AC 2007-729: CASE-BASE FOR DELIVERING INTEGRATED EDUCATION WITH MULTIMEDIA DECISION-SUPPORT

Mireille Battikha, Consultant
Case-Base for Delivering Integrated Education with Multimedia Decision-Support

Abstract

This paper illustrates the use of a multimedia case-based system designed to enhance the learning process by providing decision-support for integrated education in construction engineering as well as with other engineering disciplines. Sections of digital videos related to construction methods and materials, schedules as well as design alternatives have been collected to compile knowledge of construction activities and products from different construction projects. Cases are designed to compose sets of scenarios useful in analytical and decision-making processes for the delivery of integrated teaching. This consists of using compiled predefined representations including sections of digital videos capturing real construction site activities and products for the composition of new sets of situations useful to several management processes and engineering concepts under a current/new study. Several scenarios have been illustrated and findings summarized including advantages and limitations for further research and implementation. The case-based system will provide the educator with an effective tool to deliver the construction knowledge by integrating several concepts in the course, which will help prepare engineers to solve real construction situations. The benefits are drawn from an enhanced flexibility in manipulating the knowledge to evaluate alternatives using real visual sections of videos to effectively convey the integrated processes among disciplines. Example tasks include the selection from several compiled choices, viewing, composing, and decomposing cases. This flexible user-technology interaction furnishes direct visual understanding and integration of several engineering concepts in the processes. Use of the case-based system will allow (1) integrated teaching with other educators; (2) enhanced students understanding and visualization of the concepts involved; and (3) collaborative access with and/or among students to complete assignments and problem-solve. Implementation requires the collaboration of a multidisciplinary team to develop substantial sets of case studies relating the concepts of different engineering programs.

Introduction

A common and evident problem encountered in teaching construction engineering is the difficulty to bring the construction site to the classroom and to have access to real construction projects during the lecture schedules. A video about an entire project or part of it may clarify some aspects of the concepts. However, the manipulation of this knowledge to deal with specific construction situations and integrated analyses is impractical unless the video is obtained digitally, so that it can be truncated into manageable and useful sections. Visually capturing construction activities and their products in manageable pieces of information allows one to carry out several analyses to demonstrate real construction situations by integrating several concepts in the management process. This will enhance the preparation of engineering students to deal with real construction projects, which requires the development of their abilities to handle several engineering concepts in an integrated fashion. Integrated management processes are complex and crucial for solving most real construction situations. Whether a construction project involves developing a schedule, a plan, or an estimate, selecting a construction method and material, or improving its productivity and quality, engineers must possess the skills to carry out
integrated analytical and decision-making processes taking into consideration the effect that each of these functions has on the other. Teaching engineering students how to carry out these processes can be improved with ample exposure and effective delivery methods to enable them to grasp the inherent and intricate concepts and perform relevant hands-on applications for an adequate preparation for their careers.

This paper illustrates the use of a multimedia case-based system designed to enhance the learning process by providing decision-support for an integrated education in construction engineering as well as with other engineering disciplines. Sections of digital videos and images related to construction methods and materials, schedules as well as design alternatives have been collected to compile knowledge of construction activities and products from different construction projects. Cases are designed to compose sets of scenarios useful in analytical and decision-making processes for the delivery of integrated teaching. This consists of using compiled predefined representations including sections of digital videos capturing real construction site activities and products for the composition of new sets of situations useful to several management processes and engineering concepts under a current/new study. The case-based system will provide the educator with an effective tool to deliver the construction knowledge by integrating several concepts in the course, which will help prepare engineers to solve real construction situations.

Problem-based learning has been widely and successfully used in civil engineering education. It relies on the problem to initiate learning instead of depending on the conventional model, which places an application problem after concepts or topics have been introduced. This methodology has proven to contribute to the development of some skills and attitudes that are important for engineers’ professional practice, besides promoting the knowledge-acquisition process. Williams and Pender used problem-based learning in engineering to allow the students to apply and synthesize knowledge gained on the traditionally taught courses. The work of Chan et al. concluded that the curricula for educating construction professionals should embrace an integrated approach to provide the skills needed by each discipline, and that cannot be developed in one discipline alone. Grigg et al. embraced an integrated curriculum, which combines materials from different areas to teach design and problem-solving in civil engineering. The integrated approach offers a useful vehicle by which to add material to a 4-year program without increasing the number of credit hours, and gives flexible courses to meet goals of professional groups. Huang et al. developed a courseware engine TELD, which stands for teaching by examples and learning by doing. It provides an online tool to enable students to get involved in learning activities, collaborate in team-works, and participate in workshops or meetings.

