Hands-On, Project-Based Education in the Classroom to Solve a Real-World Problem

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Abstract

Majority of engineering courses stresses more on theory and very little on hands-on, project-based learning in the classroom. Integration of real-world engineering problems and applications in the course will generate engineers, who will be technically sound and be able to execute and manage real-world projects, when they join the workforce. The companies will get employees who will take less time to acclimatize themselves in real-world problem-solving situations. This paper discusses components of a graduate-level engineering course taught at the University of New Orleans, in which the students are required to participate and complete a class-project based on real engineering tools and concepts used regularly in the industry. The paper demonstrates the benefits of integrating hands-on, project-based learning in the classroom and provides examples of how students can get involved with data acquisition and analyses from a real world project.

Introduction

The majority of the engineering education is largely focused on the theory behind engineering concepts. Classroom-engineering courses tend to place more emphasis on theory, with limited integration of real-world engineering problems and applications. However, engineering or application of engineering concepts, is more than a compilation of theories. While it is important to understand the engineering theory, it is equally vital to connect the theory with practical, hands-on education. A significant portion of engineering education can be learned from field experience and exposure to real-world projects. The idea of hands-on engineering education allows students to apply the theoretical knowledge they have learned in a practical, real-world setting. Students comprehend more if they can apply the theory to a real-world project during the regular course offering.

Employers, on the other hand, look for entry-level engineers who are technically sound and possess a variety of professional and interpersonal skills, so they can work effectively as part of a team to execute and manage real-world projects, communicate well, and understand the economic, social, and political aspects of their professional activities.

Engineers need these skills to maximize their importance and value in society and to fulfill society's expectations of engineers. These professional expectations complicate engineering education in universities worldwide. Lack of appropriate practical skill acquisition in engineering education is a topic of debate and concern in academia and industry. The hands-on, project-based engineering education gives students the much needed confidence going into the professional work environment.

The following sections describe components of a graduate level course offered at the University of New Orleans (UNO). Examples of how hands-on, project-based engineering education is incorporated in the course will be discussed. Benefits of incorporating real-world project in the course curriculum will also be summarized.

Hands-on, Project-Based Engineering Education

The engineering education system is constantly growing and evolving and the value of hands-on, project based education for engineering students is becoming more critical. A new graduate-level course titled *Testing and Monitoring during Geotechnical Construction* is currently being offered at the University of New Orleans during the spring semester of 2014. The course covers several aspects of engineering construction, such as (i) review of field and laboratory exploration processes, (ii) in-situ soil testing, (iii) geophysical testing, (iv) testing and monitoring of shallow and deep foundation elements, (v) construction vibration monitoring, (vi) geo-environmental testing, and (vii) instrumentation for geotechnical design and construction.

In addition to homework assignments, examinations, and class quizzes, the students are required to participate in, and complete, a class-project by applying the theory learned in the course, to a real-world engineering project located in southeast Louisiana. Each student in the class works with, and under the supervision, of a professional mentor, who assists them in data collection, and guides them with the data analyses and project evaluation. Based on the components of the course, each student was assigned a different project scope and list of deliverables.

Class Project Selection Criteria

For each student, components of the class project were selected by the course instructor based on the following criteria:

- The student should be able to complete the project from start to finish within 4 months.
- Components of each project should match the theory covered in the classroom.
- The project should have multiple non-technical components (verbal and written communication with mentors, report writing, oral presentation, working with other individuals etc.)
- The project scope should include pre-defined deliverables (proposal, field visit, report, PowerPoint presentation etc.)

- The project will require the students to study additional material beyond what is covered in the classroom lecture.
- The project should include critical-thinking components that will challenge the student to apply engineering theory.

