Integrating Online Learning to Junior-Level Electromechanical Design

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Abstract

The following paper reports on the results of efforts at integrating online learning to the current Junior-level Electromechanical Design course at Wentworth Institute of Technology. This is an intense course where in one semester students are expected to complete an original design and a prototype. Project and time management are critical. Groups are typically from 3 to 5. Much of the work involves testing and prototype development in the labs and therefore requires the students' presence on campus. On the other hand, a substantial amount of work does not require actual physical meetings. This includes reports writing (proposal, 2 progress reports, weekly memos, and a final report), sharing research work and other communication. The author has been teaching this course for the last 4 years. End-of-semester assessment from carefully designed surveys consistently indicated student difficulties managing their time. This is partly due to demanding coursework, and work outside. Typically, students try to use the week of Spring Break to "catch up." However, many of them are then off campus. As a possible improvement, the author with the help of DTS (Division of Technology Services), has introduced the formation of virtual online groups whereby each group shares editing capability and the possibility of videoconferencing. This is especially helpful, during Spring Break, and for commuting group members. It permits the efficient completion of report writing, It was expected that this will lead to improved time management and efficiency, while making it easier for groups to manage and complete their projects. Assessment is based on a carefully designed anonymous survey of the students, and quantification of improvements in student performance. Results so far are encouraging. The above approach is a good example of a hybrid approach to online project-based education.

Introduction

Every spring semester, for the last 4 years, the author has been teaching Electromechanical Design (ELEC 461). This is a junior–level design course required in the interdisciplinary electromechanical engineering program at Wentworth Institute of Technology. The electromechanical engineering program is a faculty-driven, high-quality EAC-of-ABET accredited five-year interdisciplinary electromechanical engineering program [1]. It was established in 1992 at Wentworth Institute of Technology. Under EAC rules, the electromechanical engineering program had to simultaneously meet the accreditation criteria for electrical engineering and for mechanical engineering. The graduates of this program are true interdisciplinary engineers proficient in tackling interdisciplinary projects in all their electrical and mechanical complexity. In addition, the graduates have excellent laboratory and machine shop skills. Recently [1]-[2], a biomedical systems engineering specialization was established in the form of a concentration within this well established electromechanical engineering program.

In addition to its interdisciplinary approach, the electromechanical engineering program along with the biomedical systems engineering concentration is primarily project-based. This is done as follows: in the 2nd semester of their freshman year, students enrolled in the program take a freshman introduction to engineering design course, ENGR 160, having 4 credits (2 lecture hours, 4 lab hours). In the spring semester of their junior year (3rd year), students take a 3-credit junior-level design course (ELMC 461) having 1 lecture and 4 lab hours (in the form of consultations) per week. This course *integrates* the knowledge acquired in their previous courses into the design of a full prototype of an original product. The following is the Wentworth catalogue [4] description for ELMC 461:

> *Students work in teams to design and construct an interdisciplinary project. Teams, with clearly defined individual responsibilities, are required. During the course of the semester, each team undertakes the necessary activities to bring about a successful design project that is well understood, documented, and presented in both oral and written form. Emphasis is placed on research, innovation, project management, decision-making, prototyping, design for manufacturing, design for testability, environmental and ethical issues in design, depth and breadth of analysis, quality of hardware, documentation, and communications. Prerequisites: Junior Status; ELMC160 Electromechanical Design I; MECH302 Mechanics of Materials; ELEC244 Digital Systems; ELEC443 Analog Circuit Design.*

Students are subsequently required to take 2 semesters of capstone design course (8 credit hours), ELMC 831 and ELMC 881, in their 5th year. Therefore, the design projects provide a focus and *integrator* of other, more traditional, courses. This approach has been very successful as is shown by winning numerous competitions, both regional (ASME, IEEE) and national, as well as the high demand in industry for graduates of this program. Over the course of his 4 years teaching the junior-level Electromechanical Design course, the author has been continually assessing the course and introducing improvements. In prior years, this course was taught by his colleague Dr. Loutfallah Georges Chedid. When he first taught this course in 2007, the author inherited an excellent syllabus and approach from Dr. Chedid. Assessment was based on a carefully designed grading system, a comprehensive end-of-semester questionnaire, student evaluations, an end-of-semester summary by the instructor (the author), and assessment of qualified peers who attend the final presentations. The effectiveness of this design course is demonstrated by the generally excellent performance of students and the positive assessment by experienced electromechanical engineering faculty who were present at the final project presentation. Student feedback generally indicated a high level of satisfaction regarding both the amount of multidisciplinary learning achieved as well as its quality. It consistently indicated that the course objectives were fulfilled. On the other hand, students generally indicated they experienced a lot of time pressure and some suggested increasing the number of credits (above the current 3). Some suggested cutting down on requirements such as reducing the number of progress reports (from the current 2) or reducing the semester course load. None of these potential solutions seemed to the author currently feasible. Reducing the number of progress reports, while feasible, would not be advisable as it would affect the quality of communication skills to be learned,

