Using Technology to Enhance Undergraduate Learning In Large Engineering Classes

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Abstract - Lecture classes with enrollments in excess of 250 students and lab classes with enrollments of over 100 have become the status quo at many universities, and it is expected this trend will continue with class sizes becoming even larger. Traditionally, it has been thought that the quality of the learning experience is diminished in such large classes. However, as we adjust to the new norm, we are finding that it is possible to actually improve the learning experience by employing new classroom technologies and better management of existing resources. Improved internet based content delivery technology provides opportunities for blended learning strategies. In this paper, we describe how two classes are conducted at the University of Florida that employ blended learning. The first class is an introductory fluid mechanics class with an enrollment of 265. In this class, three traditional lectures a week are video-recorded with students watching these on-line at their convenience. Students then attend one mandatory recitation section per week which is devoted to problem solving. The recitation sections are relatively small with enrollment limited to 30 students. During the recitation sessions, instructors serve in the role of facilitator or mentor as students work in teams of two to apply the content covered in the internet based lectures. Conceptual errors are identified and resolved efficiently as compared to traditional instructional approaches. The other class described in this paper is a fluid mechanics/thermodynamics laboratory class with an enrollment of about 100 each semester. In this class, laboratory demonstrations are recorded for student viewing and on-line quizzes are administered. Thus, pre-lab preparation is automated and standardized across instructors and teaching assistants. During the lab sessions, student preparation for the lab is improved by allowing more time for instructors to spend interacting with students on conceptual aspects of the experiments. Specific multimedia technologies utilized in these courses include Sakai e-learning system and Camtasia Studio screen/audio capture software. The University of Florida EDGE (Electronic Delivery of Gator Engineering) facilities are also utilized for recording lectures and delivering video content via internet streaming video.

Keywords: Large-class, Sakai, Camtasia, large-lab, on-line-video

INTRODUCTION

Over the past twenty years, enrollment in classes in the Department of Mechanical and Aerospace Engineering (MAE) at the University of Florida has slowly increased from classes sizes of about thirty to sixty up to the current typical class size in excess of 150. This has occurred because the number of qualified students accepted to the university has gone up, but there has been no corresponding increase in the number of faculty due to budget cuts from the state legislature. Over the past ten years, total undergraduate enrollment in the MAE department has increased an average of 7.5% per year. The MAE department has seen the largest growth in the College, but other departments are experiencing similar trends. Traditionally, it has been thought that smaller class sizes provide better learning opportunities, and it has been suggested that perhaps more faculty should be hired to address this issue. However, it is unlikely that this will occur in the foreseeable future, and current student-faculty ratios will be the status quo. This necessitates a new approach to teaching that provides a learning experience as good, if not better, than what was attained in the smaller classrooms.

BACKGROUND INFORMATION

Twenty years ago, the typical class in the Department of Mechanical & Aerospace Engineering had approximately thirty to sixty students. A faculty member would be assigned either one or two classes per semester with the remainder of their time devoted primarily to research, and the balance to departmental administration. The instructor would lecture three times a week, and usually hold office hours for about three hours per week. Typically, one teaching assistant was assigned to help students with homework and to grade papers.

In classes of this size, faculty were usually able to meet all the students and get to know them on a first-name basis. Because the classes were small, it was obvious when students were absent which created at least some small pressure for students to attend class. Although there are no records of class attendance rates, it is thought anecdotally that attendance was better when classes were smaller.

With small classes, instructors themselves could also grade much of the work turned in by students, which meant that they could gage which teaching methods were effective, and what areas needed emphasizing. Students seemed to feel more comfortable approaching their instructors.

Over the years, enrollment has gradually increased due to population growth in Florida. The University of Florida is a land-grant institution, and as such, it has a responsibility to accept as many qualified students as possible. At the same time, per-student funding of the university has decreased, and as a result, student-to-faculty ratios have increased. Lecture classes in the Department of Mechanical & Aerospace Engineering have enrollments of approximately 125 to 250, and lab classes have enrollments of about 100-120.

METHODS

The department has an intense interest in maintaining, and even improving, the quality of education experienced by the students from twenty years ago. Technology has played an important role in the gradual evolution from the classroom of twenty years ago to what it is today.

