Implementing Online Content to Improve Learning in a Large Engineering Freshman Programming Course

David G. Taggart
Department of Mechanical, Industrial and Systems Engineering
University of Rhode Island
Kingston, RI 02881

Online teaching methods offer many potential advantages including improved learning, convenience, automated assessment, and cost-effectiveness, especially for large classes. As a result, use of online content is rapidly becoming incorporated in many academic fields. This paper will discuss the evolution of a freshman programming course at the University of Rhode Island over the past eleven years and will demonstrate the effectiveness of incorporating online content. At URI, programming with the MATLAB programming language is introduced to all freshmen engineering students during their second semester. Over the past several years, the format of this class has changed in response to growing enrollments and the availability of online teaching technologies. The evolution of this course provides an interesting case study of the effectiveness of recent changes in engineering course delivery methods. Evidence including historical grade distributions, results of student course surveys, and student comments are examined and discussed. It is shown that these data support the conclusion that use of online content provides an efficient and effective learning tool, especially for classes with large enrollments.

Corresponding Author: David G. Taggart, taggart@uri.edu

Introduction

In recent years, two trends have been observed in engineering education. In data presented by Yoder, full-time undergraduate enrollment in engineering programs in the United States has increased from approximately 368,000 in 2005 to approximately 569,000 in 2014 [1], an increase of nearly 55% over this ten year period. At most institutions, the number of faculty have not increased at a comparable rate. Hence, engineering programs have needed to modify their instructional methods to accommodate larger class sizes. During this same period, the use of online teaching technologies have improved and become more widely used in higher education. Due to these two trends, faculty members have explored the use of online teaching methods, partially in response to growing class sizes. This paper presents a case study in which online teaching methods were implemented to improve the delivery of a freshman MATLAB programming course at the University of Rhode Island.

It should also be noted that the rapid growth in online and blended courses has led to the establishment of an international organization Quality Matters [2]. The focus of this organization is to assure quality in the design of online and blended courses and to provide certification of such courses. In developing online course content, Quality Matters principles provide guidance for effective online course content.

Online methods are ideally suited for computer programming courses where content can be organized into a logical sequence of topics. Students can view video demonstrations and immediately practice the techniques on their own computers. Since students often have diverse programming backgrounds, use of online content allows students to work at their own pace. For these reasons, programming courses are becoming widely available on several “Massive Open Online Courses” sites [3-5].

Background

At the University of Rhode Island, all engineering freshmen are required to take EGR

106, an introductory MATLAB programming course in the second semester of the freshman year. Following nationwide enrollment trends in engineering programs, enrollment in this class has increased dramatically over the past 11 years. As shown in Figure 1, enrollment in EGR 106 has increased from approximately 230 students in 2005 to over 450 students in 2015. As enrollment grew, it became necessary to modify the format of this class due to limitations in resources.

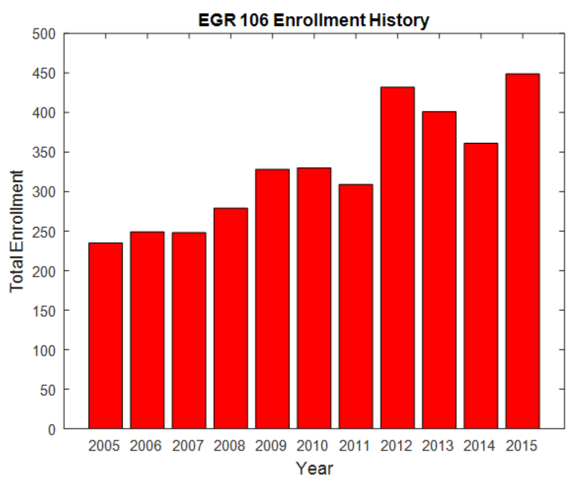

Figure 1. EGR 106 enrollment history 2005-2015.

