is partly due to the fact that curricula often use a series of courses to convey knowledge in fragments^{6,7}.

Complementing the more conventional classroom instructional tools would, ideally, include visits to construction sites or site training. There are, however, various complicating issues that make it impossible to rely on site visits. Most importantly, the instructor cannot control the availability of a project at the necessary stage of completion. Also, visits of larger groups to construction sites may not be welcome, involve risk, and are unpractical⁵. Finally, the high cost of site training is a further impediment to its extensive use for construction education^{1,2}. General computing and information technologies, and simulation in particular, have the potential to act as priceless to complement construction engineering and management education. The authors, motivated by this, have undertaken this research project that addresses the above-mentioned issue.

The paper describes the Internet based Interactive Construction Management Learning System (ICMLS) that is being developed as part of a three-year project funded by the National Science Foundation (NSF) and Arizona State University (ASU).

Overview of ICMLS

The research project is based on the development of an Internet based Construction Management Learning System (ICMLS) that will utilize: 1) active learning approaches to bridge the gap between the classroom and the actual construction site; 2) advanced Internet based computing technologies to bring the complexities of the construction site to the classroom; and 3) knowledge and expertise of construction professionals through an advising and mentorship program.

The Internet based Interactive Construction Management Learning System furnishes a simple tool that students can utilize to gain practical knowledge of construction equipment and construction processes. The key features of the ICMLS are: 1) the system uses the Internet as its launching medium, and 2) it utilizes multimedia databases, hypertext, 3-D modeling, and simulation to provide students with an interesting and realistic view of the selected construction processes and construction equipment. ICMLS uses an interactive and adaptive learning environment to train students in the area dealing with the planning of construction processes and equipment. The system is process-oriented and mimics the challenges faced by a construction manager on a real life construction project. It allows students to apply their knowledge of construction materials and methods, estimating, scheduling, resource allocation and utilization, fleet size determination, productivity and cost calculations, and decision-making in relation to construction processes. The internal structure of ICMLS is shown in Figure 1. Internally, ICMLS consists of a number of components that are described in the following sub-sections.

Construction Equipment Database

This component contains information pertaining to equipment specifications, productivity, operation, use, and manufacturers. The construction equipment has been divided into eleven categories with approximately 70 different pieces of equipment being identified in those categories. Over 200

construction equipment manufacturers have been contacted to collect information. Figure 2 shows the actual screen of ICMLS from where construction equipment information can be accessed.

