Seamless Integration of the Undergraduate Engineering Geology and an Introductory Geotechnical Engineering Courses

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Abstract

The engineering geology course, offered by the Geology Department, and the introduction to geotechnical engineering course, offered by the Civil Engineering Department, have been integrated, via “real-life,” project-based learning (PBL) concept. The seamless integration has made the engineering geology course more applied and, thus, has enabled the students to better understand the important role of geology in geotechnical engineering projects. Furthermore, the PBL approach has been a venue to introduce more design concepts in the geotechnical engineering course.

Background

Civil engineering by and large entails the conception, analysis, design, operation, and maintenance of wide variety of structures, facilities, and systems – which are built on, in, or with soil or rock (Mitchell, 2005). Accordingly, the success, economy, and safety of virtually all civil engineering projects depend, for the most part, on characteristics of the soil or rock involved at the locale. Furthermore, civil engineers deal with environmental control comprising water resources and water pollution control, waste disposal and containment, and the mitigation of natural hazards including earthquakes, floods, landslides, and volcanoes. The soil plays a major role in its interaction with the environment (Mitchell, 2005).

The successful solution of any soil related problem, stated above, requires knowledge, understanding, and appreciation of the importance of geology, materials science and testing, and mechanics. Geotechnical engineering is the subdiscipline within civil engineering that deals with all of these. Geotechnical engineering is the point where civil engineering and engineering geology meet. Environmental concerns within geotechnical work, especially those related to groundwater and the safe disposal and containment of wastes, are characterized as geoenvironmental engineering. In addition to the geological sciences, chemistry and biological sciences are also important in the geoenvironmental engineering (Mitchell, 2005).

The historical record concerning the use of soil as construction material is lost in antiquity (Day, 2000). For years, the application of soil in construction practices was largely based on past
experiences, by trial and error process. The leaning Tower of Pisa is a classical example of this era. The publication of Erdbaumechanik by Karl Terzaghi gave birth to modern soil mechanics in 1925 (Terzaghi, 1925). Shortly thereafter, the principles of soil mechanics were introduced in civil engineering curricula. Historically, civil engineering students have been required to take a soil mechanics course during their junior year. Typically, the engineering geology course has been a prerequisite for the soil mechanics course. As a matter of fact, soil mechanics has been the venue for bringing civil engineering and geology closer together. Considering the inherent variability of soil deposits, however, to study the latter (soil mechanics) and to ignore the former (engineering geology) is unrealistic in the extreme (Peck, 1941). Ordinarily, in a given situation, a handful of borings are advanced at the job site to obtain soil samples for testing and engineering evaluation. Without the knowledge and appreciation of geology, the extrapolation of limited field data and accruing results may be erroneous and misleading.

In recent years, civil and environmental engineering curricula have been the subject of continual revisions to meet the demands of global challenges (Einstein, 2002). The new paradigm has been to integrate more design in the undergraduate curricula. Among the several design integration models proposed by various National Science Foundation (NSF) Coalitions, the “Sooner City – Design Across the Curriculum” model has been one of the most effective ones implemented in the civil engineering curriculum (Kolar, et al, 2000). According to the Sooner City pedagogy, a comprehensive design project is integrated throughout the undergraduate civil engineering curriculum, commencing in the freshman year and extending through the senior year. Unlike other reform efforts, the Sooner City model does not focus only on the freshman design conceptualization or senior capstone design course. It helps integrate courses across disciplines and throughout the entire curriculum. Similarly, the principal objective of the current initiative is to integrate the basic engineering geology and the introductory geotechnical engineering courses via a ‘real-life’ design project. It is anticipated that the proposed seamless integration will serve as a model for other courses within civil engineering – eventually weaving all the relevant courses together via a comprehensive design project.

Implementation

In the past, the traditional introductory soil mechanics course and the engineering geology course at our institution have been taught independently, with limited interaction between the respective faculty members in designated programs. The guiding principle of the current project, made possible through an education grant, was to enhance the collaboration, and thus, the instructional quality of the aforementioned courses via a ‘real-life’ design project. In addition, one or more resident engineer(s) would be involved in selection and implementation of the actual design project, thus providing ample opportunities for students to interact with industry professionals.