Structure of Fluid Mechanics Course

Both the Mechanical Engineering and Aerospace Engineering majors at UF take a required introductory fluid mechanics course EGN3353C Fluid Mechanics. The course has prerequisites of Calculus III (solid analytic geometry, vectors, partial derivatives, multiple integrals), Engineering Mechanics – Statics, and Thermodynamics. The catalog description for the course is “Statics and dynamics of incompressible fluids. Application to viscous and inviscid flows. Dimensional analysis. Compressible flow.” In 2012, enrollment demand for the course increased to the point that the department was unable to meet the demand. Class sizes had increased to approximately 160 to 200 students per section, and enrollment demand had increased to about 250 students per term. The possibility existed to offer additional sections by assigning additional faculty, however classrooms were not available. The lack of available classroom space has become a chronic problem. A decision was made to try an alternate format for the course that would allow the department to meet the enrollment needs.

Starting in the Fall 2012 term, the course was offered in a blended format that includes 3 lectures per week supplemented by a one-hour recitation session each week. Lectures are held on Monday, Wednesday, and Friday.

The recitations are held on Tuesdays. The lecture is given in the UF EDGE studio classrooms (see http://www.ufedge.ufl.edu/ for more information on UF EDGE). The EDGE program is primarily focused on distance learning opportunities at the graduate level. By using the EDGE classroom, we are leveraging this established resource to augment the undergraduate instructional capabilities. The EDGE classroom have high definition video capability with a camera operator in the room to handle all recording functions. The instructor is free to focus on the lecture and may utilize traditional chalk boards, overhead projectors, computer displays (for PowerPoint, video, etc.) and SMART board interactive displays. The lecture video is converted to MP4 format (both high quality and mobile quality resolutions) in real time and uploaded to the streaming video server immediately after the lecture is finished.

EDGE has various lecture rooms available that range in size from approximately 30 to 160 student capacity. The Fluid Mechanics course made use of a video classroom that can accommodate 100 students live. There were 262 students enrolled in the course. Attendance at the live lecture was relatively light such that no students who wished to attend the live lecture had difficulty finding a seat. The recitation sessions had enrollments of approximately 30 students per session. Attendance at the recitation sessions was mandatory. Attendance was typically above 95% since 15% of the course grade was based on participation in the recitation sessions. The emphasis in these sessions was on problem solving. Students were broken into teams of two to work on problems related to the previous week's lectures. Homework covering the previous week's lectures was also collected during the recitation sessions. These two mechanisms were used to encourage students to actively watch the lectures and come prepared for the recitation sessions.

The course lectures are organized online into learning modules (Sakai e-learning software). Within a learning module, supplemental material related to the lecture topics is posted. This supplemental material includes PowerPoint slides, handouts, and video clips. Some of the video clips are drawn from the extensive video library produced by the National Committee For Fluid Mechanics Films (available online at http://web.mit.edu/hml/ncfmf.html.) This resource is of very high quality and greatly assists students in visualizing the flow phenomena and difficult concepts. Additional short video clips were produced by the course instructor utilizing the Camtasia screen/audio capture software. This software package allows the instructor to use a digital tablet computer to work supplemental example problems with a voice over. The instructor can work out an example problem while giving a narrative of the thought process involved. The video is converted to MP4 and uploaded to the video streaming server in much the same way as the recorded lectures. An additional advantage of the Camtasia software is that it does not require the EDGE video studio. The supplemental video content can be produced anywhere internet access is available.

Student feedback on the course has been generally positive. The biggest anecdotal issue cited by students is that it is very easy to fall behind in watching the lectures. The rich multimedia resources available to the students (lectures, handouts, films, and supplemental video examples) appear to have provided a learning resource for effective delivery of the traditional lecture content. The weekly recitation sessions provide direct face-to-face interaction for answering questions, refining problem solving skills, and intangible social interactions found in the traditional small classroom setting. To gauge the quality of student learning and retention, a pre-test is being utilized in the course EAS4101 Aerodynamics for which the EGN3353C Fluid Mechanics is a pre-req. The department has been administering this pre-test as a direct assessment of student learning for several years. Thus, this will provide some measure of the efficacy of the new course blended delivery format.