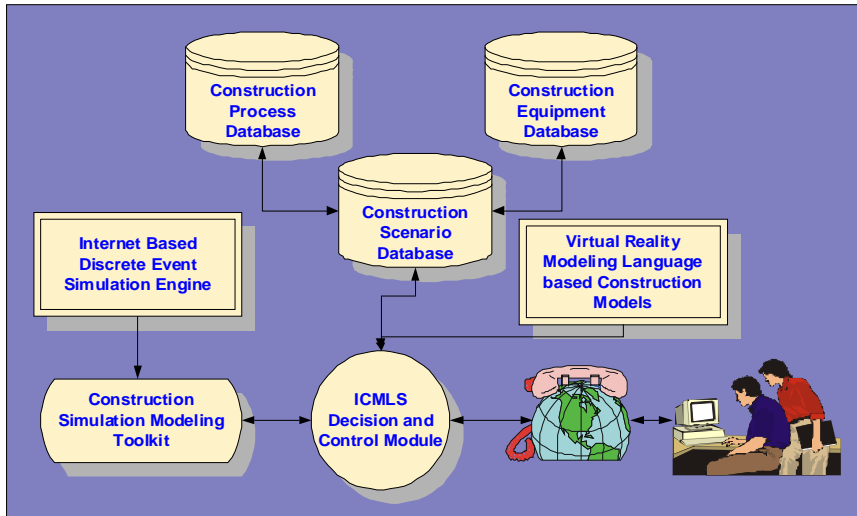


Figure 1: Internal Components of ICMLS

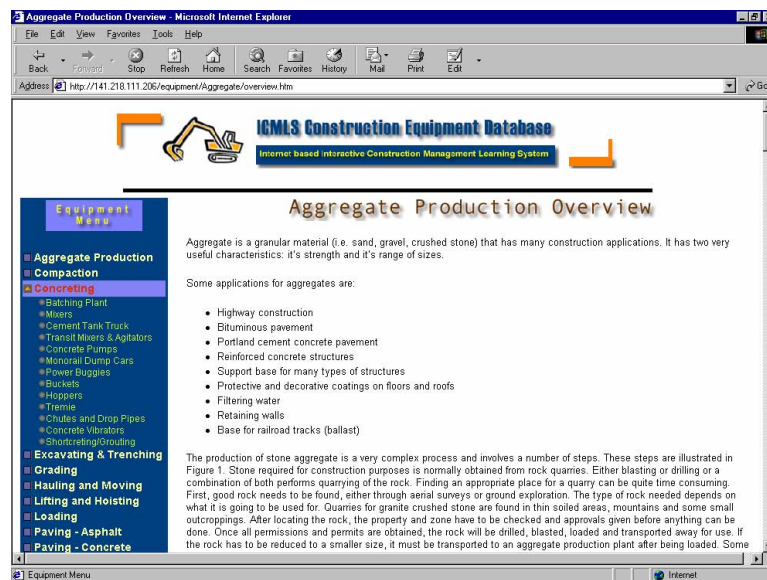


Figure 2: Construction Equipment Database

Construction Process Database

This repository contains a number of construction processes from residential, building, heavy engineering, and industrial construction. Visual as well as textual explanations of the processes are supplemented with multimedia elements. The construction process database has been divided into two broad categories that include building construction and heavy construction. Figure 3 shows the construction process database screen in ICMLS.

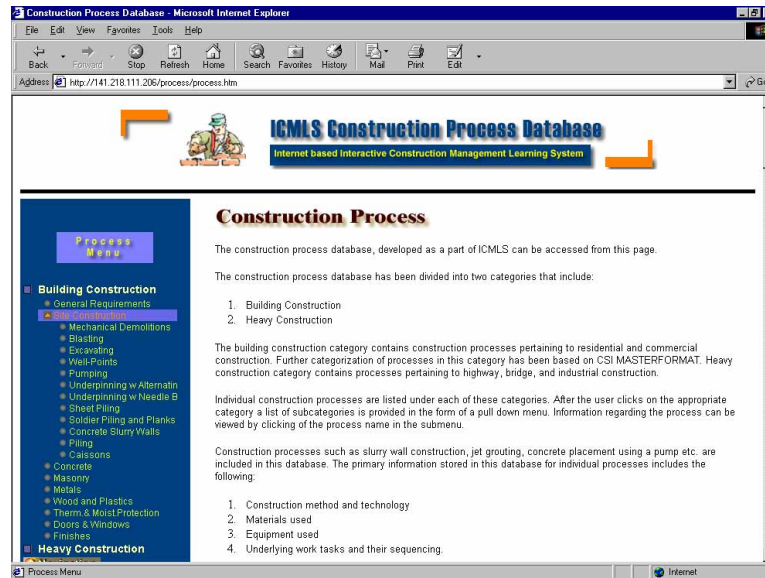


Figure 3: Construction Process Database

Construction Scenario Database

The construction scenario database contains a number of real world scenarios that will be used in the interactive mode of ICMLS. Figure 4 shows a sample from the construction scenario database. This database is internally linked to the construction process database as to synchronize the two databases. Students use this component of ICMLS to study the interactions between construction equipment and construction activities in a construction process. The interactivity in this component is further enhanced by the Virtual Reality Modeling Language (VRML) based Construction Models and Internet based Discrete Event Simulation component of ICMLS.