This course was first introduced in the mid-1990's. Up until 2010, the course was taught in small classes, with each instructor responsible for a class of approximately 30 students. The class met two times per week with the first class meeting being an overview of the topics to be introduced that week. During the second class meeting of the week, students were given programming exercises that they completed in class with the assistance of their instructor. As the semester progressed, the assignments became more challenging and students often completed their assignments on their own and submitted them the following week. This format provided excellent interpersonal communication between the students and instructors. Students became engaged in the class and attendance was generally good.

Starting in 2010 through 2012, in an effort to accommodate the increasing number of students, the format of this course changed. With the new format, the first class meeting of the week, previously offered as a small class, was held in an auditorium with a capacity of approximately 150 students. The second meeting of the week was held in a computer lab with a capacity of approximately 30 students. With this revised format, one faculty member was responsible for the lectures that were held on Monday afternoons. Each lab instructor became responsible for two lab meetings later in the week. This revised format dramatically decreased the number of faculty required for the delivery of this course. In 2008, nine instructors were needed to teach each section, meeting two times each week. In 2009, one instructor delivered two lectures at the beginning of the week and five instructors taught two lab sections, each meeting one time per week. This change reduced the number of instructors needed from nine to six, despite an increase in total enrollment from 279 students to 328 students. Unfortunately, with this new format, attendance in lecture dropped, despite efforts to take attendance and include it as a portion of the course grade. It was observed that the large lecture format resulted in students being less prepared for lab and, as will be discussed below, is believed to have contributed to an overall drop in student grades.

In 2013, the course format was modified and the large face-to-face lecture meetings were replaced with a blended format in which students had the option of attending a face-to-face lecture on Monday evenings or viewing the weekly lecture materials online. It was found that after the first few weeks, more than 90% opted to view the lecture materials online rather that attending the Monday evening lecture. These materials included a textbook reading assignment, Powerpoint slides that included weekly announcements and relevant MATLAB programming topics, and narrated video presentations of the Powerpoint slides combined with MATLAB demonstrations. Before coming to their lab meetings later in the week, students were required to take short online quizzes to assure that they had reviewed the online content.

Online Instruction Methods

Since the focus of this paper is the introduction of online teaching methods, it is useful to review how these methods were implemented in this course. URI uses the learning management system, Sakai [6], for the delivery of online content. Sakai includes a variety of tools for class management. For EGR 106, the following Sakai tools are utilized: Home, Lessons, Resources, Tests & Quizzes, and Gradebook. It was found that by providing a clear, well-organized Sakai site, students are able to be aware of the weekly course requirements and deadlines. This is especially important for freshmen, who are still developing effective work habits and time management skills. In large classes such as EGR 106, clear communication of the course requirements and scheduling is essential. For programming courses in particular, where each week's topics build on previous material, it is important that students not fall behind. These ideas are consistent with the Quality Matters rubric standards [6] for an effective online learning environment.

The Sakai "Home" tool provides a link to the course syllabus and brief announcements of each week's activities. Announcements related to last minute scheduling changes due to snow storms, etc., are provided on the Home screen.

The Sakai "Lessons" tool provides an effective summary of each week's activities. Figure 2 shows a screenshot of a typical weekly lesson. Each lesson includes: 1) the text reading assignment; 2) weekly announcements in video lecture, Powerpoint file format and pdf file format; 3) weekly MATLAB topics in video lecture, Powerpoint file format and pdf file format; and 4) an online quiz that each student must take before attending lab later in the week. It is found that the MATLAB presentations provide a useful reference that students often use during lab in completing their weekly assignments.