Responsibilities of the Course Instructor

The successful completion of the project-based class project will depend on the involvement of the course instructor from start to finish. The following section indicates some responsibilities of the instructor:

- The instructor is responsible for preparing a clearly defined class project outline for each student.
- The instructor is responsible for finding willing and competent professional mentors for the students.
- The submission deadlines and deliverables from each task of the project should be clearly defined by the instructor.
- The students should be treated as industry peers for the purpose of the real-world, hands-on course.
- The inductor should also keep track of the progress of the student's projects.

Responsibilities and Expectations of the Students

Each student is ultimately responsible for the successful completion of the class project. The following section indicates some responsibilities and desired expectations of the student:

- The students should treat industry mentors with respect
- The students should act in a professional manner with industry mentors
- The students should always communicate in a professional manner (oral and written, email, memo, etc.). The communication between the industry mentor and student is expected to mimic the communication between a senior project engineer and his staff engineer in an industry setting.
- The students are expected to plan and organize meeting times and site visit times with the professional mentors
- The students should manage the class project efficiently such that all deadlines are met.

Components of the Class Project

The objective of the class project is to mimic a real-world engineering project execution from start to finish. Before the start of the semester, the course instructor had discussed the real-world project with all the professional mentors. During the first week of class, the students are expected to contact the mentors and arrange for a meeting to gather information about the proposed project. With assistance from the mentors, the students will perform field visits, gather data from the field or laboratory, and perform analyses of

the data. The students will be required to present project progress reports two (2) times during the course. This will also provide an opportunity for each student to learn from other's projects. During these presentations, the student will summarize what project components have been accomplished thus far, and what is the plan for future tasks. Towards the end of the semester, the students will prepare an engineering report to compile all the information together. This report should be prepared professionally with assistance from the professional mentor and should mimic one prepared by a real-world engineer. The idea of hands-on, project-based learning is for the students to have exposure to a real-world project and gain practical experience and advising from an industry mentor. The industry mentor will act as senior engineer of the company and the student is the project engineer, guiding the student from start to finish.

Example of a Class Project

For the course, each student is assigned a real-world engineering project located in southeast Louisiana. One of the projects involves the use of Ground Penetrating Radar (GPR) to locate buried underground utility lines within portions of the New Orleans City Park. The professional mentor for this class project was hired by the City Park to perform this task. This real-life project was selected for the class after consultation between the course instructor and the professional mentor. A site vicinity map showing the project area is given in Figure 1.

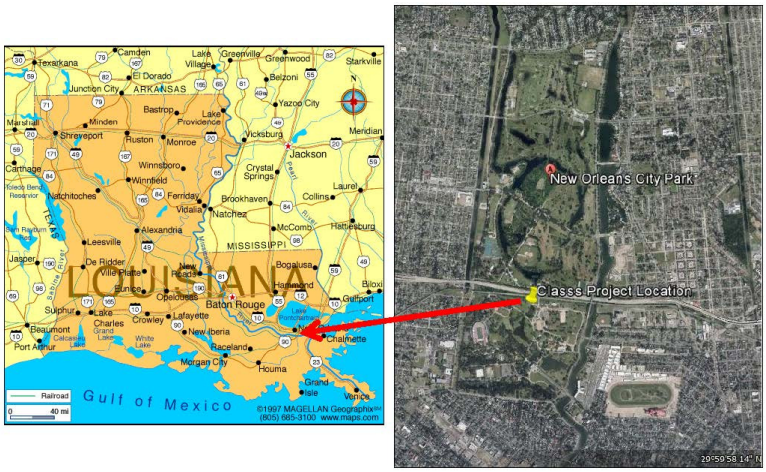

Figure 1: Site vicinity map for class project

The theory behind operations of GPR was discussed in the class. The class project will allow the student with an opportunity to apply the theory learned in the class to a real-world project. Towards the beginning of the semester, the student contacted the professional mentor and operator of the GPR unit to discuss the scope and significance of using the equipment for this project. The student was successful in gathering project information from the mentor and also to learn about the operating principles of the GPR

unit. The student had to perform additional research to gather more information about the GPR unit. The student was also able to accompany the field crew to the project site. Figure 2, taken by the student, shows the GPR unit being used at the City Park project site to locate buried utility lines.