PROBLEM SCENARIO

You are the project manager for an office building project that consists of 5 floors. The flooring system for the building is one-way solid slab system. Quantity of concrete to be poured for each floor is 185 CY.

OBJECTIVES

Selection of a concrete placement process suitable for the project. Determination of the equipment cost, duration of the concreting activity, and generation of site instructions for the selected placement process.

CLICK A TOPIC FOR MORE INFORMATION

SITE PLAN	CONCRETE PUMP
ADDITIONAL PROJECT INFORMATION	TOWER CRANE
CONCRETING PROCESS	

CLICK A STEP TO START THE SESSION

DEVELOP A SIMULATION MODEL	PRINT SCENARIO
VIEW OUTPUT	PRINT RESULTS

Figure 4: Construction Scenario Database

Virtual Reality Modeling Language based Construction Models

The Virtual Reality Modeling Language (VRML) is a three-dimensional (3-D) modeling language that can be used for describing 3-D shapes and scenery (also called a virtual world) on the World Wide Web (WWW)^{3,9}. VRML can be defined as a 3-D analogue to Hypertext Markup Language¹².

VRML files are text files that contain information regarding the objects and linkages between the objects in a virtual world. It can be applied to a number of areas including web-based entertainment, 3-D user interfaces to remote web resources, 3-D collaborative environments, interactive simulations for education, virtual museums, virtual retail spaces, and more. The ability to animate, play sound and video within the virtual world; allow users to interact with the virtual world; and control and enhance the virtual world with scripts, allows the development of dynamic and sensory-rich virtual environments on the Internet⁴. These features of VRML can be beneficially utilized to build teaching aids that will supplement classroom instruction. As part of ICMLS, the authors are using VRML to develop these innovative and accessible teaching aids. The authors have developed interactive 3-D simulations that are being used to teach construction processes. As part of this research, VRML based 3-D models of common construction processes have been developed and are available to the students on the WWW. Figure 5, 6, and 7 show an Internet based 3-D model of steps involved in residential construction. Students can access this 3-D model through a web browser that is equipped with a VRML plug-in.



