DEVELOPMENT OF A COMPUTER-ASSISTED INSTRUCTION SYSTEM FOR INFORMATION COMMUNICATION IN DESIGN STUDIO

Taeyeol Park and Valerian Miranda, Ph.D.
Department of Architecture
Texas A&M University
College Station, Texas 77843-3137, USA
t0p0924@unix.tamu.edu and vallie@archone.tamu.edu

Abstract. As a means to bridge a gap between non-studio courses and design studios, some architectural educators suggest that design studios should bring knowledge to students in the process of designing so that they can apply this knowledge to their design. In this integrated learning environment, the amount of design information increases. Design projects generate need for additional knowledge about a number of topics, but most design studios do not do enough to bring knowledge systematically into design projects when appropriate. Design studios should consider ways in which knowledge for design projects is integrally made available at the appropriate time.

This paper describes a model for the delivery of design information that can be integral with any design projects. The model is demonstrated by a computer-assisted instruction (CAI) system designed and placed on the Web to introduce basic structural concepts and to teach an in-depth concept of spatial composition in a design studio. After reporting on the development, implementation, and evaluation of the CAI system, this paper concludes with the information that we hope will be useful in developing CAI materials for reviewing and acquiring information on a number of different subjects that have relevance to architectural design in a design studio.

1. Introduction

Almost every school of architecture today makes a basic curricular separation between non-studio courses and design studios. The separated curriculum assumes that knowledge is gathered and used sequentially. However, the acquisition and application of knowledge do not occur sequentially, and therefore cannot be assigned to separate, sequential sections of the curriculum (Gelernter, 1988). Based on Schön's assumption that the fundamental concepts of designing can be grasped only in the context of the doing (Schön, 1985), Gelernter (1988) argues that the two sides of knowledge acquisition and application must be attacked simultaneously. As a means to bridge the gap between non-studio courses and design studios, some architectural educators suggest that design studios should bring knowledge to students in the process of designing so that they can apply this knowledge to their design. Boyer (1996) emphasizes the integration of non-studio courses and design studios, and Gelernter (1998) suggests linking knowledge acquisition and knowledge application intimately together. Akin (1981) also asserts knowledge acquisition in knowledge application, but he adds the need of instruction in design studio to the requirements for the integrated learning environment.

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The increasing complexity of architectural concerns and the greater demands placed on building performance have made design students face a huge and still growing body of information. Moreover, it is apparent that, in the integrated learning environment, a wide variety of information sources would even more increase the amount of information the students require. Design projects generate a need for additional knowledge about a number of topics, but too few design studios systematically make such an increasing quantity of information available. Design studios should consider ways in which knowledge for design projects is integrally made available at the appropriate time (Gelernter, 1991).

Boyer (1996) assumes that computers hold enormous promise as an integrative tool for the systematic delivery of information and effective instruction in design studios. Based on the computer's potential, how do we make a computer-based learning tool through information communication in the integrated learning environment? This question raises many issues, such as access to relevant information, links between lessons for different subjects, representation of various design concepts, effective instructional methods for learning concepts, etc., which might be critical elements of designing an information communication system for design studio instruction.

The objectives of this study are:

- To develop a model for a computer-assisted instruction (CAI) system as the integrative tool for linking non-studio courses and design studios.
- To be effective this tool must help students learn, at their own pace, architectural concepts that they need during their design projects.
- To evaluate, based on the results from responses of students and observations of the researcher and the studio instructor, the effectiveness of the system in design studio instruction.

This study provides the context-bound information necessary to understand the effectiveness of CAI as it is experienced in a design studio. Such an understanding is critical to the development of principles for designing a learning tool that meets the needs of design studio students.

2. CAI System

The CAI system developed in this study consists of a library of CAI lessons which is intended to be used for learning architectural concepts as a supplement for design studio instruction. **Figure 1** shows that the contents of the lessons can be any topics related to architectural design, and the lessons can be selected for specific design projects.

