Assessment of a Strategy to Give Graduate Students Valuable Experience Teaching a Formal Class

Olga Pierrakos[1] and Michael Alley[2]

Abstract—This paper presents an assessment of a strategy to provide graduate students experience in teaching a formal class. Occurring in a large laboratory course taught during the senior year, the teaching experience occurred through two technical lectures, taught four times by each graduate student to more than fifty undergraduates during each occasion. The main result of this assessment has been that graduate students greatly valued the experience and felt as if they significantly improved their teaching during the semester. An unexpected result was that the undergraduates appeared to have learned more from the graduate students than they did in semesters past, when professors taught those class periods. That assertion is evidenced by the increased attendance of the undergraduates at the two technical lectures and the improved quality of presentations and reports written by the undergraduates. This strategy could easily be applied to other large courses, where undergraduates cycle through different laboratory problems.

Keywords: Graduate Students, Teaching Experience, Professional Development

INTRODUCTION

When graduate students seek to gain formal teaching experience, they often find themselves teaching a small summer section of a fluids or circuits course with little time either to incorporate active learning into each class period or to assess and improve upon each class period. This paper presents the assessment of a strategy in which the graduate student teaches the same two class periods multiple times (in our case, four times) to different groups of undergraduates. Between each teaching of the class period, the graduate teaching assistant has time to evaluate the strengths and weaknesses of the teaching strategy. In doing so, the strategy allows the graduate student the opportunity to find out what worked and what did not.

In the strategy, the graduate students received four modes of feedback on their teaching efforts: (1) practicing the formal lectures in front of two experienced faculty members who served in the course, (2) surveying of the undergraduates on various aspects of the course including the lectures, (3) assessing both presentations and formal reports of the undergraduates to understand what information was transferred and what was not, and (4) having self-reflection over a significant period of time before teaching the next set of class periods. Another feature of this strategy is that it was designed to not compromise the undergraduate learning experience.

This paper presents first an overview of the large laboratory course in which the strategy occurred and then a discussion of the strategy itself. Following that is an assessment of how much the graduate students learned about teaching by applying this strategy. Given next is a comparison of how much the undergraduates in the course learned from the graduate students, as opposed to how much they typically learned when faculty taught these class periods.

[1] Mechanical Engineering Department, Virginia Tech, Blacksburg, VA 24061-0238

[2] Engineering Education Department, Virginia Tech, Blacksburg, VA 24061-0218

OVERVIEW OF THE LABORATORY COURSE

ME 4006 (Experimental Laboratory II) is a required laboratory course in mechanical engineering at Virginia Tech that serves more than 200 seniors. This course interweaves instruction on engineering principles with instruction on engineering communication [3]. The course consists of four laboratory problems that undergraduates work on in teams, but communicate in individual reports. In addition, for two of the problems, results are also communicated in team presentations. Each of these problems is described in a memorandum from a fictitious supervisor, who defines the purpose of the problem and defines the audience for the communication. For each laboratory problem, undergraduates attend two technical classes that discuss the engineering principles of those problems, and attend two laboratory sessions in which they make measurements to understand and address the problem. In previous semesters, those two technical classes were taught by faculty. However, in the Fall 2005 semester, these classes were taught by graduate students.

In addition to the two technical classes for each laboratory problem, the undergraduates attend six classes on engineering writing: organization, argumentation, illustration, clear language, fluid language, and form (grammar, punctuation, usage, and format) of writing. Finally, there are three classes on different aspects of engineering presentations: structure, presentation slides, and delivery.

The four laboratory problems are challenging. Rather than give the undergraduates a recipe of steps to follow, this course presents the undergraduates with a problem, two technical lectures on that problem, and two two-hour laboratory sessions to solve the problem. On hand during those laboratory sessions is a graduate teaching assistant who provides advice and makes sure that neither the undergraduates nor the equipment is damaged. In brief, the four laboratory problems are a hydraulics problem, an air-conditioning problem, a turbine problem, and a centrifugal fan problem, which is discussed in more detail in the following paragraph.