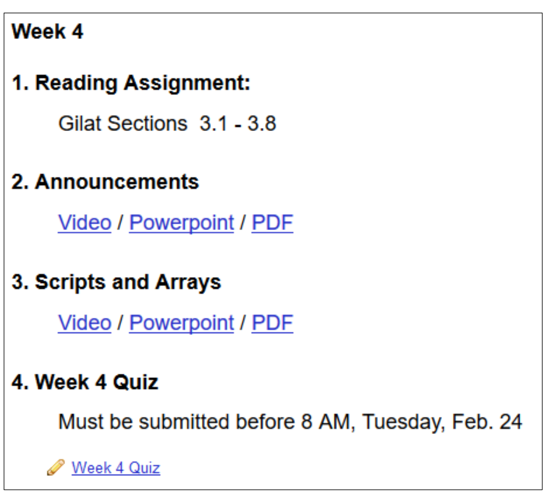

Figure 2. Typical Sakai weekly lesson.

The Sakai "Resources" tool provides links to all course materials, which are also available through links in the "Lessons" tool. The "Tests & Quizzes" tool is used for weekly online quizzes, which are also available through links in the "Lessons" tool. The "Gradebook" tool is used to post online quiz grades and in-class exam grades. For the online quizzes, students are typically given multiple attempts. After each attempt, they can view their grade in "Gradebook" and, if needed, can review the course material before retaking the quiz. Through this process, students are motivated to master the course material before coming to lab later in the week. Since students came to lab with a better understanding of the week's topics, this resulted in more effective use of lab time

Results

To assess the effectiveness of introducing online content, a course survey was administered at the end of the semester. It should be noted that this survey was administered using Sakai's quiz tool, allowing students to complete the survey on their own time. Quiz credit was given for completing the survey, resulting in a high fraction of the class providing feedback. This survey included several questions about the course and a comment section where students can provide feedback on any aspect of the course. Figures 3-5 show survey results for questions related to the effectiveness of the online content of the course. As can be seen, a large majority of the class agreed that the online video lectures and online quizzes were effective. Similarly, a majority of the class expressed a preference for online lectures for courses like EGR 106. These opinions were supported by feedback in the survey comments section. It was observed that comments related to the online content were nearly all positive. Representative comments included:

- "The online lectures are a great way for someone like myself to take this course at his leisure and provide useful information at the click of a button. I really appreciate how thoroughly the course was laid out on the Sakai site (a practice that not enough of my professors shared)."
- "I based all of my learning from this course from the Powerpoints and they were very well

constructed and very well written. I was able to succeed in the course thanks to those."

- "I feel that this was a great way to introduce engineering students to MATLAB and its formatting."
- "I liked that we could choose between attending the lecture and looking at an online video."
- "I pretty much exclusively used the online lectures, which I thought were very good at introducing and demonstrating concepts."
- "I think that this was a good, solid course. It was a great way to get students introduced to programming."
- "Throughout the semester, I found this course to be very straightforward as to what was expected from every student. The online lectures and the pdf copies of the presentation as a resource on Sakai really proved to be helpful when not only trying to learn and review the material but also when attempting to complete the weekly lab assignments. Overall I really enjoyed this course and how it was taught."

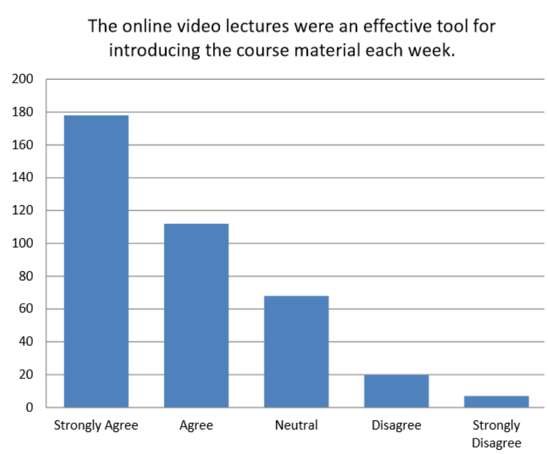

Figure 3. Survey: effectiveness of online lectures.