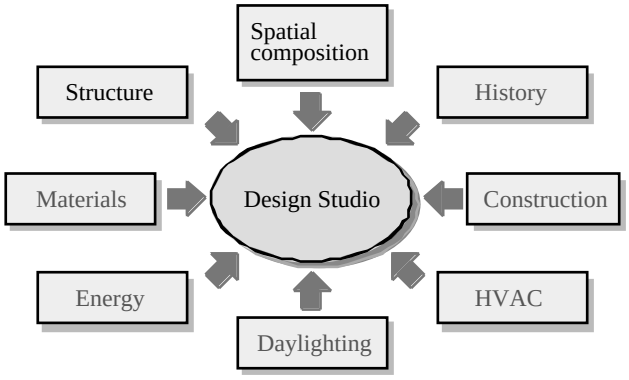


Figure 1. A library of CAI lessons.

2.1. LESSON DESIGN

For the purpose of demonstrating this model, we designed two lessons, one on "Structure" for introducing architectural structure and another on "Spatial Organization" for a deeper study of spatial composition. The content of each lesson consists of concept definitions, concept attributes, and concept examples. Designing the lesson was based on Merrill's (1992) instructional design guide for a concept lesson, and implanting the lesson in a CAI format was based on the CAI lesson design principles which Hannafin (1988) and Rieber (1994) suggest.

The main procedures for designing concept lesson materials are grouped into five steps in this study:

1. Analyzing the structure of lesson content to determine the relationships between concepts within the content area and to identify the attributes of each concept.
2. Defining concepts to identify the names to classify concepts and to write concise definitions for the concepts.
3. Collecting examples and non-examples of concepts reviewed by instructors in the subject areas of the concepts to be taught.
4. Collecting information of concept examples.
5. Identifying instructional strategy for representing concept information with concept examples and non-examples.

2.1.1. Designing the Lesson on Structure

The concepts chosen for this lesson were the concepts of structural systems—bearing wall, arch, vault, dome, truss, space frame, geodesic frame, post and beam, suspension, cantilever, and slab, which are categorized by forces—compression, tension, bending, and shear. **Figure 2** shows how the contents of this lesson are organized. The organization of the lesson contents represents the relationships between the structural systems and forces. Based on this organization, the lesson was developed and delivered. The concepts and their relevant examples were adapted from (Schodek, 1980), (Corkil, Puderbaugh, and Sawyers, 1974), and other texts normally used in

architectural structures courses and design studios. For the description of the attributes of the forces and the structural concepts, animation of load distribution in structures were used as shown in **Figure 3**. Each concept has two examples, and each chosen example is presented by a picture of a building in which the structural concept is employed. Since the purpose of this lesson is to introduce the basic structural concepts, the instructional strategy chosen for this lesson is the "direct instruction" method, in which concept information and concept examples are directly presented to students along with identifying concept names and providing attribute prompts.

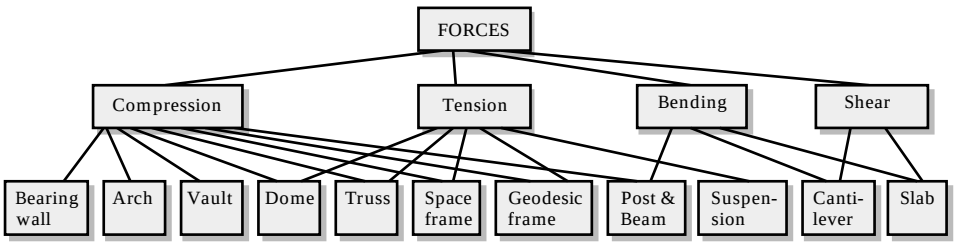
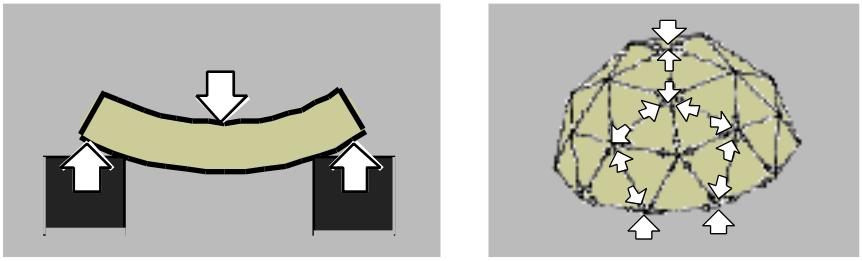


Figure 2. Organization of the contents of the Lesson Structure.