The set-up for one such laboratory problem is shown in Figure 1. In this problem, undergraduates have to decide upon an inlet guide vane setting for a centrifugal fan that will reduce fan's power requirement by a certain percentage. According to the problem's scenario, which is defined in a memo, a company is having problems with an overloaded motor on its production line. Frequently, this AC induction motor trips the overload breakers (because of a rush of current at high loads) and shuts down. The motor provides power to a conveyor belt on the main unit as well as to a centrifugal fan that supplies ventilation air to a 9000-ft^3 generator room. The undergraduates then must test different settings for the inlet guide vanes to determine which vane setting reduces the power by an appropriate amount. To solve this problem, undergraduates must understand several concepts about fluid mechanics and must be able to analyze a large set of data. In the report and presentation, the undergraduates must make an assertion about which vane setting(s) would work and defend that assertion with evidence, much of it graphical.

Figure 1. Laboratory set-up for one of the course's four problems. The undergraduates must take pressure and power measurements for several different settings of inlet guide vanes on a centrifugal fan.

STRATEGY TO GIVE GRADUATE STUDENTS TEACHING EXPERIENCE

Given that the course is so large (220–240 undergraduates) and that there are four technical projects, the class is split into four groups A, B, C, and D (each group being 55–60 undergraduates). Consequently, as shown in Table 1, the course has one graduate student teaching technical lectures for each of the problems. These graduate students encounter four rounds of undergraduates during the semester.

Our strategy to give graduate students formal teaching experience began with each graduate student giving the first technical lecture to at least two experienced faculty members who manage the course. The faculty members provided the graduate student with feedback about the lecture before the graduate student actually faced the undergraduates. This arrangement allowed the graduate students to obtain feedback about teaching and presentation style as well as technical comments on the lecture material.

The next step was for the graduate students to present their respective lectures to the undergraduates and then to obtain feedback. After the first technical lecture, an in-class assignment was given to the undergraduates as a means to see what information was transferred and what topics needed more clarification. In addition, after the first round of technical problems, the faculty members serving in the course administered a survey to the undergraduates. This feedback gave a quantitative assessment of how well the graduate students taught the technical lectures and will be further discussed in the next section.

Table 1. Class breakdown among the four graduate students (the class is split into four groups A, B, C, and D).

	GTA 1 (Hydraulics Lab)	GTA 2 (AC Lab)	GTA 3 (Fan Lab)	GTA 4 (Turbine Lab)
Round 1	A	B	C	D
Round 2	D	A	B	C
Round 3	C	D	A	B
Round 4	B	C	D	A

A third form of feedback was to observe how the undergraduates communicated their solutions to the technical problems. In this course, the undergraduates were required to give a technical presentation for two of the four problems and to write a technical laboratory report for each of the four problems. The presentation assignments were done in teams, while the reports were written individually. For the reports, the undergraduates were allowed to collaborate on illustrations and calculations. Therefore, observing these presentations and also reading over reports gave the graduate students more feedback about the knowledge that the undergraduates gained on the subject matter and served as a good basis for assessing the teaching experience.

The last mode of feedback was self-reflection in the periods between the technical lectures. The graduate student was given the opportunity to reevaluate his or her teaching efforts in order to improve the content of the lecture material, the style for presenting that content, and the delivery of the presentation.

In summary, the strategy was designed to give the graduate students four modes of feedback on their teaching effort: (1) practicing the formal lecture with experienced faculty members, (2) surveying the undergraduates on various aspects of the course, (3) seeing the undergraduates present the lab work as well as formal reports, and (4) self-reflection throughout the entire process.

ASSESSMENT OF HOW MUCH THE GRADUATE STUDENTS LEARNED

The assessment of how much the graduate students learned during this teaching experience was based on a survey given to the four graduate students. In this survey, the graduate students were asked about their overall

teaching experience, their personal inspection of the technical lectures from the beginning of the semester to the end, and their evaluation of the undergraduates' knowledge gained. The overall remarks about this experience were very positive. The graduate students recognized that there was great improvement in their technical lectures from Round 1 to Round 4. These graduate students attributed this improvement not only to the interaction with the undergraduates and supervising faculty, but also to the self-reflection periods between rounds that provided them time to reevaluate and improve the technical presentation, style, and delivery. Additionally, according to the graduate students, assessments by the undergraduates of their overall teaching after Round 1 and Round 2 revealed some of the topics that the undergraduates struggled with and allowed the graduate students the opportunity to communicate those topics more clearly.