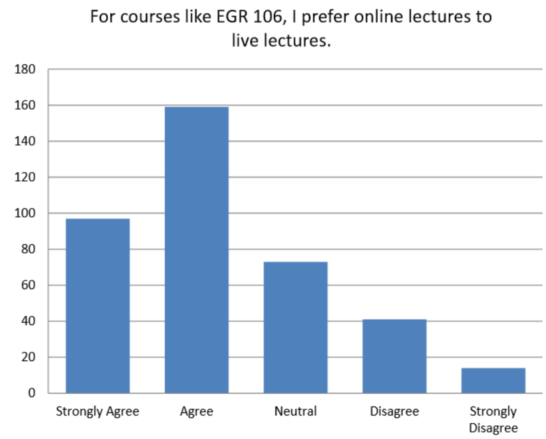

Figure 4. Survey: preference for online lectures.

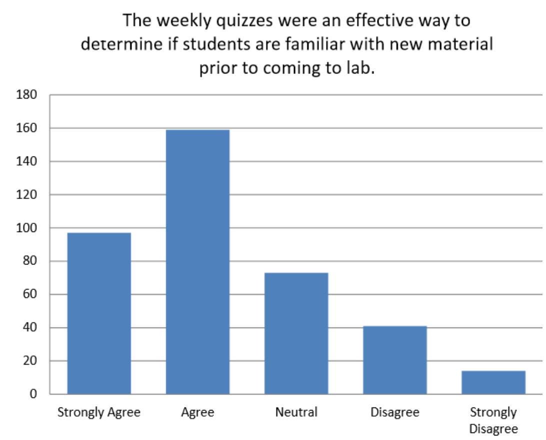

Figure 5. Survey: effectiveness of online quizzes.

Analysis of Results

To quantify the effectiveness of the introduction of online content in this course, an analysis of the final course grades over the period 2005-2015 was performed. It should be noted that course grades fluctuate from year to year for a variety of reasons, including different instructors, varying levels of student preparedness, and changes in difficulty of assignments and exams. It is believed however, for a large class with several instructors, the overall trends in course grades are expected to correlate with changes in course effectiveness.

Final course grades for the periods 2005-2008 (small lecture format), 2009-2012 (large lecture format), and 2013-2015 (blended format) are shown in Figures 6-8, respectively. From these data, it can be seen that changing from small lecture format to large lecture format resulted in a decrease in final grade average from 3.18 (on a scale of 0-4 corresponding to grades F-A) to 3.05. Changing from a large lecture format to a blended format resulted in an increase in final grade average from 3.05 to 3.37. Similarly, the number of students with final grades of D+, D or F was dramatically reduced. These trends are illustrated in Figure 9, where the data are grouped by class format. This plot clearly shows that the blended format resulted in fewer students with very low grades and a significantly larger fraction of students earning A's and A-'s.

Conclusions

This paper presents a case study tracking the evolution in course format from small lecture to large lecture to blended format in a large freshman engineering programming course. Analysis of student survey results, student comments and final grade averages reveal that the blended format resulted in improved student satisfaction and overall grades, despite dramatic increases in course enrollment.

References

1. Yoder, Brian L. "Engineering by the Numbers." American Society for Engineering Education. 2014.
2. Quality Matters Program, Available at: https://www.qualitymatters.org/about.
3. Ledeczi, Akos, Fitzpatrick, Michael, and Tairas, Robert, "Introduction to Programming with MATLAB," Vanderbilt University, Available at http://www.coursera.org/course/matlab.
4. Pohl, Ira, "C++ For C Programmers", University of California, Santa Cruz, Available at: https://www.coursera.org/learn/c-plus-plus-a.
5. Severance, Charles, "Programming for Everybody (Getting Started with Python)," University of Michigan, Available at https://www.coursera.org/learn/python.
6. SAKAI Learning Management System, Available at https://sakaiproject.org/.
7. Quality Matters Rubric Standards Fifth Edition, 2014, Available at: https://www.qualitymatters.org/qm-standards-with-point-values-fifth-edition/download/QM.

