The Adoption of a Student Teaching-Based Instructional Method to Facilitate Graduate – Undergraduate Student Interaction

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Abstract

An instructional framework requiring students to teach in order to learn content has been adopted in an upper-level undergraduate/graduate Advanced Soil Mechanics course at the University of Oklahoma. The student teaching model (STM), geared towards student interpretation, synthesis, presentation, and discussion of content material, aims to improve student information processing skills, improve understanding of course content, and improve communication skills. This paper discusses the extension of the STM outside the boundaries of the classroom. Students in the Advanced Soil mechanics course were required to provide critical review and instruction to introductory level soil mechanics students. During a semester-long project carried out by the introductory level students, the upper level students provided written and oral critique of interim reports. The upper level students carried out face to face consultation sessions with the introductory level students, querying and providing project guidance. The upper level students were required to understand all facets of the project and teach unclear concepts to the introductory students when necessary. End of semester surveys revealed that both the upper level and introductory level students benefited from the exchange.

Introduction

The rapidly changing profession of engineering calls for the education of life-long learners, individuals who can adapt and thrive through change [1]. This call must be met with a balanced emphasis on process skill development (thinking, integration, discovery, communication) and product (knowledge) [2]. Engineering instructors understand very well the adage *one never really learns a subject until one teaches it*. The process of teaching and preparing to teach builds process skills, e.g., discovery, synthesis, communication, while strengthening knowledge development. Frustrated by the inability to reconcile the need for engineers who are adaptive thinkers, effective communicators, and life-long learners with the traditional lecture format, the authors developed the Student Teaching Model (STM) [3]. The STM creates a horizontal relationship between teacher and student rather than the vertical relationship that exists in the traditional lecture approach. An instructional framework that develops process and product skills in students by requiring them to teach and prepare to teach, the STM has been adopted over the past three years in an Advanced Soil Mechanics (ASM) course taught to graduate students and upper-level undergraduate students. The STM strives to foster student discovery, interpretation, internalization, synthesis, and presentation skills while strengthening knowledge.

The STM was recently extended outside the ASM classroom, as ASM students were required to provide critical review and instruction to introductory soil mechanics (ISM) students. The ASM students served as consultants/reviewers of an earth dam design project carried out by the ISM students. ISM student groups submitted interim and final reports to the ASM student consultants/reviewers. The ASM students in turn, prepared written critiques of the interim and final reports, and prepared for oral critique and discussion of design issues during face to face consultation with the ISM students. The ASM students were required to understand all facets of the project and be prepared to teach all concepts to the ISM students. This paper describes this extension of the STM and discusses the benefits, advantages, and disadvantages of such an approach.

Student Teaching Model

The STM is an instructional format that strives to build student interpretation, synthesis, presentation, and discussion by putting into practice the adage *one never really learns a subject until one teaches it*. While briefly described here, the reader is encouraged to seek a full description, complete with the cognitive underpinnings, elsewhere [3]. Each week during a semester course, students are required to prepare to teach and discuss four to six related issues within a general topic (the issues are assigned at least two weeks in advance). For example, within the general topic of clay soil properties in the ASM course, assigned issues might include the following: (1) Explain the difference in mineral composition between clay and sand; (2) Elaborate on the nature of, and the differences between types of clay minerals; and (3) Explain how the Atterberg limits relate to clay-water interaction and why they differ across clay types.

Students develop an understanding by seeking multiple references (e.g., textbooks, periodicals, internet) and are strongly encouraged to both collaborate with their peers and to consult the instructor for feedback and clarification during preparation. During class, students *teach* and *lead* discussions (by volunteering or selection) with their peers pertaining to one or more of the assigned issues. “Student teaching” involves communication and discussion of the principles and relevant examples to an educated audience of peers and the instructor. The classroom environment is designed to be informal and non-threatening. Student presentation and discussion in any effective manner is encouraged (e.g., seated, at a chalkboard or overhead). The presenter is encouraged to ask/entertain questions of/from their peers and to discuss difficulties encountered with their own understanding. Classmates, who also prepare to teach, are instructed to foster a discussion by offering their questions, personal interpretations, and additional examples.

