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Infusing Practical Components into Construction Education

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The importance of integrating practical components in construction education has been emphasized by industry advisory councils and accrediting agencies. This paper presents the most important approaches to infuse such practical components, including some implementation examples. Specifically, it discusses simulation and gaming, case-based instruction, and internships. It also briefly discusses several minor and derived techniques, i.e., service learning, field trips, and application papers.

Keywords: Education, Construction Management, Simulation, Gaming, Case-Based Instruction, Internship, Service Learning

Introduction

The importance of combining practical elements into the teaching of any specialty has been long recognized (e.g., Kimball, 1995; Redlich, 1914; Schon, 1983). The retention of class contents is greatly enhanced when several learning modes are combined in the class delivery (Wankat and Oreovicz, 1993). To achieve this mix of learning modes, the instructor can incorporate laboratory experiences, group exercises, and audiovisual components into lectures. These approaches are particularly critical for Construction Management education. Practical activities are probably more important than theory in this field. Furthermore, the best laboratory for construction management is the construction project itself. There is no substitute for knowledge derived from a guided experience in the field.

Unfortunately, there is no single formula on how to integrate practice into construction education not only because of the number of variables in a construction project, but also because these variables are interrelated in many possibilities and combinations. Situations in construction management are frequently uncertain and ambiguous. Construction managers usually make decisions based on the experience and cases or situations they have previously encountered. This creates a big challenge for construction educators. How can students learn how to integrate the required elements and make appropriate decisions? How can they be exposed to all aspects of the problems, instead of a single aspect? Very often educators teach these elements separately. Although this approach makes problems more manageable, it sacrifices the discussion and understanding of the interrelationships among these elements.

This paper presents a summary of several major techniques used in incorporating practical elements into the construction curriculum, with some insights into their implementation. Specifically, simulation and gaming, case-based instruction, and internships are discussed.

Service integration, field trips and application papers are also included though with less emphasis.

Simulation and Gaming

A first level of practical situations can be found in simulation and gaming. Simulation has been defined by Davies and O'Keefe (1989) as "the construction of an abstract model representing some system in the real world." The ability to create lifelike scenarios without the complexity and dangers of the real world is appealing in many instructional situations. A closely related area is that of gaming. Educational gaming is an important genre of simulation wherein the rules and outcomes are more clearly stated than in other simulations which try to convey more real-life environments. Games usually (but not always) have a conclusion and reflective stage, whereas in other types of simulation the opposite is usually true.

There are many advantages associated with simulation and gaming.

- The complexity of a construction project is difficult to simplify for the beginning student, and the point being made for a particular topic may be obscured by the environmental "noise." In contrast, simulations are designed to emphasize the main points and provide some notion of the effect of other concurrent variables.
- Although a simulation is commonly time-consuming to develop, it is reusable. The instructor gains insight on how to teach the simulation and what conclusions to draw.
- A student making a bad decision in the simulation or game does not have any impact on a real project. Consequently, more fundamental decisions are allowed from the student. Other practical approaches, such as an internship, prevent students from making potentially damaging decisions.
- Simulations provide feedback in a compressed time frame. The consequences of a management decision can be evaluated immediately, as opposed to the relatively long periods of time involved in a construction project.

In the last decade, simulation has been almost entirely identified with computer programs interacting with students. In fact, there are manual games that provide all the advantages of their computerized counterparts. Such a game is the Lego Hotel used at the University of New Mexico by Prof. Greg Howell. In this game, team dynamics are exposed by requesting groups of students to compete in duplicating a complicated figure made with the interlocking blocks used by children. Another manual game is Low Bidder, a bidding game introduced in the 1970s by Entelek, Inc.

The bulk of the current academic and training simulation has been implemented in computer software. SuperBid is another bidding game developed by Siman Abourizk at the University of Alberta, with such details as variable subcontractor reliability and computer-generated financial statements. Even some commercial computer games can be used for training. Maxis/Sim-Business publishes a series of simulators as Simcity. They provide useful scenarios for city planning. Halpin and Riggs (1992) discuss several simulation applications developed with MicroCYCLONE. Halpin (1985) also developed CONSTRUCTO, a comprehensive construction management gaming environment that unfortunately has not been ported to personal computers. Davies and O'Keefe (1989) provide numerous examples of simulation for other industries.

