Design of the Learning Environment : Professional-project-Based Learning in Construction Education

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Abstract

With increased emphasis on the end result of student learning rather than on the process of teaching/instruction, the design of the learning environment has become a major task for faculty. For engineering and technology curricula not only should this environment include involvement of students in simplified versions of their professional practice but also emphasize both the continuity of knowledge in a curriculum as well as the importance of using and retaining competency acquired in <u>all</u> courses. This paper focuses on three undertakings in construction technology education that has the above objectives in their design and implementation.

Introduction

The new movement in higher education is an ever-increasing emphasis on assessment of the outcomes of the education process. As a result the focus is on the end result of student learning rather than on the process of teaching/instruction. This in itself has made the design of the learning environment become the major task for faculty in all disciplines. For engineering and technology curricula not only should this environment include involvement of students in simplified versions of their professional practice in a teamwork format but also emphasize both the continuity of knowledge in a curriculum as well as the importance of using and retaining competency acquired in <u>all</u> courses

The Need/Problem

A serious deficiency common to all textbooks used in design, analysis, and problem-solving courses in engineering technology programs is the isolated nature of problems contained in each chapter. These problems, in general, stress the concepts and techniques covered in that chapter without really striving to establish a continuity with the previous chapters. The implicit assumption is that the students will be able to bridge the gap between the chapters and grasp the continuity of context, see the overall picture, and perceive where they are headed.

According to my experience, however, this does not necessarily happen without special effort on the part of the faculty member. My class work and exams are designed to make the student aware of how each chapter builds up on the previous ones and that an understanding of the big picture is expected at the end. Still, I have often found ascertaining of mastery of competencies expected to be difficult within the inevitable limitations of examination/quiz duration and context. I have tried to make up for the deficiencies of the examinations in this respect in terms of semester projects that entail a wider scope. Nevertheless, the scopes of these assignments, in my opinion, were still limited in terms of what will be expected of our students in their future careers.

Another problem along the same line is that the students are not always cognizant of the continuity between classes. More often than not, students accept taking a course as an end in itself, and once a course is completed, everything learned can be laid aside and hopefully never used again if possible.

Solutions/Methodology

Some technical educational programs are trying to address these problems in terms of capstone or senior design courses which entail students working on industry-scale problems assisted by collaborative teaching, coaching and advising by faculty. As ideal as this approach may seem, implementation of such undertakings often run into administrative and scheduling conflicts in technology programs due to high teaching loads and time limitations on the part of faculty, as well as, on the part of those from the industry who are asked to participate. Time constraints on the part of the students employed part-time or full time in industry is also a handicap. Also, due to varying class sizes, such capstone courses are sometimes not made available at all when the class size falls below a cutoff limit.

My solution to this problem was based on the premise that building of knowledge, rather than just conveyance of information should be the basis of educational undertakings with the understanding that "knowledge" is what results from use of "information" for a particular application.

Projects

The method employed for the design of these projects was based on cognitive stimulation through problem solving (in terms of analysis and design) that will be undertaken by the student in each stage of the a big project. All the technical competencies that will most likely be expected of the students in their future careers are listed and the problem design will be tailored to address these competencies.

Within the context of having students work on projects similar to the ones that they will be faced with in their careers and build knowledge by applying information towards a particular application, I designed three wide-scale, industry oriented, professional projects for classroom use. The courses involved for this undertaking were:

1. ART 284 - Mechanical Systems in Buildings
2. CNT 330 - Construction Field Operations
3. CET 430 - Foundation Systems

ART 284 - Mechanical Systems in Buildings course: For this course students were given a floor plan for a single-story wood-frame-construction house on crawl space and all the relevant information in terms of locality, door and window schedules, external wall cross-section data including insulation values, and plumbing fixtures information . Students are asked to:

- Calculate the heating and cooling loads
- Determine the amount of heating and cooling energy use and cost for diverse fuel types
- Check for possible condensation problems and insulation provisions
- Change the orientation of the house and recalculate heating/cooling loads to see the variations

- Design a solar system for 50 % of the heating load
- Design the potable water supply and size the pipes, the meter, etc.
- Design gutters, downspouts, etc for rainfall drainage
- Find the total cost of insulation
- Write a report on how they would go about decreasing the heating load to a prescribed level, what kind of options they would consider to do this and in which order, how much of a marginal cost each option would bring, and what the payback periods will be for the different kinds of options and fuel types.

CNT 330 Construction Field Operations course**:** For this course the project involves the construction of an impervious core earth-fill dam for which the soils to be used for the body of the dam will be obtained from borrow pits and transported to the site for compaction.