Even more valuable in assessing how much the undergraduates understood, though, were the presentations by the undergraduates. These presentations allowed the graduate students to identify which specific concepts the undergraduates understood and which they did not [3]. This feedback gave the graduate students the basis and direction to better evaluate and improve their latter lectures. On that note, the graduate students also noticed that the latter groups of undergraduates seemed to learn more than the first group of undergraduates. Evidence of this observation is attributed to the increase in grades of both the technical presentations and the laboratory reports from the beginning of the semester to the end. Last, all the graduate students agreed that this teaching experience and the unique strategy granted them "many valuable lessons," a great deal of confidence with teaching, and provided them the feedback and self-reflection to become a stronger lecturer.

ASSESSMENT OF EFFECTIVENESS OF TEACHING BY THE GRADUATE STUDENTS

A second type of assessment for our strategy was on how effective the technical lectures were in teaching the undergraduates. There were five means of making this assessment: (1) in-class assignments administered in the technical lectures to determine how much the undergraduates were learning, (2) attendance by the undergraduates at the technical lectures to determine how much value the undergraduates placed on the lectures, (3) monitoring of how often undergraduates accessed the posted slides from the technical lectures, (4) evaluations by the undergraduates of the technical lectures, and (5) assessment of the technical presentations and technical reports to determine how much the undergraduates learned.

The in-class assignments that the graduate students administered to the undergraduates after the technical lecture aided us in assessing what knowledge they had gained and what topics needed to be better addressed the next time. These in-class assignments included specific short-answer technical questions about the lecture. By monitoring the answers of these questions throughout the semester from Round 1 to Round 4, we were able to indirectly assess how well the graduate student taught the technical lecture. Although this assessment is qualitative, we believe that the general trend from Round 1 to Round 4 shows an improvement in the amount of material that the undergraduates retained after each technical lecture.

Attendance was another form of assessment for the value of the technical lectures. It was evident that attendance levels were good throughout the semester. In fact, according to the two faculty who managed the course, attendance was much higher in comparison with previous years when professors taught the technical lectures—particularly at the end of the semester when undergraduates have had opportunities to assess the worth of these lectures. Moreover, the second technical lecture (follow-up lecture) for each of the four rounds also showed good levels of attendance (more than half of the undergraduates). In past semesters, the attendance at this second lecture was often poor (less than one-third attendance). As an example, for the turbine technical lectures this semester, attendance was taken in class and calculated to be 85 to 90 % of the undergraduates.

Third, we were able to monitor how frequently the undergraduates accessed the posted slides of the technical lectures from the course website. This form of feedback provides us with a quantitative measure of how informative the undergraduates found the technical presentations to be and how often they accessed the material. With faculty giving the technical lectures, we did not have posted technical lectures, because the faculty did not feel inclined to prepare a formal presentation that could be posted—they preferred giving a chalk lecture. This year, though, all four graduate students provided professional sets of slides to be posted, and the 240 undergraduates in the course frequently visited these postings. Figure 2 illustrates the number of times that undergraduates downloaded the four technical lectures in the months of September, October, and November. For example, the turbine lecture was

downloaded 793 times, which corresponds to 3.3 downloads per undergraduate in the course. These results reveal that the undergraduates valued the lectures and accessed them under no requirement at least once.