A more sophisticated level of simulations has been developed in the recent past. Georgia Tech is experimenting with "virtual worlds," which emulate, for example, the performance of an excavator operator (Op den Bosch and Baker, 1995). This simulation is strictly sensorial, and does not attempt to draw conclusions for management purposes.

Simulation has limitations as well. It relies on the soundness of its creator's assumptions, a precarious ground in construction management since the fundamental framework of project behavior is still to be fully understood. Furthermore, the simplified world used in a simulation can be detrimental to the understanding of the complex nature of construction. Finally, a good simulation is difficult and time-consuming to develop. This factor has been a major problem for its widespread use in construction education.

Case-Based Instruction

Case-Based Instruction (known by some as problem-based instruction, although they have minor differences) is at the next level of practice infusion in construction education. It has been successful for the instruction of disciplines having a similar dilemma of practice and theory, such as law (Redlich, 1914), business (Christensen, 1987), education (Silverman, Welty and Lyon, 1996), social work (Boud and Feletti, 1991); and nursing (Green and Holloway, 1996). It is well suited to a multi-perspective approach, since analyzing cases helps learners think clearly in the ambiguous or ill-structured situations of practice (Ashbaugh & Kasten, 1995).

Wasserman (1993) describes four common components of Case-Based teaching: a case report, study questions, small group work, and whole group discussion (debriefing).

A case report contains information necessary for the students to address the problem. Ertmer and Russell (1995) suggest the following organization for the case report:

- Case Overview: State the goal of the case (the supporting concepts and principles learners should pick up from the case).
- Case Objectives: Supporting concepts and principles students should use in analyzing the case issues.
- Case Background: problem scenario. It includes context, constraints and players.
- Relevant Data: facts, events, circumstances directly related to the case.
- Overall Description: Present a clear, concise, and complete description of all aspects of the situation. Present a realistic problem description (authentic, plausible, and technically valid).

Study questions are listed at the end of each case. Those questions are the key areas and issues which teachers want students to address. Study questions should be well prepared in order to achieve the best result.

A streamlined example of a case report containing the above elements is presented in the Appendix. It is based on an actual situation experienced by the author of this article. This example was introduced in the 1997 ASC Region IV meeting with the paper "Case-based instruction: a powerful alternative for construction education" (Senior, 1997).

Ertmer and Russell (1995) also suggest that "following the case presentation, students work individually or in groups to analyze the data, evaluate the nature of the problem(s), decide upon applicable principles, and recommend a solution or course of action. Small group work, in or out of class, gives students the opportunity to discuss cases and questions: with each other prior to the whole class discussion that follows. These sessions give students their first chance to examine the issues presented in the case study; ideas are tried out in the safest of contexts. Study groups engage students in thoughtful consideration of the case issues and primes them for the more demanding whole-class discussion that follows."

The final component, a whole class discussion or debriefing, is where the true value of case-based instruction is thought to reside. Christensen (1987) is eloquent on this aspect: "Each class provides an experience in learning to listen to the views of one's peers and in learning how to express one's self and perhaps to persuade others to one's point of view. The method provides a most invaluable opportunity to learn how far one can go by rigorous logical analysis on one or another judgment comes into play when many factors which have no common denomination must be weighed."

There are many benefits associated with Case-Based Instruction. Kirshman (1996) cites fifteen such advantages. From an educational perspective for Construction Management, some significant advantages are:

- Enhancing students’ analytical and reflective skills. Case-Based Instruction teaching requires students to analyze all information in order to determine the problems. "In real world practice, problems do not present themselves to the practitioner as givens" (Schon, 1983).
- Improving students’ ability to integrate all elements of knowledge as well as improving their problem solving skills. A case will present students with a complex situation which consists of several elements of knowledge. Students are required to analyze each element of knowledge and the interrelation among them, and eventually to integrate them into solutions.
- Allowing students’ views and opinions to be expressed. After the presentation of the analysis, ideas and assumptions will be questioned and criticized by the other students. This also helps in reexamining each student’s opinions and assumptions. It will improve students’ communication skills. Each student is required to make a presentation. S/he will gradually learn how to arrange his/her thoughts, what was learned from the case, and present them to the class.