Figure 2: Student witness field operation at New Orleans City Park

The student is currently working with the professional mentor to analyze the data obtained during field explorations at the New Orleans City Park project. Once the data is analyzed, the student will write a report documenting every aspect of the project. This will include (i) project information, (ii) project objectives, (iii) field procedures, (iv) analysis of data, (v) interpretation of the data, and (vi) recommendations submitted to the client. This report will be prepared by the student in discussion with the professional mentor. The student will also prepare a PowerPoint presentation and deliver the findings of the project to the entire class. The professional mentor of the student will be invited during this presentation. The student will be evaluated by the course instructor, the professional mentors, and classmates.

Assessment of the Class Project

The value of project-based learning in engineering curriculum is substantial. It allows students to observe real-world projects and also receive critiques from the instructor and industry mentor. The assessment gives students the opportunity to improve their skills that are required in the class project. The success of the class-project should be evaluated by the instructor from input given by the students and industry mentors. Students will greatly benefit from not only observing and critiquing their own projects, but also of their peers. The assessment will provide opportunity to gather ideas for future class projects

and ways to improve the contents of the class project. The following questions will be used to assess the graduate class taught at UNO in Spring 2014.

- How would you rate the class-project?
- Indicate some positive features of the class project.
- Indicate Areas of Improvement for the class-project for future semesters.
- Provide improvement suggestions for the Instructor related to the class-project.
- Provide improvement suggestions for the Professional mentors of the class-project.
- Provide improvement suggestions for students as they relate to the class project
- To improve the quality of the class-project, how would you approach it differently as a professional mentor in the future?

Benefits of Project-based Learning in Engineering Education

The benefits of the hands-on, real-world engineering education are not just applicable to the students, but also to the industry mentors, faculty, and university. While the emphasis is on the engineering students, this form of education opens up opportunities for improvement and benefit within the educational structure of engineering and possibly in the industry. The project-based graduate-level course being offered at the University of New Orleans generates the following benefits for students, professional mentors, and the course instructor:

- *Benefits to the Students:*
  1. Students are able to apply classroom theory to analyze and evaluate a real-world engineering project
  2. Students learn about (a) the importance of interpersonal communication skills, (b) benefits of working in a team, (c) how work environment will be after they graduate and join a company, (d) and proper time management.
  3. Students learn about valuable professional and life experiences from experienced professional mentors
  4. Students learn about effective presentation skills (written and verbal)
  5. Students get the opportunity to network with industry peers for future job opportunities

- *Benefits to the Professional Mentors:*
  1. The professional mentors make important connection with potential interns/part-time employees
  2. The professional mentors enjoy interacting with future-generation engineers and giving back to their profession.

- *Benefits to Faculty and University:*
  1. Faculty is able to make contact with key players of the local industry
  2. This interaction can lead to collaboration opportunities with professional mentors on research activities and journal publications

3. Feedback from professional mentors can help the faculty improve the course content for future semesters

Summary and Conclusions

Majority of engineering courses stresses more on theory and very little on hands-on, project-based learning in the classroom. Integration of real-world engineering problems and applications in the course will generate engineers, who will be technically sound and be able to execute and manage real-world projects, when they join the workforce. It will expose engineering students to the entire process of project execution, which is sometimes difficult to cover in a traditional course lecture. With the field and industry exposure, students are better prepared before entering the workforce. The real-world, hands-on education, not only benefits the student, but also the industry mentors and the university. Students can apply classroom theory to analyze and evaluate a real-world engineering project. Through this unique experience, they learn the importance of interpersonal communication skills and proper time management. The professional mentors enjoy interacting with future-generation engineers and giving back to their profession, while making important connection with potential interns/part-time employees. The university faculty makes crucial connection with local industry leaders, who can help the faculty improve the course content for future semesters. This interaction can lead to collaboration opportunities with professional mentors on research activities and journal publications

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