The instructor’s role is one of facilitator and resource, guiding the dialogue and instruction in a positive direction. As facilitator, the instructor assumes a perceptive position, able to evaluate student comprehension, inject poignant questions, direct discussion, and provide clarification. Based on the instructor’s evaluation of classroom activity, he or she can create targeted mini-presentations, question-answer sessions, individual and group exercises, and design problems to further student comprehension and address problems that arise. Generally, the first 75-minute class of the week is dedicated to student teaching and discussion. Student teaching and discussion is continued during the second 75-minute session interspersed with mini-presentations and exercises. The authors surmise that the STM could be effectively adopted in many course formats.

The roots of the teaching adage and thus the foundation of the STM lies in cognitive psychology, a theoretical perspective focused on human thought, perception, memory, and problem solving. The cognitive paradigm emphasizes both process (i.e., how teaching and learning take place) and product (i.e., content), both of which must be nurtured in engineering students to meet the call for the education of life-long learners [1]. Three important cognitive principles upon which the STM focuses are: (1) depth of learning, (2) metacognition, or the thought process of an individual, and (3) social interaction (see [3] for a complete discussion of the cognitive underpinnings).

STM Application Outside the Course

The STM has been adopted for the past three years with great success in Advanced Soil Mechanics (ASM). During the most recent adoption, in addition to preparing to teach in the ASM classroom setting, the students were required to serve as client consultants/reviewers for an earth dam design being carried out by the introductory soil mechanics (ISM) students concurrently offered at the University of Oklahoma. The earth dam project was assigned to the ISM students during the 5^{th} week of the semester and continued until the 16^{th} and final week. Each ISM student group (4 to 5 participants per group) functioned as an engineering firm; the ISM instructor served as principal of each firm, disseminating tasks and vital information via discussions and memorandums. Each ISM team worked on the earth dam design for the client (the ASM instructor) and the client's engineers (ASM students). The ASM students carried out analysis related to the earth dam design during weeks prior to the ISM student activity.

Two meetings were held between the ISM and ASM students in a conference-room setting during weeks 10 and 16. At each one-half hour meeting, both the ASM and ISM instructors remained in the background to observe, critique student participation, move the discussion in a positive manner if necessary, and settle technical disputes. Prior to each meeting, ISM teams submitted reports summarizing their analyses and design recommendations. ASM students then rigorously reviewed the reports, preparing both written critiques and a list of questions for discussion. ASM students also prepared to teach the ISM students concepts that were incorrectly interpreted during design. There was significant activity by both ISM and ASM students prior to and after the official meetings.

The goals of the ASM-ISM meetings were: (1) to make ISM students more accountable by having them defend their design work in a simulated engineer-client environment, (2) to have the ASM students operate from "the other side of the table," (3) to have the ASM students critique reports and teach concepts to the ISM students, and (4) for both ISM and ASM students to communicate technically. The ISM and ASM students were motivated to do well due to peer pressure. The ISM and ASM students were also being evaluated by the instructors.

Results

Given the small ASM class size (eight students), assessment of the ASM-ISM interaction was limited to student survey response. From the response of seven students, the following points were discovered:

- When asked if serving as a consultant/reviewer enhanced their understanding of the geotechnical concepts involved, the seven ASM students responded yes.
- All students felt that serving as a consultant/reviewer helped them learn the material better than if it had been presented in a lecture-style format.
- Six of seven students felt the experience would help them to be a better practicing engineer. Reasons included: "it helped in gaining confidence while talking about soil mechanics," "provided more chances to communicate," "I know what to see in a report, what points I have to look for." One student was unsure in this regard.

The ASM students enjoyed the role of consultants/reviewer. Students echoed that they felt empowered and responsible in this position. ASM students also felt the content material was presented to them in a practical and interesting manner. Moreover, pride played a key role as the ASM students felt they had to be ready for all questions from the ISM students.

