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Developing Across the Curriculum Examples to Use in the Construction Classroom

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Abstract

This paper presents an across the curriculum case study used at the University of Maine within some of the core courses of the Construction Management Technology program. Exercises have been developed using this case study as the reference project. Students are first introduced to the project as sophomores and refer to the project in select exercises in courses through and including in their senior year. The consistency in using a familiar project helps students grasp construction concepts within the context of a working project. Use of this project also illustrates to inexperienced students how varied curriculum courses are all intertwined within the context of a project.

Though this paper is anecdotal in development, it offers a framework in which others can create similar dynamic case histories to apply to their unique courses within their own programs. This case history is supported through our university's facility management office, tenants of the existing facility, and faculty dedicated to implementing examples around the case history.

Introduction

College courses are often taught as discrete subject related topics that are not integrated into the subject matter of other discrete courses. Often these courses do have pre-requisites to build on the respective subject material, but integration between topics is isolated. Students often don't make connections between the discrete topics as having any sort of relationship. Construction related courses are no exception. Core topics such as estimating and scheduling at UMaine are usually taught separately and students don't tie these two important aspects of the construction project together. The author has observed that students who work in summer construction positions are more likely able to recognize the relationship between a project estimate and the preliminary schedule.

To help students experience the interrelationships between topics within the construction curriculum at the University of Maine, some members of the construction management faculty have created exercises from one common project in their respective courses. These dynamic exercises expose students to varied parts of the project so that they can see the interrelationships of subject material. The project can't illustrate all aspects of construction projects and faculty members do use other examples. However, the common project serves as a method to tie together some of the key relationships.

Meaningful construction exercises are difficult to bring into the classroom. Construction projects are unique and the situations encountered are varied. Success and failure are defined by the circumstances of the project, the principals involved, and end results as perceived by the end users. The dynamics of the Owner, Designer, and Contractor set the tone for the project defined by the cost, schedule, and quality features. These variables make the whole experience unique.

Jonassen, Strobel, and Lee discuss the importance of solving workplace problems through experiences. They concluded that "in any new problem situation, people examine the situation and attempt to retrieve previously encountered experiences that resemble the current one."[1]

Jonassen, Strobel, and Lee conducted a series of interviews with practicing engineers to quantify how workplace problems are best solved. From these interviews, they made several observations that are relevant in how practicing professionals solve problems in the workplace.

1. Workplace problems are ill-structured. Constraints and unanticipated problems impact seemingly straight forward projects.
2. Ill-structured problems are aggregates of well structured problems. By taking individual aspects, larger problems can be readily solved.
3. Ill-structured problems have multiple, often conflicting goals. One possible solution can impact another area fairly easily.
4. Ill-structured problems are solved in many different ways. Textbook problems usually direct toward a preferred solution, does that follow the way in life practice?
5. Success is rarely measured by engineering standards. Many engineering standards are not the standards that are used to describe the success of a project. The survey indicated that many engineers use satisfaction of the client, completing on time, and staying under budget as the most common criteria for success.
6. Most constraints are non-engineering. Most engineering education programs treat problems as engineering-only problems.
7. Problem-solving knowledge is distributed among team members. Learning is recognized less as a solitary act of individuals but rather is distributed among people, their tools and communication, media, history, and artifacts they create.
8. Most problems require extensive collaboration. Collaborations are most successful when the roles and relationships are well defined and they share a common goal.
9. Engineers primarily rely on experiential knowledge. Experience is the most common determinant of expertise and the recall of historical information is the most frequent strategy for solving problems.
10. Engineering problems often encounter unanticipated problems. Most everyday problems are dynamic; that is, the conditions change over time.
11. Engineers use multiple forms of problem representation. Problems can be viewed in many different ways and need to be understandable.
12. Engineers recommend more communication skill in engineering curricula. Individuals have mental representations derived from experience or observations, but that knowledge is often useless unless it is shared.[2]

The framework established by the work of Jonassen, Strobel, and Lee help provide the background for taking a consistent project that can be used in across the curriculum exercises to reinforce subject specific information. These exercises help create the intertwined coursework and "experiential" familiarity with a project.

Project description

The Innovation Engineering program was formed as a hybrid program in consortium with the College of Engineering, College of Business, and College of Liberal Arts. It was created to give Students from any program a variety of courses leading to a minor in innovation engineering or a graduate certificate in innovation. This program helps students turn ideas into marketable businesses. The students learn to put together ideas through the four stage process of "define, discover, develop, and deliver." The Foster Center provides young entrepreneurs with a variety of resources from stationery to working space to develop business plans. To match the unique mission of the Innovation Engineering program, a unique building was designed and built to be the headquarters.