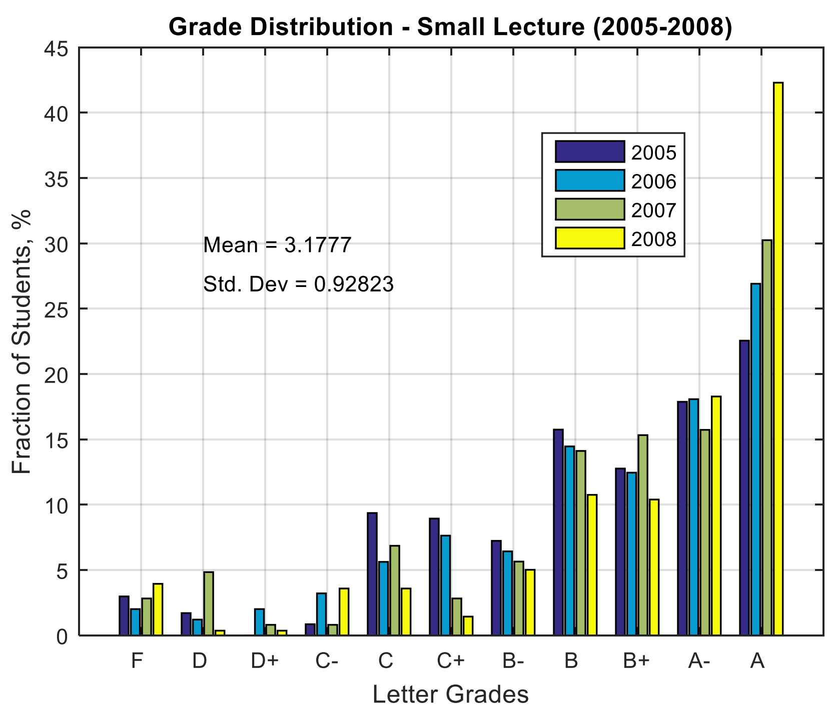

Figure 6. Final grade distribution for small lecture format, years 2005-2008.

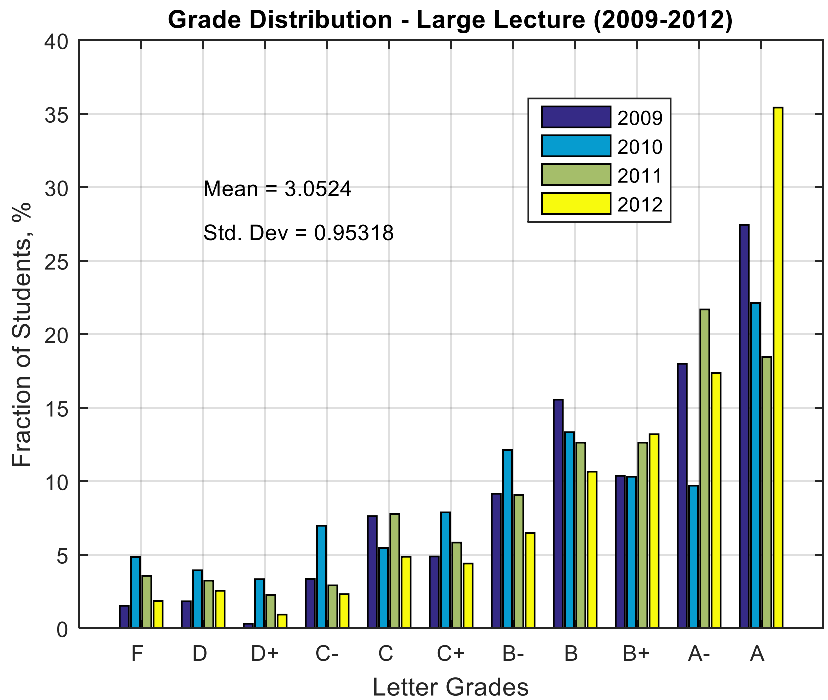

Figure 7. Final grade distribution for large lecture format, years 2009-2012.