Force: Bending Structural systemt: Geodesic frame

Figure 3. Diagrams for the animation presenting load distribution in structures.

2.1.2. Designing the Lesson on Spatial Organization

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. **Figure 4** shows the organization of the contents of this lesson. The organization represents the relationships between the spatial composition concepts and their elements. Based on this organization, the lesson was developed and delivered. The concepts and their relevant examples were adapted from Clark (1985), Ching (1979), and other texts normally used in design studios. Since this lesson is for in-depth study of the spatial composition concepts, the instructional strategy chosen for this lesson is "discovery" method, in which students are asked to find a similarity from given examples and to abstract a concept without identifying concept names and providing attribute prompts. At the end of each concept lesson, for describing the attributes of a concept, a conceptual diagram of spatial composition in an example building is provided as shown in **Figure 5**. 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 names of a building.

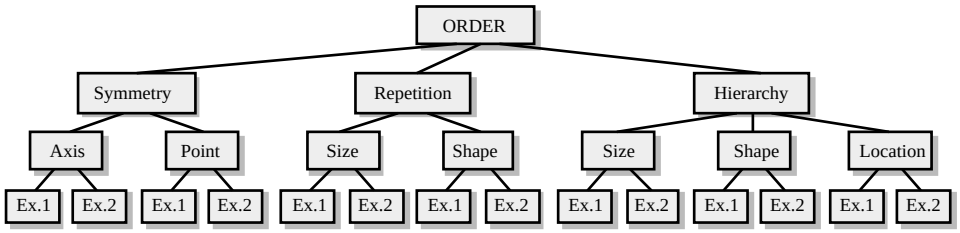
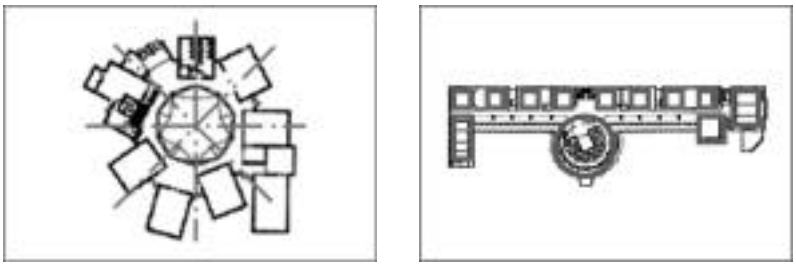


Figure 4. Organization of the contents of the Lesson Space.



Symmetry: Axis Hierarchy: Shape

Figure 5. Diagrams of spatial composition concepts

2.2. LINKING LESSONS

The CAI lesson system was prepared with HyperText Markup Language (HTML) files, Common Gate Interface (CGI) scripts, and Java scripts, and placed on an Intranet site (internal web site) to be accessed only by the students of a design studio. While, for easy organization and modification of the files for the lessons, we located the HTML files and graphic (GIF) files for the two lessons in the same directory in a server, this was not necessary for linking the two lessons. Even if the files for the two lessons are located in different places, they can be linked with each other. Such an ability to make connections between bodies of information, students and instructors is one of the factors that make the library of CAI lessons a powerful integrative tool. **Figure 6** illustrates the organization of the CAI lesson system and the information communication between the components and the users of the system.