Martini reported that the benefits of technology-enabled teaching extend to the highly visual approach, which will allow visual critical analysis of phenomena and features visible in photographs. This is advantageous due to the special characteristics of digital images including the use of digital enhancement, annotation, and manipulation to convey concepts, clarify phenomena, and provide image-based homework assignments. Digital technologies have been effectively used in management functions related to construction activities. Abeid and Arditi developed a dynamic scheduling system that links digital movies of construction activities, a work schedule, and progress control of construction. They used a time-lapse technique condensing months of construction performance viewed in minutes. In addition, they introduced a method to produce a digital movie, which allows thousands of pictures to be compiled and
managed. In their study focusing on digital technologies, Abeid and Arditi\textsuperscript{12} have also developed a database containing digital photography, which permits the viewer with play back at lower frame rates identify the tasks and their problems. It provides an effective mechanism for detecting and monitoring problems such as analyzing claims and investigating accidents. The enhancement of management activities with digital videos is gaining success due to the enriching visual aspect provided to the user, and the array of possibilities of information manageability that can be performed in a digital environment\textsuperscript{10,11,12}

**Case-Base Design Concepts**

To demonstrate the approach, several examples have been explored for experimentation to provide a basis for (1) designing the case-base; (2) structuring the relationships between the entities forming the case-base; and (3) defining the functions associated with the entities that manipulate the compiled knowledge to form new sets of scenarios. These examples have been selected from multiple construction sites and include several high-rise residential and commercial projects to demonstrate the analyses. For instance, the educator and/or students can use the case-based system to compose a sequence of construction activities that clarifies the construction process with visual understanding. Further, the product can be seen from different perspectives. By manipulating the digital videos, alternative construction methods can be compared to evaluate the pace of the project. Similarly, several alternatives can be composed to examine the effects on the cost and the product design. Other integrated analyses and decision-making processes can be performed such as studying the site layout based on the use of construction equipments and their constraints; allocating the adequate resources used in an activity for estimating and scheduling purposes; and, preventing possible problems in site rocks and unforeseen events in excavation activities. The benefits are drawn from an enhanced flexibility in manipulating the videos to understand and analyze the processes using real visual sections, and to make decisions before the project is built. In addition, the multimedia case-base of digital formats provides the tool to integrate education among multiple engineering fields.

**Elements and Structure**

The elements of the case-base include a repository of cases and/or pieces of cases stored in multimedia environments including digital videos and photographs compiled in relationship with the components and the activities of a project that are represented with a generic information model. The manipulation of the elements consists of using digital videos and images capturing real construction site activities and products for the composition of new sets of situations pertaining to several engineering applications including integrated management processes and concepts. To organize the stored digital images and sections of videos, a representation model is utilized in order to provide effective compilation and manipulation of digital knowledge. This model will allow the housing of the knowledge of different concepts in formats that can be integrated and used for several purposes and construction engineering aspects. Construction products or assemblies of a construction project (e.g., column, footing, wall, slab) form the core to which associations of digital entities are made. The associations include the intermediate products related to the assemblies, and the activities that shaped them. Figure 1 shows an example of how images/videos about construction products are associated to some of their corresponding images/videos about construction activities.
**User-System Interaction**

Sorting and composing construction scenarios from a case-base of digital images and videos will enable the study of construction products and processes. Each picture, or entity is identified by a list of criteria that specify the material, construction method, equipment, labor, cost, time, and the sequential placement within the construction process. When a combination of specifications is entered, it will trigger the retrieval of a single entity or a sequence of entities corresponding to the construction scenario entered. The retrieved/composed results reflect the scope of the specifications entered. Figure 2 illustrates an interface for user-system interaction. The interface will direct the user to select a single option under each factor to obtain a final result of a single image or video. Otherwise, the user can choose to generalize the options, which returns a list of results, rather than a single one. Retrieval of an image or video from the case-base follows user input, or selection of the identifying factors such as type of project, activity, sub-activity, product, etc.