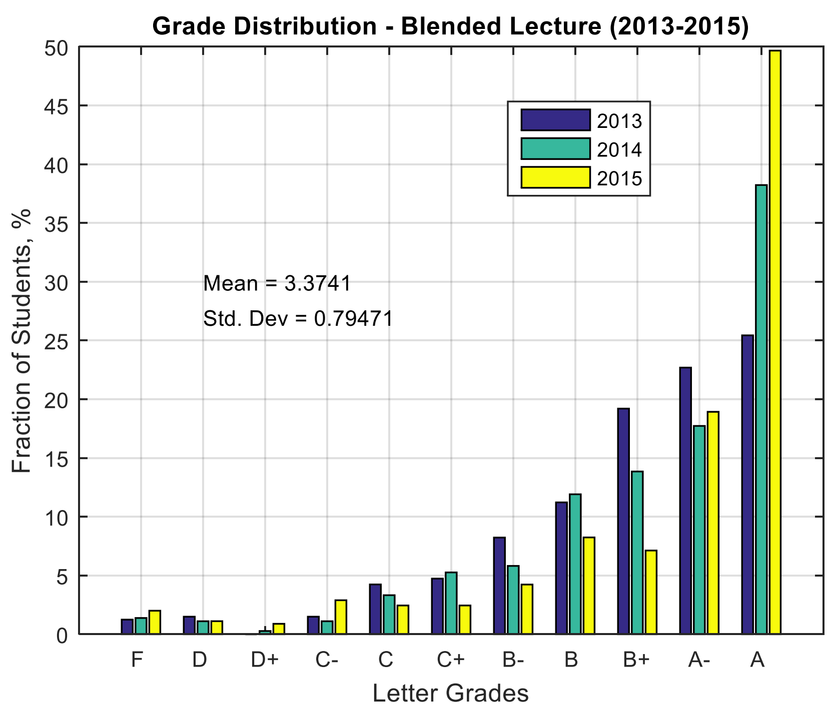

Figure 8. Final grade distribution for blended lecture format, years 2013-2015.

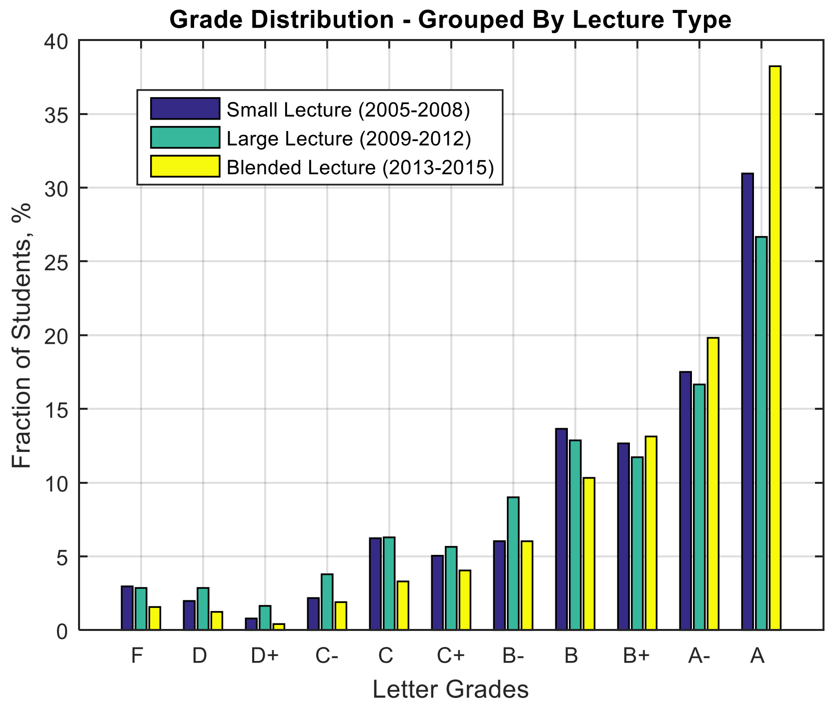

Figure 9. Final grade distribution for small lecture, large lecture and blended lecture formats.