The Foster Center for Student Innovation is an approximately 5850 ft^2 semi-open concept, one story classroom building with conference room, student workspaces, and administrative offices. It was built in 2005 to serve the newly formed innovation engineering program at the University of Maine. The U.S. Green Building Council rated the facility as Silver under the Leadership in Energy and Environmental Design (LEED) program. Because of its uniqueness, the American School Board Journal gave a citation of excellence in green building and recognizes the building as one of the top new educational facilities in the country.[3]

The project is sited on the campus of the University of Maine near several dormitories and engineering related classroom and research buildings. It is located on a wooded lot at the apex of a hillside with an abutting designated marshland. The building has several unique features including a slightly pitched flat roof, floor to ceiling glass along one face, and centrally piped steam heat. The interior is finished in composite woods with moveable roll-up translucent panel walls to open up the classroom and conference room spaces to a common area. This structure is built on a slab with perimeter footings. Some of these features are not commonly used with typical classroom buildings in this region and university.

Construction exercises

In the past 5 years, several of the core courses within the construction management technology program have consistently used exercises relating to the innovation center. These exercises have been developed to also incorporate selected ABET (ETAC) goals as defined under criterion 3B for student outcomes in baccalaureate degree programs. The outcomes most addressed are defined as:

a. an ability to select and apply the knowledge, techniques, skills, and modern tools of the discipline to broadly-defined engineering technology activities;
d. an ability to design systems, components, or processes for broadly-defined engineering technology problems appropriate to program educational objectives;
e. an ability to function effectively as a member or leader on a technical team;
f. an ability to identify, analyze, and solve broadly-defined engineering technology problems;

g. an ability to apply written, oral, and graphical communication in both technical and non-technical environments; and an ability to identify and use appropriate technical literature;[4]

Many of the ABET (ETAC) criterion 3 items parallel the findings of Jonassen, Strobel, and Lee relating to solving workplace problems. The solutions to problems are best done in team environments recognizing the influences of other areas to the standards commonly employed. There is always more than one way to solve the problem. The best solutions come through communicating the idea.

The core courses in our curriculum that use examples from the innovation center include the following:

CET 221 Construction Methods
CET 356 Construction Documentation and Administration
CET 360 Construction Estimating
CET 462 Construction Scheduling
CET 458 Construction Administration (capstone)

To better understand how the innovation center examples are employed, brief discussions of implemented exercises will illustrate.

CET 221 is a sophomore course that introduces students to the equipment and techniques used in construction projects. It provides students with an overview of heavy civil and commercial building techniques. Two basic exercises using the innovation center are assigned in this class. Students self select teams of up to 4 students to develop a written overview of how they would build that aspect of the project. Students are given ½ size .pdf files of the plan set for use. There are no stated guidelines other than how would you build this aspect using your current knowledge. What would be the equipment and resources needed and general steps that you would use? What considerations should you make? No other guidelines are given and teams have 2 weeks to prepare a solution. The first exercise is for the site development from clearing the land to preparing the slab foundation. This particular exercise is evaluated as a minimum for the sequence and equipment used. Other items of interest are addressing the runoff to the adjoining marshland, traffic control on the campus, and staging the site. The second exercise is for constructing the building. Again, the minimum is the sequence and equipment, but other items include logistics of all of the trades involved, storing equipment, creating the envelope, and safety. Particular ABET criteria that is relevant is 3B; a., d., e., g. Evaluation for these exercises is through a matrix that highlights the minimum criteria and suggests other items for consideration. At the sophomore level, students generally evaluate minimums reasonably and don't consider many of the other items such as surface runoff, staging, and traffic control. Generally speaking, many have had limited work experiences and these are reflected in their ability to analyze the situations.

CET 356 is a first semester junior course that introduces students to the overall construction process of pre-bidding through to project close-out. Many of the documentation requirements along with external influences on a project are discussed. Part of the course requirement is a writing intensive lab where students write several general exercises as either individuals or in a collaborative team exercise. The innovation center is the backdrop for these written exercises. Students have access to ½ size .pdf plans and .pdf files of the 2 volume specification set. Individual exercises include a formal letter documenting a discrepancy in a progress inspection at the innovation center, the minutes of a construction meeting for the project, employee memos addressing information from the construction meeting, and field notes. Team based exercises are for a work plan, safety plan, change order, and RFI. The expectation for the work plan and safety plan are more detailed documents than the earlier exercises for "how would you build it" assigned in CET 221. The change order and RFI exercises have the student think through what is learned through the text to apply to the innovation center. The letter, minutes, memos, and field notes exercises reinforce the non-technical aspects of the project with emphasis on the communication of the ideas all relating to the innovation center. These exercises are all evaluated through matrices that not only evaluate content, but presentation, grammar, and tone. ABET criteria is 3B, a., d., e., f., g. At this point, students have some familiarity with the project. Many have had a little more practical work experience through the summer and have some greater knowledge of the background of documentation and administration. Generally speaking, students provide more thoughtful detail, but have average to poor writing skills. Items such as safety plans and work plans have detail likely contributed through team efforts. Items such as the letter, minutes, and memos lack key aspects presented to the students. Experiences from summer jobs begin to show in how these assignments are executed.