Lately, in his search for a solution, the author has concluded that the course could be more efficiently organized. He looked for a way to help students manage their projects more effectively within the current time constraints. Groups include typically from 3 to 5 members. In the first week of the semester, students are to form their groups and brainstorm for the choice of a suitable group project. This is followed with a formal written proposal and presentation of the proposal. Much of the project work involves testing and prototype development in the labs and therefore requires the students' presence on campus. On the other hand, a substantial amount of work does not require actual face-to-face meetings or students' presence on campus. This includes substantial writing of formal reports (1 proposal, 2 progress reports, weekly memos, and a final report), sharing results of research work and other types of communication. Along with the formal written reports, each group makes a twenty-minute formal presentation. The instructor meets each group once a week at a "consultation" session and also outside regular hours on a need basis. In addition, there are frequent email communications between group members and between them and the instructor, to discuss problems or share information. Aside from this, a one-hour lecture is presented once a week. In this one-semester intense course, time and project management are obviously critical. Because of the multidimensional demands of the projects, typically more than half of the groups end up not completing the expected full prototype for "lack of time," even though their performance may be otherwise excellent. The author has often read student comments in their course evaluations such as this: "all we needed is another week of testing." Typically, students try to use the week of Spring Break to "catch up." However, most of them are then off campus, which limits severely what they can do.

As a possible improvement and solution, the author, with the help of DTS (the Division of Technology Services), has introduced an online structure of virtual groups whereby each group shares real-time editing capability and the possibility of videoconferencing. In the author's mind, this would be especially helpful, during Spring Break, for commuting group members, and for the many students who work off campus. It helps students to save time and more efficiently complete their reports. It was expected that this would lead to improved time management and efficiency, while making it easier for groups to manage and complete their projects. The planned assessment [8], [10], [16], [18] is based on 2 carefully designed anonymous surveys of the students, at midterm and the end of semester, and quantification of improvements in student performance, including comparison to previous classes. Results so far are encouraging. The above approach may be considered as a good example of a hybrid or blended online project-based education in engineering.

How the online system was developed

Previously, there was no significant online component to this course. The author had used Blackboard [5] minimally while teaching this course in the past, essentially to post relevant information such as syllabi, announcements and short tutorials of general interest on topics such as microcontrollers, motors, and servos. However, the author had no other experience or knowledge of the state of the art in online education and technology, especially the part relevant to the design course of interest. The author asked himself and set to answer the following questions:

- What is the state-of the art in online technology?
- What technology is most appropriate and how does it work?
- What is the experience of faculty in other institutions?
- How can online education be integrated to the interdisciplinary electromechanical design course?

To answer the third question, the author has carried out extensive research by studying professional journals [6]-[18].and attending workshops provided by Cristy Maldonado and Ron Frattura of DTS at Wentworth. This research and workshops convinced him that online education satisfies a real need, is rapidly growing, and will probably be a significant component of higher education in the future. He also concluded that, depending on the particular course being taught, the optimal solution in the future would generally be a “hybrid” solution, combining on-site and face-to-face education, as in traditional college settings, and online education. Many courses may be entirely effectively provided online such as in some current reputable online MBA programs [19]. It became also clear to the author that a significant segment of the population will be well served by online education, especially adult learners, but also younger students who are capable but cannot afford the costly education of traditional colleges and universities. His research also indicated that online education so far typically dealt with lecture-based courses, and when a lab component is included it is in the form of simulations [14].

Based on his research, and because the interdisciplinary electromechanical engineering program at Wentworth is unique [1]-[2], the author concluded he had to custom design an approach suitable to this program. He estimated that probably half or more of the activities, involved in electromechanical design do not require a face-to-face meeting or real-time synchronous communication between team members. For example, the editing of reports and memos, and the project literature research. On the contrary, online communication is probably more effective because of its flexibility, especially for the large number of students who have at least one job off campus, in addition to their demanding semester schedule. On the other hand, the building of product modules and testing requires some physical presence on campus to use lab facilities. Convinced of the potential benefits of the introduction of online education into the course, the author started by attending two workshops provided by Cristy Maldonado and Ron Frattura of DTS, in order to educate himself in the state-of-the-art technologies. This was followed by several consultations with them regarding the most suitable technologies to use.

The virtual infrastructure:

Based on the above research, workshops, and consultations, the author developed the following plan in his current (Spring 2009) teaching of Electromechanical Design:

1- Use Blackboard for general announcements and as a resource for relevant tutorials and information of general interest to the class. In other words, in the author’s mind, use Blackboard essentially as an online specialized library for the group projects. The reason is that Blackboard could not provide all the functionality required of group projects such as simultaneous online editing of documents. Actually, some other open-source software packages [31]-[32] seem to be more suitable in that respect.

2- Create a "Google Docs" website in the Google Apps that is affiliated with Wentworth with the instructor as "owner."