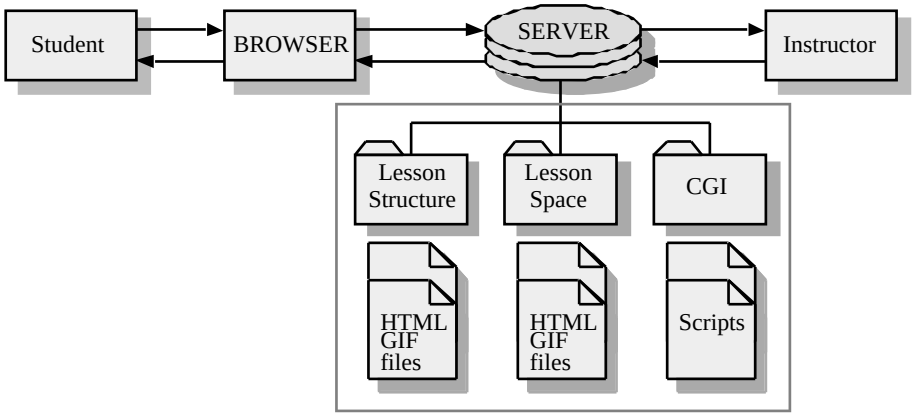


Figure 6. Communication between system components and users.

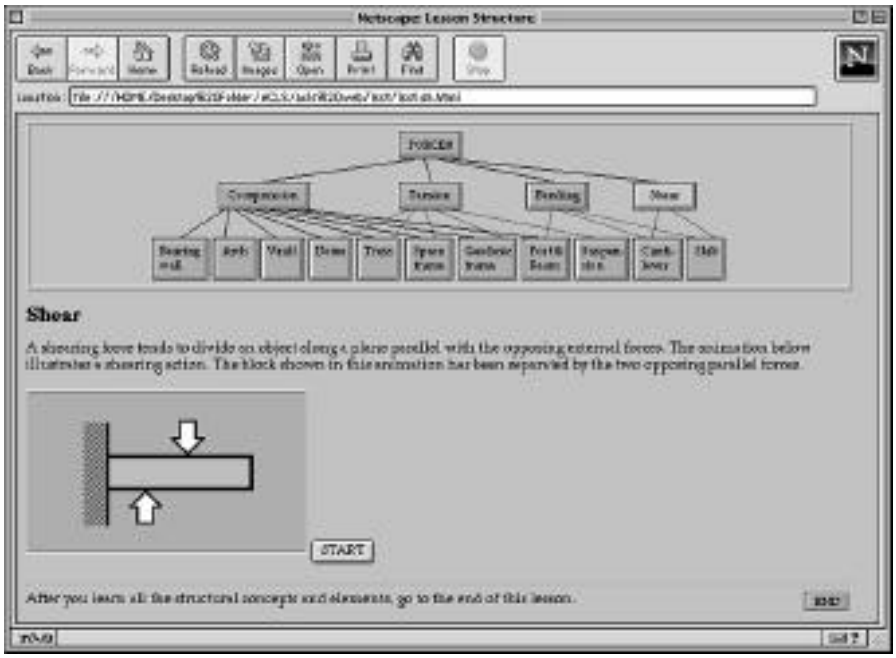


Figure 7. Sample page from lesson on forces.

2.3. USING LESSONS

In order to access this CAI lesson system, students need a password which was installed to limit the system's users to a design studio students. After getting the password from the design studio instructor, they can access the lessons in the system whenever they need the lessons using any platforms in which any Web browser is installed.

2.3.1. Delivering the Lesson on Structure

In the lesson on Structure, students can grasp the relationship between the forces and the structural systems with the map placed at the top of every lesson page as shown in **Figure 7**. The map also provides the buttons to go to the pages of the forces and the structural systems. The lesson begins with the pages explaining the forces—compression, tension, bending, and shear. In each "force" page, a force is introduced with its example as well as a its name, definition, and attribute. The example of a force is presented by animation, which shows how the forces affect an object. The Start button in **Figure 7** is for running the animation. After the "force" page, the students go to the "structural system" page, where they learn about a structural system that relates to the force. As shown in **Figure 8**, this page provides two examples of the structural system and an animation that shows how loads, forces, are distributed in the structural system.

