Learning architectural concepts through the study of precedents is a common activity in design studios. Traditionally, an instructor presents a design concept by showing selected examples using slides, photographs, drawings, texts, and verbal analysis. This method relies on a linear mode of conveying design knowledge and is time bound. It emphasizes information retention and recall of facts rather than an understanding of information.

However, if information on architectural precedents are represented digitally in a system designed to promote understanding of the material rather than just present facts, then some disadvantages of the traditional method may be overcome and additional advantages may be achieved. This paper describes a computer-assisted lesson system designed to represent architectural concepts related to spatial composition in design by using graphic images and text and reports on its development, implementation, and testing. The system relies on many characteristics, such as accessibility, interactivity, flexibility, rapid feedback, etc., which are known to foster effective concept learning. The paper also evaluates the viability and effectiveness of this system from a technological and logistical viewpoint as well as from a concept learning viewpoint, and concludes with a discussion on other potential applications.
Introduction

Understanding design concepts such as spatial concepts, structural concepts, energy concepts, etc., is necessary for students to increase their ability to fully perceive visual information. This ability ultimately provides for developing a good sense to insist on a quality environment (Winters 1986). Learning architectural concepts through the study of precedents is a common activity in design studio. Precedents can be considered as a type of representation of design knowledge and concepts can be formed by abstracting information from precedents (Howard 1987). The important role of precedents in concept learning can be understood from this characteristic of precedents. After learning concepts, students can interpret precedents to get design ideas. A design idea may be derived from precedent where the use of a form or shape is used to establish the framework of the development of the design (Billings and Akkach 1999).

Traditionally, an instructor presents a design concept by showing selected examples using slides, photographs, drawings, texts, and verbal analysis. This method relies on a linear mode of conveying design knowledge and is bound by both, time and location. It emphasizes information retention and recall of facts rather than an understanding of information. These are not necessarily effective ways of learning concepts. Additionally, there is no informal means of a student evaluating his or her own understanding of the concepts learned. Based on Akin’s (1981) definition of higher learning, a mode of concept learning is to be able to abstract concepts from instances encountered in a form to enable their application to other instances. According to Akin (1981), if instruction provides all such abstractions and students are not required to learn abstraction skills, their growth beyond the materials presented in class will be stifled. For effective concept learning, an instructor must expose the student to useful examples of architecture and other relevant instances of concepts.

This study investigates representation of spatial organization concepts embedded in building precedents as a means to improve students’ concept learning.

The computer-assisted lesson system was designed to represent architectural concepts related to spatial composition in design by using graphic images and text. The system works with any computer that is capable of displaying graphics and accessing the Internet. The system relies on many characteristics, such as accessibility, interactivity, flexibility, rapid feedback, etc., which are known to foster effective concept learning. The paper also evaluates the viability and effectiveness of this system from a technological and logistical viewpoint as well as from a concept learning viewpoint, and concludes with a discussion on other potential applications.

System Design

The results of recent cognitive studies have shown that the way knowledge can be represented is an important design variable for the teaching and learning of concepts (Merrill 1992). If information on architectural precedents are represented digitally in a system designed to promote understanding of the material rather than just present facts, then some disadvantages of the traditional method may be overcome and additional advantages may be achieved.

Figure 1 shows the organization of various parts of this project. Architectural concepts to be learned and the concept learning methods combine to form the basis for lesson design.
leaving a lesson delivery or interface component to complete the project design. The design of the concept learning system was therefore viewed as having two distinct parts, the lesson design and the interface design.

**Lesson design**

Designing the lesson was based on Merrill’s (1997) design guide for a concept lesson. Implanting the lesson in a CAI format was based on the CAI lesson design principles of Hammel (1988) and Bieber (1995). Applying the CAI lesson to the Web environment was based on Web design guides of Morris & Hinrichs (1996) and Weinman (1996).

The concept-learning system chosen for this investigation provides a Computer-Assisted Instruction (CAI) lesson for design studio students to learn architectural concepts through the study of precedents. Development of the concept learning system is based on authoring and delivering, which are two main activities for CAI design (Bradford 1992). Authoring deals with how instructors assemble lesson materials which include all the information to be used for the lesson system. Delivering deals with how students access these materials and receive the information in the system and how instructors make the process as easy and efficient as possible for the students with the constraints of the system. These two activities are concerned with how instructors represent information of example buildings in the system for students effective concept learning. Finally, a testing procedure was devised to provide students with feedback on their understanding of the concepts presented. This procedure was also used to provide the researcher with data on the effectiveness of the lesson structure.

The concepts chosen for this lesson were spatial organization concepts of symmetry, repetition, and hierarchy, which belong to the design principle “order” which is one of the generic themes of spatial composition in architectural design. The concepts and their relevant examples were adapted from Clark (1985), Ching (1972), texts normally used in a design studio. Each chosen example consists of a main plan, an axonometric view, an elevation and/or section, information about the architect, design date, the location and the name of a building.

The procedure used for preparing the concept lesson materials is as follows:

- **Lesson content analysis**: Content analysis determined the relationships between concepts within the content area to be studied and identified the critical and general elements of each concept to be taught. The result of the content analysis is the concept taxonomy shown in Figure 2.

- **Defining concepts**: Identifying the name that will be used to classify the concept and writing a concise definition for the concept.

- **Developing instance pool**: Collecting examples and non-examples of concepts. These instances were reviewed by consultants (instructors in architectural design and history).

- **Collecting information of the concept examples**:

  - **Lesson text**: The prepared lessons were then tested for a variety of interface issues such as readability, accuracy of links, ease of use, ambiguity, speed of response to user input, display on multiple platforms, etc.