Of additional interest to the authors was the impact the interaction had on the ISM students. Approximately two thirds of the ISM students felt it was beneficial while one third felt is was not very helpful. During a project survey, 24 out of 45 students indicated the interaction was an excellent to very good experience as shown in Fig. 1(a). When asked *Did the meetings with Advanced Soil Mechanics students help you?*, 28 out of 43 responded much to very much as shown in Fig. 1(b). When asked *in what way* the meetings helped, positive ISM comments such as the following were made:

- "you really had to understand what you did to explain it to them"
- "filled the gaps, clarified problems"
- "helped us understand principles behind the concepts"
- "they let us know where we went wrong"
- "they gave us ideas that we should include"
- "gave us experience in project presentations"
- "experience in defending design"
- "it made our group realize our mistakes"
- "constructive criticism and suggestions"

Many similar positive comments were made. Fifteen of the 43 students felt that the meetings were not very helpful, six provided comments as follows:

- "meeting with the professor was more helpful"
- "unclear as to how to handle meetings, feel we could have gotten the same info from the professor"
- "too short on time"
- "we spoke only twice, more often would help"
- "they were too critical, not really helpful"
- "anyone who could've pointed out our flaws would have been helpful"

A further indication of the success of the ASM-ISM interaction was the participation of the students during the meetings. During each meeting the ISM instructor assigned a qualitative grade to each student by quantifying how much each student contributed to the meeting in terms of both the amount and quality of participation. The results shown in Fig. 2 suggest that approximately 85% and 70% of the class made a significant contribution during the first and second meeting, respectively. Reduced participation during the second meeting is attributed to timing; the final meeting was held during the last week of classes when the students are generally overwhelmed with work.

Given this was the first attempt to integrate the two classes via the STM model, the authors are pleased with the generally successful outcome indicated by the surveys and are encouraged to further develop the interaction. In the future we will promote greater interaction between ASM and ISM students by providing additional meetings to discuss various design issues. The difficulties with implementing such collaboration are real, e.g., coordination between classes and time commitment of the instructors, however, based on the authors experience, the benefits outweigh the costs.

The authors believe that the STM used both in the ASM classroom and the ASM-ISM consultant meetings empowered the ASM students and instilled a motivating sense of responsibility. ASM students were more engaged in discovery learning, internalization, and monitoring during preparation. Within the classroom and particularly the conference room, the ASM students actively questioned the ISM students, provided written and oral critiques of student reports, and presented organized explanations of missed concepts. The authors believe that the dual emphasis on process skills and product (knowledge) builds life-long learners, engineers who can adapt in a dynamic industry and thrive through change.