Figure 5: VRML based Animation of Residential Construction



Figure 6: VRML based Animation of Residential Construction

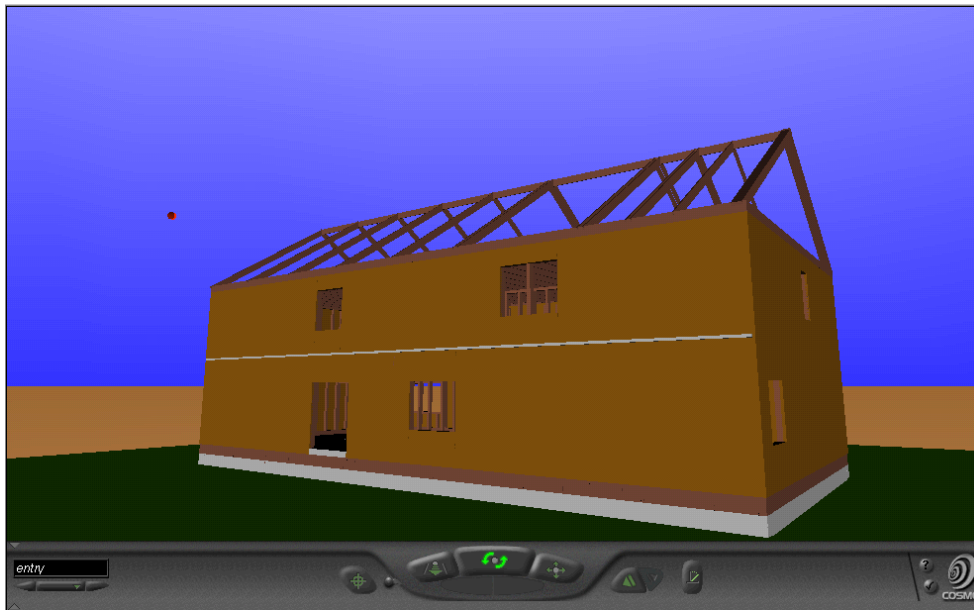


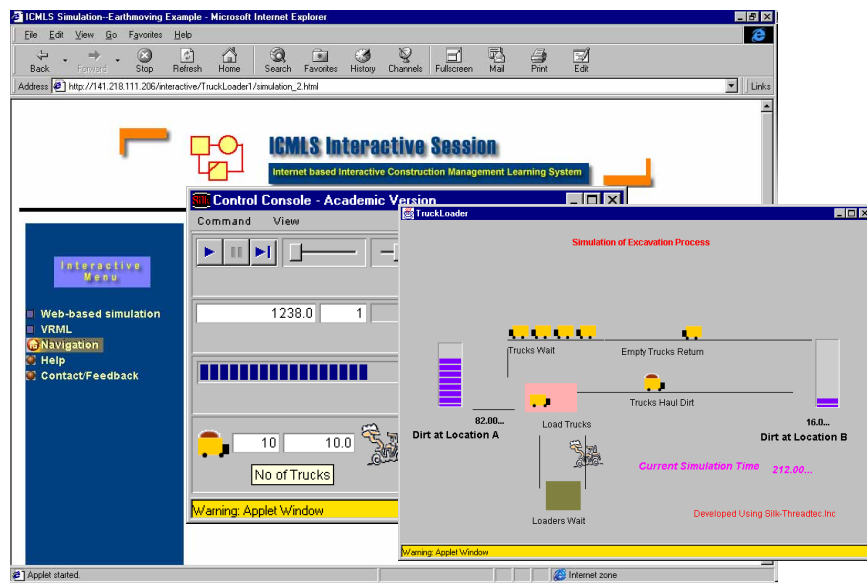
Figure 7: VRML based Animation of Residential Construction

Internet based Discrete Event Simulation

One of the key components that adds interactivity to ICMLS is discrete-event simulation. Traditionally, simulation has been defined as a tool that can be used to mimic reality and provide responses of a system under consideration to external and internal factors. Simulation has been applied in the design and analysis of construction processes by researchers and some large construction organizations⁸. In addition to industrial uses, simulation can also be used for educational purposes, especially for civil and construction engineering education. This is based on the hypothesis that “simulated environments” can act as excellent catalysts in the learning process. In a recent study, Suda¹⁴ reported that, “simulation can be a powerful trigger to learning of project management principles.”

With the advancement of computing technology and widespread adoption of the Java programming language as a standard for Internet based computing, application of simulation in education is becoming a reality. Tools are now available to allow development of "simulated environments" that are accessible to students over the Internet. In ICMLS, the authors have utilized Java-based simulation to allow students to interactively manage construction processes in a simulated environment. This development is based on the Silk™ environment^{11, 10}.

The Java-based simulation component of ICMLS allows users to model common construction processes. Students select a problem scenario from an existing list displayed by the system. For example, students can select a scenario in which they are required to supervise the moving of 234,000 units of earth for a canal project. Students can then utilize Java-based simulation to study the earthmoving process. They can use the session to: 1) select a fleet of equipment—in this case front end loaders and dump trucks—to accomplish the earthmoving; 2) determine total productivity; 3) determine total project cost; and 4) determine total duration of the earthmoving process. Figure 8 shows a sample screen of ICMLS for the simulation of the earthmoving process.