Students were given the cross-section for an impervious core earth fill dam and asked to consider the following construction operations and the determine the corresponding equipment requirements:

- Clearing of land from trees and vegetation - determining bulldozer requirements
- Excavation of topsoil at the construction site - determining bulldozer requirements
- Loading of excavated topsoil - determining wheel loader requirements
- Hauling of excavated topsoil - truck fleet design
- Borrow soil amount determination for the impervious core (I.C)
- Power shovel (excavator) fleet design for borrow pit excavation (I.C)
- Truck fleet design for hauling of impervious core soil from borrow pit to construction site
- Sheep's foot roller requirements for compaction of the impervious core for the dam
- Tractor fleet design for pulling sheep's foot rollers
- Calculation of combined cost of excavation and hauling for impervious core soil
- Borrow material need calculations for pervious upstream and downstream banks of the dam
- Scraper fleet design for pervious bank soil excavation and hauling at the borrow pit
- Evaluation of pusher tractor needs for scraper operations
- Pneumatic roller compaction equipment needs for pervious banks
- Tire pressure calculations for pneumatic rollers
- Dragline operations design for upstream and downstream channel rehabilitation
- Crane operations design for unloading penstock pipes
- Quarrying operations design for rip-rap stone production for linings
- Compressor requirements evaluation for quarrying operations
- Conveyor belt operations design for transportation of rip-rap stone
- Pumping operations design for water storage and diversion

CET 430 Foundation Systems course: For this course the project entails design of diverse foundation systems, such as individual footings, piles, caissons, mat foundations, as well as, some ancillary structures and roads, for a site housing several industrial storage tanks for crude oil. Students are given a full set of drawings and relevant data about the project and asked to do the following :

- Determination of number and depth of soil borings required
- Determination of technical soil data from boring results
- Design of Individual Footings for oil tanks

- Design of Mat Foundation on Ground for oil tanks
- Design of Mat Foundation supported by reinforced concrete piles
- Design of Mat Foundation supported by reinforced concrete caissons
- Design of reinforced concrete Cantilever Retaining Wall
- Design of Reinforced Earth retaining structure
- Trench Shoring design for piping trenches
- Slope Stability Analysis
- Settlement calculations for Individual Footings
- Analysis of Earthquake induced stresses on Mat foundation on ground
- Analysis of wind induced stresses in piles for Mat foundation on piles
- Analysis of service road compaction parameters

Method of Implementation

The projects described are implemented collaboratively by having students work on these projects in teams. The idea is not only to have students work on simplified professional projects but also work on them in the manner they will be working on such projects in real practice.

Method of Evaluation

The above described undertaking is being evaluated in two stages, *formative and summative*. In the formative evaluation, the evaluation in the short run, student response to the undertaking is being assessed by means of a questionnaire combined with informal input from students. This input will be used for enhancing and possibly widening the scope of the projects. For the summative evaluation, the evaluation in the long run, students who have been through the courses employing such projects will be contacted at several points in their career to obtain their opinion of the undertakings in retrospect.

Significance of and Expectations from the Undertaking

It is expected that this work will have a wide impact in view of the following considerations:

- The increasing demand by the community that there should be a measure of accountability on the part of the universities and what they teach that makes their graduates employable,
- Increasing emphasis being placed on assessment of competencies gained by students of diverse programs and establishment of planning and improvement guidelines for enhancement of programs
- having students work collaboratively in teams and thus be able to reap the benefits of "collaborative learning" which is being touted increasingly as the way to enhance learning efficiency.
- In the long run, the foundations for a capstone course are laid, which can be gradually built should a sincere need develop and should an environment under which such a course can be offered flourish.
- The proposed approach inherently elevates the learning process to an experiential platform that typically stimulates cognitive skills and hands-on learning much more than other approaches that simply rely on conveyance of information and dry reading.
- It is also envisioned that the project materials that will be used and inevitably improved over time can be used for "custom publishing" of some parts of a practice-oriented textbook as is now the case for some of the engineering and technology texts.

- Perhaps the most significant aspect of the proposed projects is their infinite flexibility in addressing different learning requirements of the students through its inherent suitability for continuous improvement by the faculty member to incorporate future concepts and skills as the demands of the workplace and the nature of the technology changes.

Conclusions

Formative evaluation results obtained so far indicates that students are very positively motivated by projects which put what they have learned in a course into as real a perspective as possible. Students spend more time on these projects than they do for exams and other work but do not complain. There is always an ongoing dialogue between the students themselves and between the faculty member and the students in relation to the projects which enhances the learning environment. My own opinion is that project-based learning should be given serious consideration by all who want to use it as a tool for the design of a productive learning environment.

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