2.3.2. Delivering the lesson on Spatial Organization

At the beginning of each concept in the lesson on Spatial Organization, without providing a concept name and concept attribute prompts, four instances (two examples and two non-examples) of the concept are presented, and students are asked to select the two examples of the concepts as shown in **Figure 9**. The students must discern the common attributes and elements from the instances. This process encourages them to abstract a certain concept from the given instances. After selecting the correct examples, they are allowed to get the detailed information of the example buildings. After reviewing the information, they are asked to label the concept and its elements referring the concept **definitions** given in every lesson page. This process of labeling is done by selecting one of the concept and element names given in the **pop-up menu boxes** at the top of the lesson page. **Figure 10** shows how the example building information, the concept definitions, and the pop-up menu boxes are organized in a lesson page. After learning all the concepts and selecting all the names of the concepts and elements, the students are asked to review the names they selected. After the review, they finish the lesson.

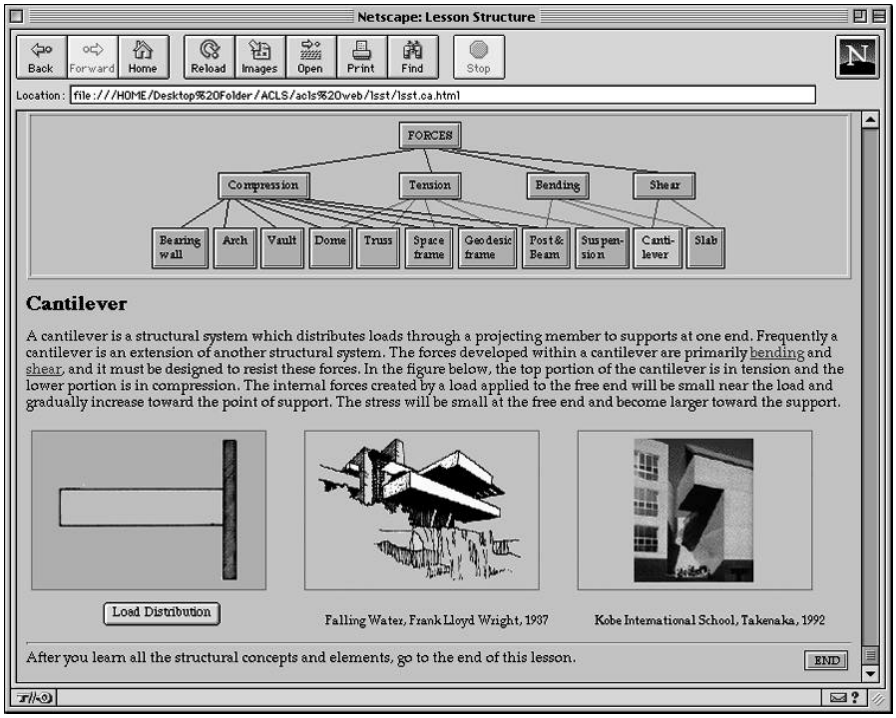


Figure 8. Sample page for a structural system.

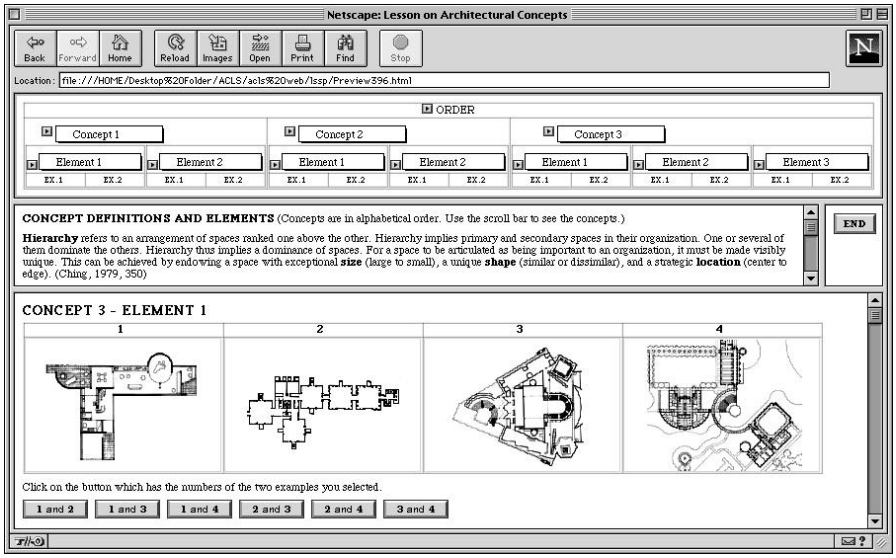


Figure 9. Sample page for selecting the examples of a concept.