Case-Based Instruction classrooms have been described by Wasserman (1994) as being places "in which no single, correct answer is sought; where discussions are left, suspended, without closure; where students leave class with unanswered questions; where the frustration of not knowing for sure is allowed to ferment." Thus, some instructors and students feel uncomfortable with Case-Based Instruction because there is no room for the single, clear-cut answers so important for some learning styles. Preparing a subject for Case-Based Instruction is a very time consuming process, and instructors may feel that they lose some control over the class. Learning outcomes cannot be easily measured, and therefore instructors cannot be certain that students are learning all the contents of the subject compared with traditional lecturing. Some students also feel uncomfortable working with others, which is a basic component of this approach.

At Colorado State University, a combination of simulation and Case-Based Instruction has been attempted. The construction operations simulation training (COST) room provides an environment in which students can re-create an actual project's planning activities. For example, it is used to drill students for the ASC regional competition. The COST concept has proven to be difficult to implement due to its comprehensive nature, among other factors. Several improvements are planned to streamline its operation in the 1997-98 academic year.

Internships

While Simulation and Case-Based Instruction are classroom-based alternatives, internships immerse the student in an actual supervised professional situation. Internships are probably the oldest and most widely used format for experiential learning (Wolf, 1980). For centuries, professional education consisted mainly of an apprenticeship with relatively few collegiate requirements, and only in the last two centuries did classroom education gain the favor it now enjoys among educators. Gross (1981) defines an internship as "a practical experience outside the educational institution in an organization that deals with the line of work you hope to enter. More specifically, an internship is a relation you have with a company or organization in which you are treated as a quasi employee."

From a student's perspective, the internship experience is clearly positive. A survey of interns in the Media program at Loyola College (Ciofalo, 1992) found that:

- 85% agreed that the experience gave them a feeling for their profession.
- 77% found that their bosses treated them as entry-level professionals.
- 83% felt that their work as interns made a significant contribution to the company's mission.
- 74% agreed that their supervisors took the time to teach them on the job.
- Only 4% claimed that the attitudes of co-workers somewhat interfered with their effectiveness on the job.

The implementation of internships varies widely among institutions. An informal survey conducted by the author in 1996 among ASC faculty found that the need for an internship as part of the construction curriculum is almost universally supported by faculty across the country. The level of intervention is, however, quite different among colleges. At one end of the spectrum are programs like Purdue's Construction Engineering and Management, which make their internship a required component of the curriculum. Furthermore, Purdue has a full-time internship director, who recruits sponsors and is the liaison between them and their interns. The minimalist approach to internships, shared by several institutions, is to allow the campus Co-Op program to administer the internship. Students are responsible for contacting sponsors. The number of interns hired and their work conditions are totally discretionary to the sponsors.

The most important aspect of internship administration appears to be the assignment of relevant duties to interns, and the means for accountability from sponsors and interns. This is usually achieved by the explicitly defining college expectations, and by monitoring the performance of sponsors and interns via visits and periodic written reports.

Appropriate monitoring is one of the major problems in implementing internships. Interns can be supervised by individual faculty members in the department (each faculty is assigned several interns), by a full-time internship director, or by another college department (usually along the Co-Op program). Another problem faced by internships is establishing the physical framework for the internship. In most cases, the length of the internship is four to six months. Purdue's Construction Engineering and Management requires three 12-week periods. The available alternatives are to require students to work in the summer break, or extend the program's duration. Finally, but not least, there is the problem of how to give credit to the internship experience. In some programs, the internship is totally optional. In others, it is required but no academic credit is earned. In some others, like the one being implemented at Colorado State University, the internship is required and the student earns academic credit upon its completion. The real problem is how and if credit should be given to experienced and working students toward the completion of the internship. Policies vary from not counting previous experience to waiving the requirement.

Regardless of the implementation approach taken, internships are an increasingly popular method incorporating practice into the construction curriculum. Many of the problems faced by colleges instituting an internship program will be solved as more collective experience is accrued.