In this organization scheme, the digital knowledge about products captures sections of videos of the product from different views. The knowledge about construction activities contains sections of videos, which reflect construction changes with time. The set of predefined videos are stored in formats, whereby the selection of these videos, to be used in a new project/analysis, is performed under the user’s control. Each video section can be sorted and manipulated with activities and products of different projects to compose a series of activities and products suitable for the current/new analysis. The user can view the sequence of the construction of a product while selecting different methods or materials and analyze their effect on the design, schedule, or estimate. The selection of design alternatives can also be explored by viewing and studying the various methods, schedules, and estimates. Integrated analyses and decision-making processes can also be extended with the application of various concepts and the study of their implications on other engineering disciplines. This graphical user interaction allows direct visual understanding and integration of several engineering concepts.
System Functions
The functions supported by the case-based system include but are not limited to the following:

- Sorting multimedia entities based on several indexing properties and constructs.
- Composing and decomposing a scenario based on engineering concepts such as building a residential high-rise or explaining a construction method.
- Analyzing the effect of multiple factors on defined criteria to support decision-making.
- Integrating concepts and applications in construction engineering and with other engineering disciplines to problem solve.

Demonstration
Shots of several construction projects have been obtained to demonstrate the described approach as captured in Figure 3. Some index assignments (listed under each picture) are exemplified in this figure and refer to the data-fields defined in the interface by the user. The first row shows a series of completed products or design alternatives about an exterior wall. There are several options for an exterior wall that the user can explore, such as a closed wall with concrete/metal/brick panels, windows, or a combination of these elements and materials. The second row illustrates the construction methods to build columns, and walls including concrete mixing, transporting, and delivery. It also captures the wooden forms in which concrete is poured. The selection of materials for the building structural frame and stairs based on time and cost criteria is presented in the third row. Some internal structural frames consist of steel columns, as opposed to concrete columns. Staircases can also be built with steel or concrete.
Figure 3. Compilation of Digital Entities in Association with Products and Processes
Concrete columns, slabs, walls, and superstructure are shown in the fourth row. In addition, equipment used in concrete placement and finishing, as well as for transporting materials to high floors is depicted. This sequence provides an overview of the construction process of a concrete building. It represents one of the capabilities of the case-based system, which allows the composition of building a complete project using pieces of videos capturing real construction activities and products. The excavation activity and the woodpiles, shown in Figure 4, are used to study and demonstrate integrated concepts in the prevention of problems and consequent claims due to unforeseen events. The user is advised that construction must not interfere with the neighboring surroundings, such as homes, businesses, streets, or sidewalks. This application describes problem-solving techniques with the identification of potential risks and solutions.

![Image of construction site]

**Figure 4. Retrieved/Composed Scenario for Integrated Analyses**

**Conclusions**

Decision-making often involves the evaluation of several alternatives for the selection of the most suitable one based on established criteria. This paper has described the use of a multimedia case-based system designed to enhance the learning process by providing decision-support for integrated education in construction engineering as well as with other engineering disciplines. This technology furnishes an environment capable of capturing knowledge in flexible formats, which allow its manipulation in order to carry out integrated analyses and decision-making processes. Teaching engineering students how to handle these integrated studies can be improved with ample exposure and effective delivery methods to enable them to grasp the inherent and intricate concepts, perform relevant hands-on applications, and analyze and synthesize in real situations for an adequate preparation for their career. Several examples have been collected from multiple construction sites to design the case-base and to demonstrate its elements and functions. For effective retrieval and manipulation, these examples have been compiled in association with a generic information product/process model representing a construction project. Use of the case-based system will allow (1) integrated teaching with other educators; (2) enhanced students understanding and visualization of the concepts involved; and (3) collaborative access with and/or among students to complete assignments and problem-solve. Students will refine their skills by engaging in a learning approach which involves (1) simultaneous performance of multi-domain engineering studies; (2) exposure to real pieces of situations and acquisition of up-to-date knowledge; (3) engineering design and management in a computer-based environment using a compiled spectrum of real cases; and (4) integration of
architectural, engineering and construction concepts during the different phases of the project development. Limitations of the case-based system encompass the adequate selection and storage of reusable formats captured from previous cases to fit a new case under analysis. This can be improved with extensive experimentation with the predefined formats and their adjustments to cover the most critical analyses expected in a new case. Online use of the tool for future improvement is contemplated to allow maximum sharing and collaboration among users.

References