Structure of Lab Courses

The Mechanical Engineering major as well as the Aerospace Engineering major requires a laboratory course called EML4303C Thermo-Fluids Design and Lab. Mechanical engineers also are required to take a laboratory course called EML4147C Thermo-Fluids Design and Lab. Aerospace engineers can take EML4147C as a technical elective. Both of these courses have a lecture component which meets for fifty minutes twice a week, and each course has five labs associated with it. The students work in groups in the labs, and each of the lab exercises spans two weeks. In that two week period, each group meets to conduct the lab for 57 minutes. There are two in-class tests each semester, and eight homework assignments. There is also a design project each semester which requires a written report and an oral report.

EML4304C is offered three times per year which includes the Fall, Spring, and Summer semesters and has a typical enrollment of 100 students each semester. EML4147C is offered twice a year in the Fall and Spring semesters and typically has 120 students enrolled each semester. Sections run continuously all day Tuesday through Thursday, and

Friday morning. Labs are not scheduled on Monday since they conflict with many holidays and require make-up periods which are not conveniently available.

One faculty member is assigned to teach both courses. There are normally five graduate teaching assistants assigned to the course, and four undergraduate teaching assistants. The faculty member grades all the tests and design reports. The graduate TAs grade the lab reports, and the undergraduate TAs grade the homework. The faculty member is responsible for twenty-two graded items per student each semester. In the Fall and Spring semesters, that is approximately 4740 graded items each semester.

Six years ago, the biggest problem in these classes was preparing the students for the lab periods. Students would arrive for their lab periods, and would see the equipment for the first time. The entire period was spent with an explanation by the instructor on how to use the equipment. The demonstration was repeated approximately sixteen times per course for each lab. During the semester, this meant 160 demonstrations.

It was decided to address this problem by taking advantage of some of the technology offerings available to instructors at the University of Florida. The university has a network of studios available for recording lectures. The instructor has now recorded a lecture containing background theory for the lab period, and has also recorded the lab equipment demonstration. The videos are available to the students through the on-line course management system at UF called Sakai. Students are required to watch the video by 4:00 on the Thursday of the week prior to the first meeting of that particular lab. Sakai offers the ability to create on-line quizzes. To ensure that students watch the video, they are required to take an on-line quiz that covers material in the video. They must pass the quiz with a perfect score. The quiz does not count towards their final grade, but they are not eligible to participate in the lab until the quiz is complete. They are given five attempts to achieve the perfect score. If they do not get a perfect score, they may contact the instructor who has the option of providing more attempts.

It is estimated that by using the videos, approximately 160 hours of instructor time is saved each semester. It has also increased the amount of time the students are actually performing the experiment since they watch the videos at home, and all their lab time is spent actually operating the equipment rather than watching someone else demonstrate it. The instructor now spends that time meeting with students discussing theory and experimental technique in small groups.

SIGNIFICANT RESULTS

The quality of the labs has definitely improved since the introduction of pre-recorded lab demonstration videos. Approximately twice as much lab time is now spent actually performing labs. Students can now usually complete the lab in one period. As a result, we have been able to institute "feedback sessions" into the lab. During the second week of the lab, students are required to meet in small groups with a graduate TA to go over their work. They are required to have made "significant progress" on their lab report prior to this meeting. The TA is able to critique their work and provide good quality which the authors believe is one of the most important aspects of the lab. Students have reported they feel the videos are excellent ways to learn the labs.

A significant feature of the large lab class is that there is a large amount of funding available for the class to buy equipment. The classes are able to afford to purchase sophisticated equipment and are able to maintain it with no problem.

In the fluid mechanics course, the new format has allowed the department to offer unlimited capacity during peak enrollment semesters. Student learning appears to be comparable to traditional lecture formats. An additional benefit of the new format is that students on internships or study abroad may take the course.

CONCLUSIONS

There is a perception among many that small class size leads to better instruction. We have demonstrated that in two courses, that a large course enrollment need not be an impediment to good quality instruction and learning. One course is a traditional theory course (Fluid Mechanics) and the second course is a laboratory course (Thermo/Fluids Lab) Although the student-faculty ratio is high, there is plenty of time for students to meet with the instructor just as in a small class. Ready internet access to video-taped lectures, example problems, and pre-lab instruction provides students schedule flexibility. This access also allows students to re-watch key material as needed when working homework or reviewing for exams.