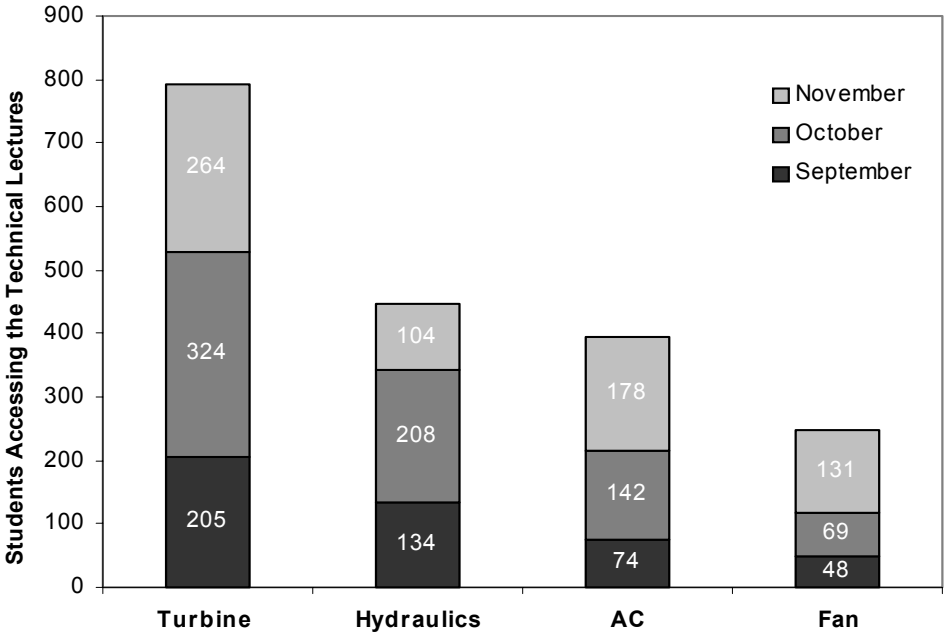

Figure 2. Number of undergraduates accessing each of the four technical lectures in the months of September, October, and November.

Another direct form of how informative the undergraduates valued the technical lectures came from the student surveys that were administered by the faculty members supervising the course. More specifically, the undergraduates were asked to "assess the technical lecture" by giving a score from one to five (five being the highest). The averaged score of all four GTAs was compared with averaged scores from previous years, when professors taught the technical lectures. The results are shown in Figure 3. In 2002 and 2003, professors taught the technical lectures and their average overall scores, as assessed by the undergraduates, were 3.56 and 3.15, respectively. This year, though, with the graduate students teaching, we observed a 3% and 16% increase in the score compared with 2003 and 2004, correspondingly.

Evaluating the technical reports and technical presentations of the undergraduates served as the final feedback method for assessing how much undergraduates learned from the technical lectures. It must be noted that this feedback method was subjective considering that the undergraduates also closely interacted with their laboratory GTAs, who certainly aided in their learning experience. Therefore, the assessment of technical reports and presentations provided a partial view of how much the undergraduates learned from the technical lectures. Given that, evaluation of the reports and presentations revealed increased improvements in their knowledge and understanding of the subject matter when compared with undergraduates of previous years. It should also be pointed out that when undergraduates did a presentation in accompaniment with a technical report, the undergraduates performed significantly better on the technical reports than they did when they just wrote the report. This finding is not surprising considering the extra time that the undergraduates had (one extra week) to digest the material, the feedback that the undergraduates received during the presentation on their understanding of the material, and the motivation of the undergraduates to show an understanding of the subject matter in front of their peers. Last, it must be noted that the supervising faculty, who attended all the technical presentations of the undergraduates, confirmed that the presentations this year were the strongest set thus far in terms of content and the apparent knowledge the undergraduates possessed.