Traditional teaching styles consist of lectures on technical concepts, allowing little or no discussion, individual homework on simplified problems, and problem-solving exams (Kolar, 2000). Another feature of the aforementioned seamless integration was to promote interactive learning environment. In such environment, students could contribute in a dynamic, team-oriented approach; realize the unified nature of the civil engineering and non-engineering curricula. Furthermore, they would be solving open-ended problems, possess advanced critical thinking skills, and communicate more effectively. Furthermore, the preceding enhancement would provide an ideal venue for other popular educational initiatives such as “just-in-time”
learning, collaborative learning, retention, and hands-on laboratories. The ABET (Accreditation Board of Engineering and Technology) criteria concerning the emphasis on design and outcome-based assessment would be the integral part of this endeavor.

Through an internal education grant, the two respective faculty members responsible for teaching the engineering geology and geotechnical engineering courses received assigned times to attend each other’s classes for the entire semester. The engineering geology course was offered during the fall semester while the geotechnical engineering course was offered in spring. Following this opportunity, the designated faculty members collaborated to integrate both courses via a “real-life” design project. Subsequently, they teamed with a local geotechnical engineer to identify an appropriate (located nearby campus) project. During the summer, prior to the offering of next group of engineering geology and geotechnical engineering courses, the subsurface investigation and foundation design of a proposed four-story building was identified to serve as the “real-life” project to integrate the aforementioned courses. Accordingly, the preliminary information was obtained in preparation for the syllabi and framework of the year-long project.

The actual project was introduced in the engineering geology course, at the beginning of fall semester, through a series of guest speakers and a site visit. The speaker series included the architect, project manager, and the resident geotechnical engineer for the identified project. As the course lectures continued throughout the semester, covering the fundamentals of engineering geology, the project site remained at the core of all discussions. For example, the geologic cycle was described in details and it was elaborated how the soil at the project site was derived through weathering processes. In the revised course redesign, the subsurface investigation and characterization had become an integral part of the engineering geology course. As a result, soil-sampling techniques were explained and students were guided to collect soil samples from the project site. Subsequently, students conducted all the required laboratory experiments to classify the soil at hand. The experiments involved sample preparation, specific gravity determination, grain size distribution analysis, and the liquid and plastic limits of soil to enable them to classify the soil based on both AASHTO and Unified soil classification systems.

Our traditional introductory soil mechanics course was transformed into an introduction to geotechnical engineering course. Offered in spring semester, sequel to the engineering geology course, the newly revised geotechnical engineering course and the accompanying laboratory sections were again revolved around the preceding real-life design project. With the geology related topics and subsurface investigation discussions covered in the previous course, it was now possible to cover additional topics in relation to foundation design. Nearly one-third of the laboratory experiments had already been completed in the engineering geology course for soil classification purposes, thus, allowing extra time to focus on the design project. The remaining laboratory experiments including soil compaction, permeability, direct shear, consolidation, unconfined compression, and traixial compression tests were all conducted on the same soil samples collected from the project site. The resident geotechnical engineer made several presentations and participated in Q/A about the project site throughout the semester. Student groups prepared individual geotechnical reports and made recommendations regarding the allowable bearing capacity, compaction specifications, and types and proportions of foundations. The geotechnical report for the project, prepared by the resident geotechnical engineer was made available to students at the end of the semester for comparison and further discussion.
Results of Various Surveys

One of the surveys included the following questionnaire that was distributed to all civil engineering chairs/heads via the ASCE’s (American Society of Civil Engineers’) listserve. Approximately, 19% responses (50 out of 261) were received. The questions and corresponding results are summarized below.

1. **What are the required and elective geotechnical courses you offer in your department?**
   Of the 50 respondents 30 (60%) only require one introductory (either soil mechanics or geotechnical engineering) course; 18 (36%) require both introductory and a foundation design (or equivalent: geotechnical design) course; for one program, geotechnical related courses are optional; and one of the programs is unclear how many geotechnical related courses are required and/or electives.

2. **Is engineering geology (or general geology) a pre-requisite for your geotechnical courses?** Geology is a required course for 6 of the 50 responses.

3. **If engineering (or general) geology is not a pre-requisite for your geotechnical courses, do you introduce the geology topics in your introductory geotechnical course and to what extent?** From 50 responses received: 15 no’s (or not applicable, if they require geology), 6 no responses, and the remainder (29) yes.

4. **What is your recommendation - should engineering geology be a pre-requisite for geotechnical courses?** From 50 responses: 16 definite yes, 34 either no or “depends.”

5. **Any other comments?** Following are relevant comments: geology is one of several science courses students can take to fulfill ABET’s requirement, difficult to offer a geology course without having a geology department, geology is an elective, engineering geology recommended for students specializing in geotechnical engineering, and some program would rather have students take an undergraduate nanotechnology course instead of geology if it was not for the ABET’s requirement of a “basic science.”