**Interface design**

The lesson system was prepared with HyperText Markup Language (HTML), documents and Common Gateway Interface (CGI) scripts, and placed on an Intranet site (internal web site) to be accessed only by the students of a design stu-
dio class. Widely accepted principles and guidelines such as those of Morris, Hinrichs and Wineman were followed. Figure 3 illustrates the organization of the delivery interface portion of the system. The interface guides the student through the various components of the lesson which is structured according to the taxonomy of the lesson content.

**Implementation**

**Lesson Structure**

The diagram below shows the structure of the whole lesson. This lesson is for three concepts: Symmetry, Repetition and Hierarchy (CONCEPT 1, CONCEPT 2, and CONCEPT 3) which are parts of a principle (ORDER). The examples of each concept are grouped by its elements (ELEMENT 1, ELEMENT 2 or ELEMENT 3). Each element group has two examples (EX 1 and EX 2). The typical structure of the lesson is shown in Figure 4.

**Lesson Components**

The lesson consists of a series of pages, each page of which consists of three sections: top, middle, and bottom, as shown in Figure 5. The top and middle sections are the same in each page, and the bottom section is different in every page through the lesson. The top section shows the lesson structure as a map. The arrowhead takes you to the pages you need. The pop-up menu box is used when you are asked to select names of the concepts you learned in this lesson.

The middle section has definitions of concepts and the end button. The definitions are used when you are asked to select names of the concepts and the elements. After learning the all concepts and selecting all the names of concepts and elements, click the end button.

The bottom section provides space for text and explanations about concepts. It also contains directions for proceeding with the lesson.

**Lesson Process**

The lesson starts from the principle ORDER, and goes to the concepts and to its elements and its examples. In the CONCEPT page of the lesson, four instances (two examples and two non-examples) of the concept are presented, and students are encouraged to abstract a certain concept from them. Figure 6 shows a sample page.
Figure 6. Sample page showing a choice of example buildings.

Figure 7. Sample page showing typical information about an example building.

representation of architectural concepts in the study of precedents: A concept-learning system

**content**

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**introduction**

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</table>

Figure 8. Summary of student responses from post-lesson survey.

evaluation

The evaluation of this project consisted of observations of the researcher, observations of the instructor of the studio, test scores from the lessons, and student surveys conducted after the lesson was taken. The data was then summarized from a technical and logistical viewpoint and an instructional viewpoint. Figure 8 shows a summary of students responses in a post-lesson survey evaluating the concept learning system. Dots in the YES column denote students who agreed positively with the issue in the left column.

It is evident that a majority of the students felt that the lesson had a beneficial result. As expected, more students felt that the content was more difficult than the interface, leading the researcher to believe (from comments in the survey) that more attention should be given to explanations in the lesson. Additionally, all of the students who were aware of the concepts prior to taking the lesson felt that they had learned more about the concepts and had deepened their understanding after the lesson.

Students who took the lesson unanimously agreed that these types of lessons would enhance the design studio experience. Most felt that such lessons should not totally replace a lecture, but should supplement personal discussions with an instructor. A variety of topics
were suggested for lesson content, many of these topics are not traditionally or discreetly addressed in design studio.

- technical and logistical viewpoint

–HTML and its editor allows the programming novice to make and modify Web pages quickly and painlessly. The ease and simplicity of HTML contributed to the development of the lesson system.

–The lessons can easily be tailored to a number of different studies and the information of the lesson cannot be accessed by outside users because of password protection.

–Despite the heavy graphics content, access speed and loading time are relatively fast. However, if student accesses the lesson by a modem, some delays between requesting and viewing a page may be expected.

–The lessons can be accessed whenever they are needed by the students.

–There is no need for instruction in using the lessons, all students are very familiar with the World Wide Web and web browsers.

–No special facilities, either hardware or software are required.

- instructional viewpoint

–The high level of interactivity is directly related to the user’s motivation to participate, which is the most important factor for learning.

–Rapid feedback for the students’ selection of examples

–Instructors can easily change concepts to be learned by students. They can update information about the concepts and examples by replacing pieces of information (concepts, elements, definitions, and examples) into the already made lesson structure. Replacing the information is done by modifying HTML files using HTML editors, and instructors need no programming experience for this activity. For this efficiency, the information should be collected and categorized according to the organization of HTML files for the lesson materials (concept, element, instances, and example information).

–The ability to test learning is helpful to both students and instructors. Testing students concept acquisition is an integral part of concept learning and can be either sent automatically by e-mail to the instructor or retained only for the student’s use. This will enable an instructor to monitor each student’s ability and achievement. The test scoring also enables the instructor to identify and revise any aspect of the lesson that may be unclear or needs reinforcing explanation.

- conclusion

At this point in the project, we can conclude that while the concept of using a CAI lesson on background material in the design studio was established by the working prototype, the extent of material to be covered remains unanswered. Quite clearly, much more extensive and comprehensive lessons can be prepared, to the extent of being over-hearing and losing focus on the studio goals. There appears to be no restriction on the topics that can be covered by similar lessons. Linking a number of lessons together is feasible, enabling cooperation of a number of instructors in a variety of disciplines. As suggested by some senior level and graduate students, they could become involved in the collection and preparation of lesson materials thereby enabling them to revisit material long since forgotten and enhancing their understanding of many fundamentals. The access to relevant “information on demand” of these lesson systems fills a long standing need of students in design studio.

One important question raised by this project is the effect lesson design has on the lesson material and learning, would the “direct instruction” method of lesson design be more effective in introducing concepts to beginning students and the “discovery” method of lesson design be more effective for in-depth study of the con-
cepts? This project raises many more questions than it answers. However, it demonstrates that CAI can be used in the design studio and much more work needs to be done on the representation of design information and architectural knowledge in the electronic environment.

references