References

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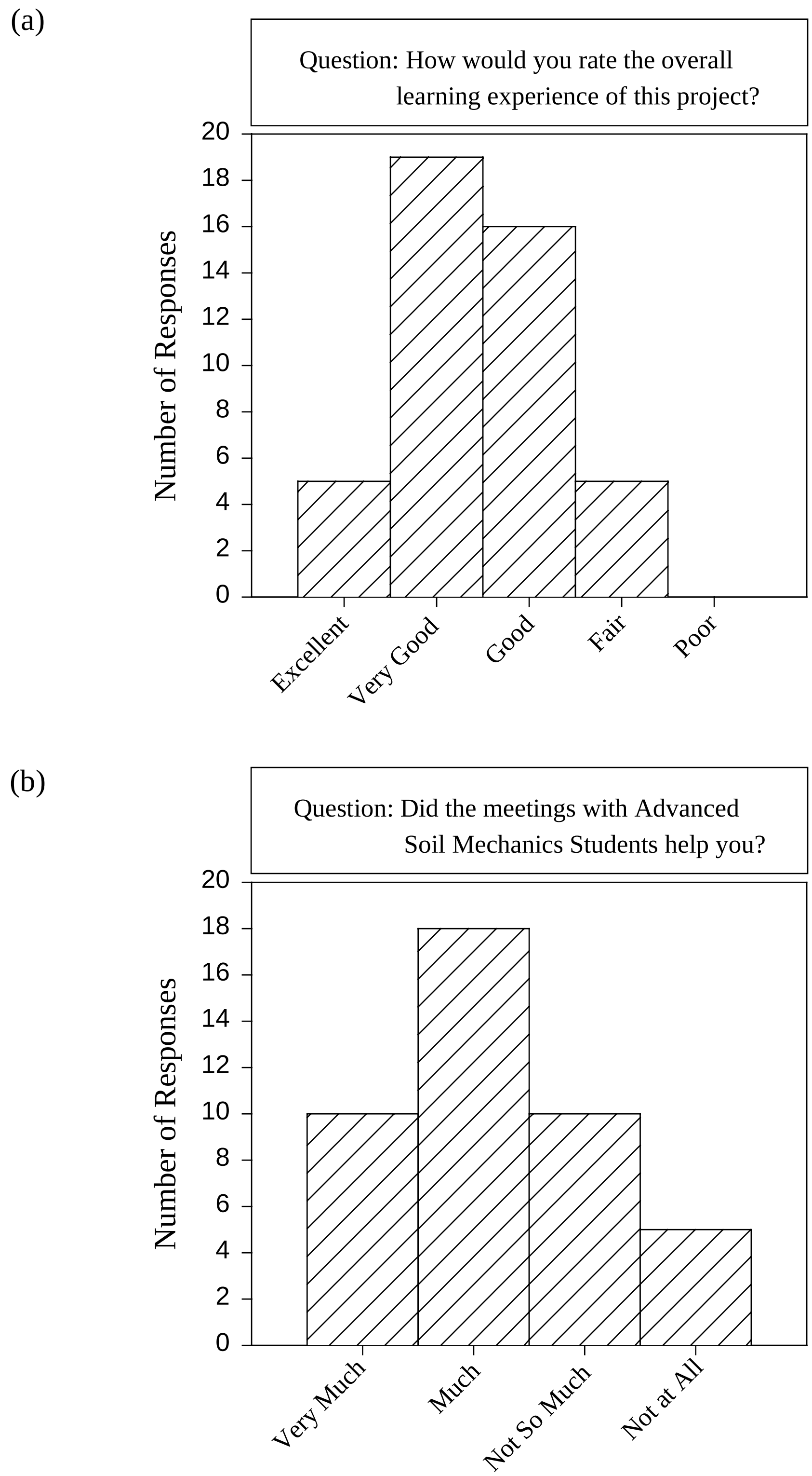

Figure 1 Results of undergraduate student assessment of: (a) the design project and, (b) meetings with graduate students.

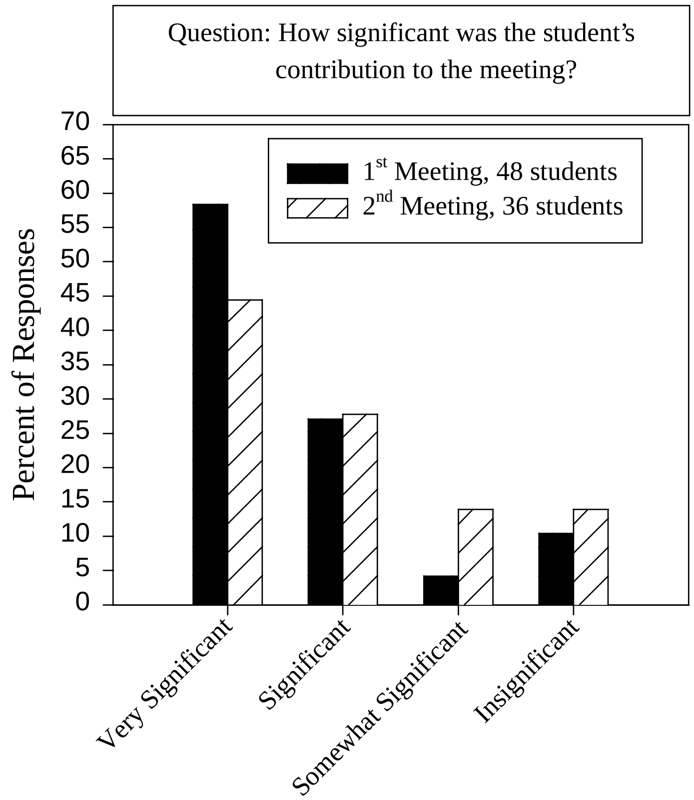

Figure 2 Results of the instructor's assessment of ISM students during meetings with ASM students.