Evaluation of teaching a two course sequence in geotechnical engineering in an integrated lecture – lab environment

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ABSTRACT
Civil Engineering majors at Florida Gulf Coast University (FGCU) are required to take a two-course sequence in Geotechnical Engineering as a part of their degree. Both courses utilize the integrated lecture – lab environment typical at FGCU, which means that for a traditional three-credit course, class will meet twice a week for 2 hours each time. This paper will provide details on course logistics, evaluate various course activities, assess student performance, and offer student and instructor thoughts on learning in the integrated lecture – lab environment.

PRESENTACIONES TECNICAS
Estudiantes de Carreras de Ingeniería Civil de la Florida Gulf Coast University (FGCU) están obligados a tomar una secuencia de dos cursos en Ingeniería del Terreno, como parte de sus estudios. Ambos cursos utilizan la conferencia integrada con el trabajo de laboratorio típico de FGCU, lo que significa que para un curso tradicional de tres créditos, la clase se reunirá dos veces por semana durante 2 horas cada vez. En este documento se proporcionan detalles sobre la logística del curso, que consiste en evaluar las diversas actividades, evaluar el desempeño estudiantil, y los pensamientos estudiante e instructor ofrecidos en el aprendizaje en la conferencia – integrada con el trabajo de laboratorio.

1 INTRODUCTION

As a requirement for graduation, Civil Engineering majors at Florida Gulf Coast University (FGCU) must take two courses in Geotechnical Engineering. The first course is a junior level course offered in the spring semester and focused on an introduction to basic principles of soil mechanics. Emphasis in the first course is on the development of a firm foundation of key concepts and learning is reinforced through homework, projects, and exams, heavily augmented with in-class and laboratory activities. The second is a senior level course offered in the fall semester and focused on analysis and design of retaining walls, slope stability, and shallow and deep foundations. Emphasis is on the application of key concepts; and individual and larger group projects, as well as the use of finite element software reinforce learning.

The majority of the engineering courses at FGCU were created to occur in an integrated lecture – lab environment. This integrated lecture – lab means that for a traditional three-credit course, class will meet twice a week for 2 hours each time. In contrast to the more established 50-minute lecture and separate lab period, all class meetings occur with the instructor and no separate lab is conducted. Combining lecture and lab allows for an immediate correlation between the lab activities and the theory and concepts presented in lecture, as well as time for collaborative discussions of course topics or more continuous development of design processes. Additionally the course is offered in a classroom modeled after the student centered active learning environment for undergraduate programs (SCALE-UP) which research has shown to be an effective means of increasing student engagement in Physics and Chemistry (Beichner et al, 2000, Oliver-Hoyo and Beichner, 2004, Beichner, 2008).

This paper will provide details on course logistics, evaluate various course activities, assess student performance, and offer instructor thoughts on learning in the integrated lecture – lab environment. Included will be personal reflections of the author's experience with teaching the first of these two courses (both lecture and laboratory components) in a more traditional environment compared to the environment introduced in the paper. A summary of the activities that have been found to be the most effective in engaging students and increasing student learning will be highlighted at the conclusion of the paper.

2 EDUCATIONAL ATMOSPHERE

Florida Gulf Coast University is a comprehensive regional university and a member of the State University System of Florida. FGCU admitted its first student in 1997 and graduated 81 students in the first class in 1998. Today the university enrolls over 10,000 students and offers undergraduate degrees in over 50 areas of study and graduate degrees or certifications in 30 different areas.

2.1 Growth of the Engineering Programs

The U.A. Whitaker School of Engineering (WSOE) opened its doors to the first class of freshman in three engineering disciplines (Bioengineering, Civil, and Environmental) in the fall of 2005. In 2008 the school expanded to include Computer Science (formerly housed in the College of Business) which will transition to Software Engineering in the 2011 – 2012 academic year.

Spring of 2009 witnessed the graduation of the charter class in all three engineering disciplines and the move into the newly completed Holmes Hall. Student enrollment has risen from the first group of 88 pioneers in 2005 to over 600 students (including Computer Science) in the spring of 2011. All three engineering programs have attained accreditation by the Engineering Accreditation Commission of ABET (ABET, 2010) and additional programs at the undergraduate and programs at the Master's level are currently being investigated.

2.2 Physical Space – Classrooms that are Labs

Holmes Hall, occupied for the first time in the spring of 2009, is a 6500 m^2 (70,000 ft^2) building dedicated to the engineering and computer science programs with classrooms designed to foster the integrated lecture – lab format. As a new school at a young university, the WSOE had the ability to create the physical space best-suited for the integrated lecture – lab environment (Blanchard, et. al., 2010). Key features include hexagonal tables designed to optimize team activities, extensive white boards, dual projectors linked to the instructor work station, and a suite of lecture, prep, and lab rooms that are reserved in tandem for all courses. Figure 1 illustrates a typical lecture classroom in the engineering building and was taken from the viewpoint of one of the back entry doors. The room is designed to have a maximum of 48 students (6 students at each of 8 tables). When looking at Figure 1 it is possible to see a majority of the first row of tables, however most of the back row is not in view. The instructor podium is situated in the front center of the room and visible in the center of the photograph. The front wall of white boards is visible, and runs a length of approximately 6 meters (18 feet).