CET 360 is a second semester junior course that introduces students to estimating both heavy civil and commercial building projects. Students are introduced to the RS Means pricing database and are instructed in the general process of estimating and bidding. Emphasis is on work breakdown structure. During class instruction, classroom examples are taken from the innovation center to illustrate how items can be priced through work breakdown. Selected items are shown through the RS Means database. Two different classes had the general innovation center as a team based project to illustrate lump sum bidding during the second half of the semester. Because of time limitations, student teams are asked to prepare a bid that covers 5 of the old 16 CSI categories including the steel, concrete, and earthwork sections. Students choose 2 other areas and subcontract prices are provided for the rest of the project. At this point, a more detailed guideline is issued that spells out that both a bid sheet as directed in the specifications and a contractor's internal bid book are required. This project is evaluated by matrix and looks at the minimums of the bid form and contractor's book. It also evaluates items such as timeliness, administration sections such as bid bonds, and incidentals. At this point, the students have worked with the innovation project through 3 semesters and have familiarity with the overall project. They do not, however, readily work with the specifications and look at administrative parts of that specification. This exercise addresses ABET 3B; a., e., and g. Team members that have had work experiences are better suited to assisting with this exercise.

CET 462 is a first semester senior course. In this course, students are introduced to basic scheduling techniques using CPM diagramming. They look at resource allocation, constraints, and cost application. In the lab portion of the class, students are introduced to Microsoft Projects and apply an example to create workable schedules. Though the innovation center is not consistently used, it has been used twice as the project to schedule. At this point, students have a familiarity with how the project is constructed and general cost information. They have looked at some of the work breakdown used. They have had more practical work experience and a better understanding as to what is involved in construction administration. Senior students can better think through the sophomore question, “how would you build this?” to include detail with time frames, predecessors, and successors. Generally, students do well in putting together a viable schedule. This project is evaluated through a matrix that looks at both technical details and ability to use the software. There are some unrealistic time frames and some unrealistic decisions in sequence. The familiarity with the project, associated coursework, and team engagement better shows in the assignment. The exercise addresses ABET 3B; a., e., g.

CET 458 is the second semester senior capstone course. In this course, students work in random teams to develop a project through the preliminary construction process. They are given minimal guidance and are evaluated on milestones for the subject project. The innovation center has been used on alternated years in which the innovation center wasn’t used in CET 360 and CET 462. Milestones include a project bid, schedule, and methods presentation. At this level students are expected to be able to adequately communicate, understand the construction administration process, the bidding process, and scheduling. Students are randomly selected to teams. Though the students are familiar with the technical details of the innovation center project, they now work with team members who are not necessarily familiar. Random assignment often pairs up dissimilar personalities and team dynamics are the variable here. This dynamic can be good, bad, or ugly as could be actually experienced in the workplace. Each exercise is evaluated through a matrix which reflects both the technical quality of the milestone product and the team performance. The exercise incorporates all of the relevant ABET 3B outcomes a., d., e., f., and g.

Lessons learned

Several lessons have been learned in using a common project across the curriculum.

1. The best projects are those that can be readily accessed by students. They need to be able to visualize the example through the plans, specifications, and proximity to the finished or developed project. Close proximity allows unanswered questions to be addressed.
2. The owner, designer, and contractor should be onboard with the instructor to use the project as an example. The owner needs to allow access to the project. The Designer needs to give permission for use of the materials in classroom settings. The Contractor can give pictorial record of the project, answer how questions, and generally discuss process.
3. Because of student learning, full size plans or CAD files are best used. In the innovation center project, the only files available are .pdfs. Limited supplies of the full size plans are available. The Designer had destroyed all of the excess plans when it was decided to use this project. Because of internal communications, some of the subcontracted design files are unavailable.
4. Photo documentation for the project will help explain some of the completed aspects of the project that are unseen in the finished project. Visualization helps many better understand items while learning.

5. Examples from the same project give students some experience through familiarity of the project. Many students have varied work experiences and may not be able to relate to particular aspects of a project. Other examples are needed to illustrate points either not covered within the subject project or not prominent within the project.
6. Instructor involvement in collecting information for a continuous project should begin in early stages of the project to insure complete sets of data. Unfortunately, information for the innovation center wasn't collected until after the final project had been accepted. Many of the documents were not available.

Conclusion

An across the curriculum construction project has been successfully used in several of the core courses of our construction curriculum. These courses cover the sophomore, junior, and senior levels of the curriculum. Students gain experience with the project through familiarity over time. They learn technical concepts within the respective coursework and apply these concepts to the subject aspects of the respective courses. They become more familiar with how to analyze the project over the period of exposure to the project. This ability to look at the project should assist them with future workplace problem solving.

To better implement this across the curriculum concept, our program is closely monitoring the development of a new building project to be built at the University of Maine during the 2013-2015 construction seasons. We anticipate further expansion in coursework based on the new project.

Bibliography

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