The second set of surveys was conducted in the engineering geology/introductory geotechnical engineering courses. A copy of the questionnaire is enclosed in the appendix. There were 38 students in one class and 39 in the second one. Out of all enrolled, 28 responded in the first one and 33 students in the second one. On the scale of 1 (strongly disagree) to 5 (strongly agree), the average response (with a standard deviation of 0.7) was 3, which is neutral. In a nutshell, students’ remarks reveal that the first course, engineering geology, had become more applied and interesting from civil engineering students’ perspective. They had a much better appreciation for the important role of engineering geology in geotechnical engineering. In addition, the “real-life” project enhanced students’ team-work and communication skills.

Conclusions

The seamless integration of the engineering geology and geotechnical engineering courses via a “real-life” design project has proven to be very beneficial in many different ways. The site investigation of a multistory building, conducted in the engineering geology course, has made the engineering geology more interesting and relevant to the civil engineering curriculum in general, and geotechnical engineering courses, in particular. The experiential learning related to
the subsurface characterization, sampling, and soil classifications have been invaluable for students enrolled in the sequence. Students are better prepared for the subsequent geotechnical engineering course, having had an applied engineering geology background. Since a significant part of the material that used to be discussed in the front end of geotechnical engineering course is now introduced in engineering geology (including several laboratory experiments), more time is allotted to foundation and retaining structure design of the identified real-life project. Furthermore, the intimate interaction of students with resident geotechnical engineer of record for the project at hand is very useful. Other features of this endeavor entail developing team-building and communication skills, geotechnical report preparation, and professional ethics, and yearning for life-long learning. Although the two courses are housed in two separate departments/colleges and taught by two different faculty members, the PBL has made the integration seamless.

References


Assessment of GEO 218 – CEE 312 Integration

As you know, the Geology and Civil Engineering Departments are collaborating to enhance integration between engineering geology and geotechnical engineering by incorporating a “real-life” design project that will span two semesters. Among other things, the integration is intended to enable implementation of applied geology related to design of foundations and earth structures and will provide opportunities for interacting with professional engineers.

We would greatly appreciate your candid response to the following questionnaire to gauge our progress toward implementing this plan. Please note that this is an evolutionary process, and the present evaluation is intended to serve as a benchmark on the path toward eventual seamless integration of the two courses.

Please indicate your agreement or disagreement with the following statements:

1) At the completion of this course I feel well-prepared to continue on to CEE 312.
   Strongly Agree    Agree    Neutral    Disagree    Strongly Disagree    Not Applicable
2) Having completed this course, I now have a good understanding of the relationship between geology and geotechnical engineering.
   Strongly Agree    Agree    Neutral    Disagree    Strongly Disagree    Not Applicable
3) The integrative project (i.e., the soils classification project that we completed as a prelude to the CEE 312) improved my understanding of the significance of subsurface investigation in the design of foundations and earth structures.
   Strongly Agree    Agree    Neutral    Disagree    Strongly Disagree    Not Applicable
4) Bringing practicing engineers (such as Mark Carlson) into class to discuss real-life case studies enhances my understanding of how geology relates to the practice of geotechnical engineering.
   Strongly Agree    Agree    Neutral    Disagree    Strongly Disagree    Not Applicable
5) The integrative project enhanced my familiarity with the basic laboratory procedures used in soil characterization for foundation design.
   Strongly Agree    Agree    Neutral    Disagree    Strongly Disagree    Not Applicable
6) The integrative project enhanced my teamwork skills.
   Strongly Agree    Agree    Neutral    Disagree    Strongly Disagree    Not Applicable
7) The integrative project improved my ability to interpret and create professional reports.
   Strongly Agree    Agree    Neutral    Disagree    Strongly Disagree    Not Applicable
8) The integrative project improved my communication skills.
   Strongly Agree    Agree    Neutral    Disagree    Strongly Disagree    Not Applicable
9) The integrative project provides a valuable ‘real-life’ perspective.
   Strongly Agree    Agree    Neutral    Disagree    Strongly Disagree    Not Applicable
10) I believe the implementation of an integrated, ‘real-life’ project between GEO218 and CEE312 enhances both the pedagogy and content of the geotechnical engineering program at the University of Dayton.
    Strongly Agree    Agree    Neutral    Disagree    Strongly Disagree    Not Applicable
11) In the space below please share your comments, insights, or suggestions for instituting the integration of GEO218 and CEE 312
Biographical Information

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