Figure 1. Representative lecture classroom in Holmes Hall at FGCU

A second viewpoint of the classroom is presented in Figure 2. This view is taken from the centerline of the room and shows slightly more than half of the room. Both figures show a few of the numerous portable white boards placed around the rooms to allow students to actively engaged in assigned board work during the class. The majority of these rolling boards are in the back of the classroom, which effectively creates a room that has writing surfaces available on all walls.

Figure 2. View along Centerline of Lecture Classroom

Also seen in Figure 2 is one of the ceiling mounted projectors and associated screens. The second faces the opposite wall. The projectors feed from either the classroom computer, document camera, or an attached personal laptop. The instructor can choose to project the same image to both screens, or different devices to each of the projectors. The safety shower in the left of the figure is one of two in the classroom, while the door to the right leads to the prep storage room which divides the lecture classroom from the laboratory classroom. The back wall (not visible in either figure) has countertops that run the entire length with ample storage below as well as overhead cabinets interspersed with windows to allow natural light. Lighting for the rooms can be adjusted to be at eight different levels including various percentages of the total light as well as dimming whichever side one might be projecting to at that time. These adjustments can be made at three different points in the classroom.

Figure 3 presents the laboratory classroom accessible either through the prep storage room or main hallway. While most of the lecture classrooms are similar, laboratory classrooms differ based upon the expected activities. Figure 3 is an illustration of the laboratory classroom in the dry teaching suite. This set of rooms is used for classes such as Geotechnical Engineering, Mechanics of Materials, CE Materials, and Reinforced Concrete. Laboratory classrooms are designed for a maximum of 24 students rather than the 48 for the lecture classrooms. As with the lecture classrooms, the room contains an instructor podium with a computer, document camera, and wiring for laptop hook-up; all of which can feed to the overhead projector. For the laboratory classroom there is a single projector with the screen in the front center of the room.

Although the suite of rooms is reserved for each course, often times the class as a whole is in only the lecture or laboratory classroom, which allows instructors of other courses taught in the same suite the ability to access the prep storage room for equipment and laboratory preparation, or even the laboratory classroom for activity setup prior to the start of class. Scheduling conflicts are minimized due to the fact that the instructors for the courses are all within the same school and all faculty offices are located in the engineering building.

Figure 3. Laboratory Classroom for Dry Teaching Suite

3 GEOTECHNICAL ENGINEERING IN THE INTEGRATED LECTURE – LAB ENVIRONMENT

As one of the focus areas of the civil engineering program at FGCU, all CE majors are required to take both courses in the two-course geotechnical engineering sequence. Course focus and lab activities vary between the classes, but both employ aspects of the integrated SCALE-UP environment.

3.1 Geotechnical Engineering I Activities

Geotechnical Engineering I is the common introductory soil mechanics course with topic coverage including physical properties and classification of soils, compaction, one and two dimensional flow of water through soil, stress distribution from overburden and external loading, consolidation and settlement, and shear properties of soil.

The course also has a large laboratory component with many of the traditional soil characterization tests including specific gravity, sieve and hydrometer analysis, Atterberg limits, permeability, compaction, consolidation, and direct shear, as well as several other non-traditional "labs" including visual classification and microscopy (Kunberger, 2009) and finite element analysis of seepage problems. Because of the large number of labs (11 total), lab exercises comprise almost 30% of the overall course grade. Other assessment mechanisms in the course include exams, homework, quizzes, and in class activities.

As an indicator to students that the course utilizes the integrated lecture – lab environment, the first class introduces several of the concepts employed throughout the semester. Students enter the classroom to find models at each of the tables representing each of the different types of mineralogical sheets comprising clay minerals. They are asked to think about how this course relates to others they have taken and the significance of geotechnical engineering in a broader picture; then are asked to share with their table before contributing to the full class discussion. When the topic of specific gravity of soils is introduced, tables are asked to send a representative to the back of the room to collect the supplies needed to conduct an actual specific gravity test. Since all eight tables utilize the same soil, the lab activity is a perfect one for introducing not only lab in the classroom, but also the significance of precision and accuracy. The specific gravity topic is positioned towards the middle of the class and the lab provides a break from the lecture while still engaging students in relevant activities. The first day ends with an assignment to independently collect a sample of soil which will be utilized in several of the subsequent lab assignments.

Lessons without traditional lab components still seek to utilize the classroom arrangement. Students are asked to engage in "think-pair-share" activities, or asked to work in groups on sample problems. Since the overhead projectors can be cast onto the screen or the whiteboard itself, oftentimes the instructor will project a graph to the whiteboard and use it as a basis for discussion. For example, when methods for determining preconsolidation pressure from a consolidation curve are discussed, the instructor can present the steps then split the class in two, project a curve onto opposite white boards and assign each table a step in the process. What evolves is each table sending an individual to the board to complete their stage of the process and final results that can be compared and discussed with the entire class.