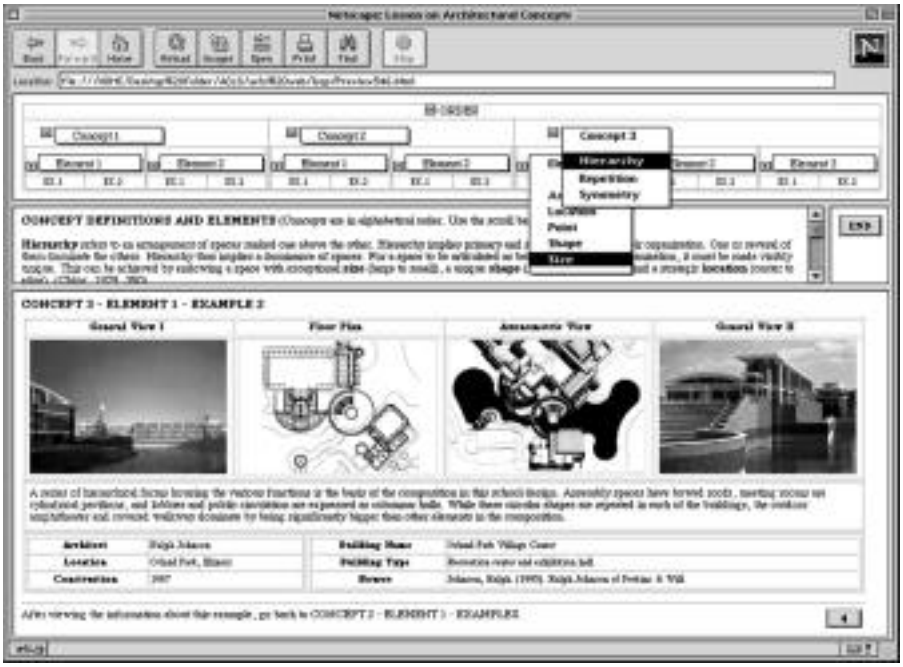


Figure 10. Sample page for the information of an example building.

3. Evaluation

Evaluation of this CAI lesson system consisted of observation by the researcher, observations by the instructor of the studio, and students' responses on the survey conducted after the lessons were taken.

3.1. DATA COLLECTION

In its first section, the post-lesson survey asked students to rate the difficulty level of the lesson content, structure, and method. It also established students' previous knowledge on the subject matter and whether the lesson served to new knowledge or as a review of previously gained knowledge. The second section required the students to be more descriptive and judgmental in the answers. They were asked to suggest topics for future lessons, describe interesting elements and uncomfortable elements in the lessons as well as comment or criticize the use of CAI lessons in design studio.

Observation by the researchers and instructor focussed on the logistics of administering these lessons, the effort involved in collecting and preparing materials, the availability of hardware, the individual help required for students intimidated by computing and the stress caused to students by this "new" method.

3.2. DATA ANALYSIS

Questionnaire responses were categorized by the two instructional methods, and were listed by lesson difficulty, prior knowledge, and comments. Individual student data was compared to find relationships between the different categories, relationships between students and within the whole group. The group data of all students were also compared to find relationships between the different instructional methods. Group data was compared with individual data to search for trends. Those patterns and relationships from the analysis of the quantitative and the qualitative data provided insights to some of the questions of this study.

4. Conclusion

Statistical validity for the quantitative has not as yet been established, however, the results of the data analysis indicate a strong trend that such an integrated learning environment is certainly a valid concept and that CAI lessons can perform as integrative learning tools in the architectural design studio. There appears to be potential for this concept to extend beyond the design studio to the area of continuing education in the profession of architecture.

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