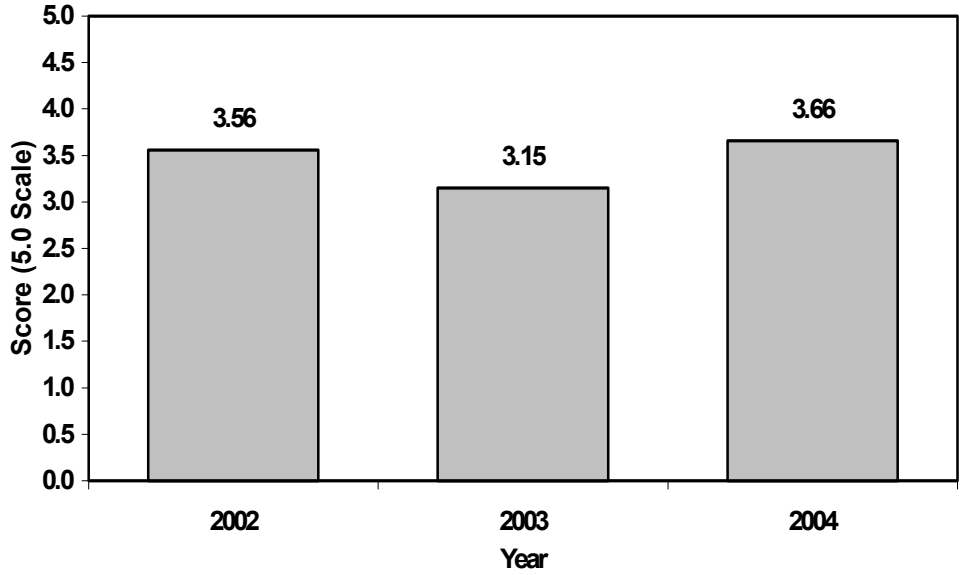

Figure 3. Average score (on a 5.0 scale) of the technical lectures assessed by the undergraduates.

CONCLUSIONS

This paper has presented and evaluated a strategy to allow graduate students to gain experience teaching two class periods, with a large number of undergraduates, without a compromise of the quality of instruction for the undergraduates in the course. One result of the incorporation of the strategy was to provide graduate students with valuable teaching experience. A second result was the experience was positive and successful for both the graduate students and the undergraduates. The undergraduates appreciated the technical class periods, and the graduate students felt that the time invested in those class periods was time well spent. The undergraduates had higher attendance and gave higher evaluations of the technical lectures with the graduate students teaching when compared to previous years when professors taught the lectures. Also, the graduate students greatly valued the teaching experience because it instilled much confidence into them in regard to having to teach a large class.

The strategy was so designed to give graduate students four modes of feedback on their teaching efforts: (1) practicing the formal lecture with at least two experienced faculty members, (2) surveying of the undergraduates on the effectiveness of the class periods, (3) critiquing both presentations and formal reports of the undergraduates to understand what information was transferred and what was not, and (4) having self-reflection before teaching the next set of two class periods.

An unexpected result was that the undergraduates appeared to have understood the technical issues of the lectures given by the graduate students better than they did in years past, when faculty gave those lectures. This strategy could be applied to any number of engineering courses in which large numbers of undergraduates are involved. More specifically, this strategy could be applied to large laboratory courses that allow for rotations of experiments and can serve as an excellent introductory teaching experience for graduate students.

ACKNOWLEDGMENT

This work was funded through an NSF Advance Grant: SBE0244916.

REFERENCES

[1] Alley, Michael, and Harry Robertshaw, "Interweaving Engineering and Writing: A Model Large-Laboratory Course at Virginia Tech," *2001 ASEE Annual Conference* (Albuquerque: ASEE, June 2001).

[2] Robertshaw, Harry, and Michael Alley, "Raising the Ship: Using Engineering Graduate Students Rather Than English TAs to Teach Writing to Undergraduate Engineers," *2001 ASEE Southeast Regional Conference* (Charleston, S.C.: ASEE, April 2001).

[3] Alley, Michael, and Harry Robertshaw, ""Effective Incorporation of Student Presentations in a Large Laboratory Course," *Proceedings of the ASEE National Conference* (Nashville, TN: ASEE, June 22, 2003).

Olga Pierrakos is a Ph.D. candidate in the Department of Mechanical Engineering at Virginia Tech. Her current research endeavors involve vortex dynamics and flow characterization of left ventricular flows using an experimental fluid mechanics method, Particle Image Velocimetry (PIV). She is expected to complete her Ph.D. in the summer of 2005.

Michael Alley is an associate professor in the Department of Engineering Education at Virginia Tech. He is the author of *The Craft of Scientific Writing* (Springer, 1996) and *The Craft of Scientific Presentations* (2003). He is also the lead editor of the *Writing Guidelines for Engineering Students* (http://writing.vt.edu/).