Student Interaction with ICMLS

The critical factor in the success of the Interactive Learning System is the clear identification of student interaction with the system. The system will be utilized in the construction materials and methods, construction estimating, construction scheduling, and construction project management courses. The students will utilize the system in consultation with an industry mentor. In addition, the system will be utilized in other civil engineering courses, introductory pre-engineering courses, and for demonstrations to prospective transfer students. Figure 9 shows the student interaction process. The students will utilize the Interactive Learning System in the following three modes:

1. Mode 1: In the first mode, a student can browse through the “electronic” database of construction processes. This will give students an idea of construction site operations. For example, a student can select the slurry wall construction process and obtain textual, graphical, and multimedia explanation for the process. In this mode, the student will learn about construction technology, construction method, equipment usage, material usage, and underlying work tasks and their sequencing.
2. Mode 2: In the second mode, a student can select the “electronic” database option and browse through the available construction equipment. For example, the student can select a vibratory pile driver and obtain information about the general description of the equipment and performance factors such as amplitude, eccentric moment, frequency, vibrating weight, non-vibrating weight of the vibratory pile driver. This database also utilizes text, graphics, and multimedia to provide the students with the information related to equipment characteristics, equipment usage, and technology involved.
3. Mode 3: In the third mode, the system is used as an interactive simulation and gaming environment that presents students with real life construction problem scenarios and allows them to develop a solution, implement the solution, visually study the response of the system to the solution, and then iteratively improve the solution. This will allow students to learn subtle and complex interactions between construction costs and time. The actual solution is presented to the system by the development of a simulation model. The students will formulate the following inputs: 1) study the underlying construction method and technology; 2) develop an appropriate simulation model; 3) select equipment and allocate them to the developed simulation model; and 4) select duration for the work tasks identified as part of the simulation model.

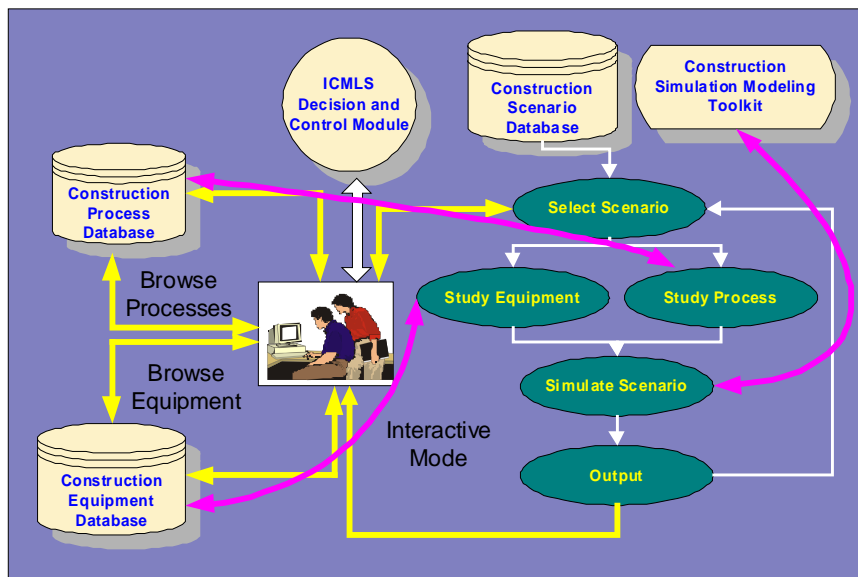


Figure 9: Student Interaction Process

Conclusions

The authors’ envision that the successful completion of this project will provide an instructional tool that clearly caters to the needs of construction engineering education in particular and civil engineering education in general. A number of benefits arise from the development of ICMLS. These include graduates that are better prepared to manage the complex dynamics, pressures, and demands of construction sites. The availability of “job-ready” graduates is becoming crucial in

trying to meet the demands of the construction industry today. The enhanced practitioner involvement and construction industry input increases practical content of the material and can provide students with increased familiarity with the construction industry. The improved recruitment, retention, and program completion for the construction engineering program are of benefit to the university. As can be seen, ultimately all parties involved, universities, students, and the construction industry, can benefit from ICMLS. The university will generate more importance and interest as an educational institution through improved recruitment and better graduates, while the students will benefit from a better education that will ultimately also benefit the construction industry.

Acknowledgements

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