Other Approaches

Service-Learning

A powerful avenue for experiential learning is the inclusion of a service-learning component in the curriculum. Although the implementation details vary among disciplines and institutions, the basic philosophy of service-learning is the application of students' skills to solve a community-oriented project. Students are usually organized in groups, and their solutions many times are adopted for the project at hand. Projects are provided to students by the instructor. In turn, the instructor contacts community organizations to find out which projects are appropriate for the class. In the case of Colorado State University, the Office of Community Services simplifies this process.

An example of service-learning is the project to be implemented for the required course *Construction Project Scheduling and Cost Control* at Colorado State University. A small hotel has been donated to a local charity. It will be relocated about two miles from its current site, and rehabilitated. Students will have to develop the budget and schedule for this project, as well as investigate the administrative hurdles to overcome. They will also take part in the project implementation.

An important part of this approach is the reflection of the learning experience. Service-learning provides a valuable opportunity to ponder professional aspects which are, regrettably, frequently overlooked. Yet, service is at the heart of any profession. The American Society of Civil Engineers (1997), for example, succinctly defines profession as "the pursuit of a learned art in a spirit of public service."

Field visits

A very common way to include some practical component into course content is field visits. These visits can be very informative, but unless the experience is well designed, they can become glorified picnics. Field visits are important because the student encounters individuals in a practical work environment. They "see, hear and smell in an organizational and practical context" (Wolf, 1980).

A field visit should have:

- Background information about the project, company or location to be visited. Why is it relevant to the class? What are the special features to be observed?
- A significant tour of the facility. A qualified employee of the project, company or location should have been assigned to the visit. Otherwise, it is preferable to return on other date or discard the project.
- A report requirement. Students should have an incentive to pay attention.

Application papers

Another widely used approach to supplement theory is the requirement for a report about a topic requiring an external and direct contact from the student. Reports of this type have been well documented in the literature (for example, Wankat and Oreovicz, 1993; Borich, 1996; Barnet and Stubbs, 1986; Houp and Pearsall, 1977).

A special case of application papers are those requiring independent field research (Wolf, 1980). In this case, the research is substantially more demanding than in a simple paper. This is a common requirement for Masters degrees.

Conclusion

There is much consensus among construction educators for the need to include practical components into the construction curriculum. This paper has presented some of the most relevant and common approaches to include components of practice into a construction program. As indicated, some methods such as application papers and field trips require a minimum level of effort from an individual instructor, while others such as an internship are department-level enterprises of great complexity. Each one of these methods do not preclude the others, and the final mix depends on the preference and commitment of each construction program.

What seems clear is that more practice-oriented curricula will be the norm and not the exception in the future. The American Council for Construction Education guidelines for a self evaluation study (Form 102) explicitly lists field trips, summer job programs and similar practical experiences as part of its evaluated material. The author has had informal communication with faculty of several construction management programs. The majority have indicate that their industry advisory boards are demanding an internship. All these developments are the right thing to do. Practice is at the heart of construction education.

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Appendix

Case Study
Loading the Dice: Resource Loading a Project Schedule

B, a planning consultant, is called by Charlie, the contractor for the rehabilitation of a state-owned drainage channel system. He was referred to Charlie by Sam, the chief engineer of an international firm supervising this project for whom B has worked before.

The project is behind schedule, and B is requested to develop a recovery program. Even though he is retained by the contractor, it is Sam who has insisted on hiring him.

An initial look at the project makes clear to B that a major factor in the delay has been the unavailability of one imported dragline. The dragline is being held by the state's custom authorities, claiming that it must pay substantial custom duties. Charlie says that the equipment will be used on a temporary basis. However, he confides to B that he intends to keep the dragline at the end of the project.

Charlie thinks that the recovery schedule should be loaded with the dragline, to reflect the effect of any further delays in its release (delays that so far he considers to be the state's fault). Sam indicates that he will not accept the inclusion of the dragline as a resource, since other equipment can be used for the operation. Charlie insists that this alternative would not be cost effective, and he would be entitled to economic compensation. Sam's position is that if more time would have been allocated to the procurement of the dragline, the problem would not exist, and that therefore it is the contractor's responsibility.

B feels confused. Should he tell Sam about Charlie's plans to keep the dragline? After all, isn't Charlie just acting as a normal contractor? Should he advocate for including the dragline as a distinct resource in the schedule? Would it be possible to develop a schedule that is fair to both parties? Should he accept this project in the first place, given the circumstances?