3.2 Geotechnical Engineering II Activities

As the second course in the sequence, Geotechnical Engineering II is heavier in design and synthesis of information. Primary topics covered are lateral earth pressure and retaining wall design, slope stability, and foundation design including settlement, bearing capacity and shear strength. Since the traditional soil characterization has been accomplished in the previous course, lab activities in the second course focus more on the students' ability to process, evaluate, critique and synthesize information.

The second half of every other class is devoted to what are called "roundtable" activities (Kunberger and O'Neill, 2010). This is a discussion forum that covers a different article every week. Students are required to read the articles outside of class and come prepared to discuss the significance of what they have read. The instructor poses questions as a starting point for discussion then acts as a facilitator for the group. Articles are historical as well as recent and cover everything from Peck's "Art and Science in Subsurface Engineering," (1962) to several articles on the history and restoration of Pisa's Leaning Tower, to articles on Karst formations that are of particular concern in the Florida region.

In addition to roundtable activities, students are challenged to become experts within some specific area related to geotechnical, geo-environmental or geological engineering through a semester specialization. These specializations require students to pursue knowledge outside of the classroom and gather information from several reliable sources to eventually integrate into a cohesive summary article by the conclusion of the course.

The extensive writing and discussion activities mentioned above are balanced with individual and group projects focused more heavily on design of specific geotechnical structures such as slopes, retaining walls, and shallow foundations. Several of these design concepts form the basis for lecture-long in-class activities – as the complexity of the theory behind many of these concepts is only fully realized when design calculations are performed.

For example, when slope stability is introduced, the instructor provides the general equations and variable descriptions for several of the methods of analysis (Swedish slip, Bishops, etc.) and then provides a scaled slope and allows the class to calculate the factor of safety for a particular failure plane. As the class progresses, the various steps are projected from the overhead to the white board– with the instructor completing slice divisions and example calculations and then allowing group work to continue. This work illustrates the time intensive nature of the analysis which transitions nicely into an introduction of software developed to optimize the process. The class period culminates with an outside project assignment to apply the program to determine the most critical slope and then correlate the computer analysis with the theory to justify use of the program. The activity reinforces the theory learned, familiarizes students with specialized software, and requires them to consciously elaborate upon limitations implicit in any software use.

4 INSTRUCTOR REFLECTIONS

Having taught a similar version of Geotechnical Engineering I (both the lecture and laboratory portions) at another university under the more traditional method, it is clear that each has its own strengths and weaknesses. One of the biggest weaknesses of the traditional format is the time lag between course coverage of topics and the associated laboratory activities. This time differential is eliminated in the integrated lecture – lab format as both are covered simultaneously. This also allows the instructor to build the lecture off of activities and lessons learned within the laboratory portion of the course, something that is more limited when lab activities are asynchronous and covered by several different individuals.

In contrast, the traditional separate lab allows ample time for the completion, or more extensive work on, laboratory activities. Also, at least in the author's experience, laboratory activities in the more traditional format are likely to be completed in fairly size-restricted groups. Past experience has these groups in the low teens for many labs and at no more than 25 for any lab activity. For the integrated lecture – lab format, the size of the lab class is dictated by the size of the lecture class. Although it is possible to split the group, this reduces the amount of time in the lecture portion – as the instructor would essentially be giving time off of class to allow for smaller lab groups. Current class sizes in the integrated environment have been in the mid-thirties, which approaches an ineffective number in the laboratory portion (at least for select activities). If the number rises to the 48 threshold it is likely to require a re-evaluation of the current activities.

Student acquisition of knowledge, from the author's perspective, is somewhat smoother in the integrated environment which can likely be attributed to the ties that can be made more seamlessly between lecture and lab concepts. Overall gains at the conclusion of the course are not noticeably different however, and no assessment has been made as to the impact of the different methods on a more long-term basis.

5 CONCLUSIONS

The two course sequence in Geotechnical Engineering at Florida Gulf Coast University is taught in the integrated lecture – lab environment. The two hour lessons twice a week are taught in a suite of rooms modeled on the SCALE-UP environment and focused on student centered hands-on learning activities. Hexagonal tables facilitates group discussions and combined with white boards surrounding the classroom lends itself to numerous in class assignments for experiential learning. The suite of rooms assures that the laboratory is only steps away from the lecture, providing for a seamless transition between the two.

While capitalizing on some of the benefits of the integrated environment is not possible in an existing building, many of the in class features, as well as the scheduling with revised blocks of time over the traditional lecture can be adjusted to any existing structure. The greatest limiting factor appears to be feasibility in larger classes – although a hybrid of the two could likely result in the incorporation of strengths from both with the reduction or elimination of specific weaknesses.

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