Google Docs [20], [21] is "*a free, Web-based word processor, spreadsheet, presentation, form, and data storage service offered by Google. It allows users to create and edit documents online while collaborating in real-time with other users*" [21]. Google Apps [22], [23] is "*a service from Google for using custom domain names with several Google products. It features several Web applications with similar functionality to traditional office suites, including: Gmail, Google Calendar, Talk, Docs and Sites*"[22]. The Education edition is free and provides 7 GB space for emails. After the site was created by the author, he constructed 2 *virtual sections* in the form of folders one for each section (ELMC461-01 and ELMC461-03). Within each virtual section, he created 7 subfolders in ELMC 461-01 and 6 subfolders in ELMC 461-03. Each subfolder represents the virtual space allotted to each group project. No student is allowed access to another group space. The instructor (the author) named the subfolders with the respective project names. The author then proceeded to "invite" all group members to their respective group project, giving each group member editorial rights. He also provided a link to an online Google Docs video explaining how Google Docs works [24].The instructor is a team member in each group project. This was done not only to monitor student progress but also to better communicate relevant information between group members and the instructor. Earlier in the semester, the instructor asked each team to elect a "project leader" or "coordinator" to facilitate communication both within groups and between groups and the instructor. Group leaders are also tasked with making sure the online group operation works effectively and report any difficulties encountered to the instructor. Prior to his invitation, the instructor discussed the online plan in a session involving all group leaders who were tasked in turn to report to their respective groups. Groups were expected to put all information regarding their projects in creatively labeled folders in their respective virtual space. While this online structure is implemented, students were also encouraged to contribute with any ideas they may have. One primary objective was that the structure be in place prior to Spring Break so students will be able to use it during the break.

Next, the author wanted to expand this online format to create a comprehensive and effective model that would incorporate videoconferencing. Further research and consultations with Cristy Maldonado and Ron Frattura of the DTS showed that Google Docs, while quite effective for online asynchronous and synchronous communication and real-time editing, does not provide opportunity for videoconferencing. There are many videoconferencing technologies [25]-[30]. DimDim [26]-[27] was chosen for the following reason: It is free and suitable for groups of up to 5 members. Beyond this number, it is not suitable because of limitations on the bandwidth. Therefore, groups could videoconference at any time following an email invitation by the group leader. The author then invited Cristy Maldonado and Ron Frattura to conduct a 45 minutes workshop in class to demonstrate to the students how to use DimDim prior to going on Spring Break. The level of interest by students was evident.

The author went further by introducing videoconferencing at the class level. Cristy Maldonado and Ron Frattura of the DTS recommended the use of Adobe-Connect [28]-[30] as their experience indicated that it is a quality videoconferencing software that can accommodate numbers larger than the class size (currently about 25) and has good bandwidth and more functionality than DimDim. This software was demonstrated to the author who deemed it suitable. In addition, this proprietary software is available at Wentworth. Videoconferencing at the class level may be used for lecturing and for meetings between the instructor and the 13 group leaders. Though not tried yet, this format will be tested before the end of the semester. The author created, in parallel, a virtual space reserved for his communications with group leaders. He invited all group leaders to this virtual space.

Assessment:

Assessment is performed as follows [8], [10],[16],[18]: From the instructor's point of view immediate benefits were obtained as soon as the online structure was completed. He has been incorporating some articles discovered in his research relating to particular projects into their respective virtual space in a folder which he uploaded. Without the Google Docs virtual infrastructure, he would either have waited many days until consultation time to report the articles or email the articles which is time consuming and not efficient. Another advantage both for the instructor and group members is the ability to share all relevant information with anyone anywhere there is an internet connection. The instructor himself experienced this benefit as follows: During a weekend he visited a friend, a senior engineer specializing in radars, and consulted with him regarding a particular project involving the design of a collision-avoidance system for the MBTA (Massachusetts Bay Transportation Authority). The author spent a good hour discussing the possible solutions. At that time the Google Docs site was not set up yet. In retrospect, having the site would have facilitated significantly the discussion, by simply logging in and reviewing the group project proposal with him. Another example is a group of students involved in the design of a leg brace for injured horses. Recently, they visited a professor of veterinary medicine at Tufts University, some 30 miles from the Wentworth campus, to consult with him regarding their project. These students could more efficiently communicate with the professor because of their ready access to their virtual project space in the Google Docs website.

On an anecdotal basis, the instructor (the author) met with the above-mentioned MBTA collision avoidance project members, one day after their presentation of their first progress report, in order to discuss their project. They stated that they were happy about the initiative and that it helped them save time in their writing of the progress report and memo. There has not been enough time so far for getting comprehensive feedback from students. A comprehensive questionnaire has been distributed recently at midterm and another one will be distributed at the end of the semester, by April 30. This questionnaire focuses on quantitatively and qualitatively gauging student satisfaction level with all aspects of this online initiative, and analyzing their comments on ways they propose to improve it. Based on this feedback, the author will refine the above proposed model.

Conclusion:

In order to improve the teaching of the interdisciplinary junior-level electromechanical design course, the author has developed a hybrid model by integrating an online model to the traditional interdisciplinary project course structure. This online model partly involves the use of

Blackboard as a virtual repository of information of general interest such as syllabi, announcements and tutorials. But, the specificity of the model is the online virtual group structure. This involves a Google-Docs site "owned" by the instructor, where each group is "invited" to its specific virtual space, the instructor being a member of all virtual groups. Group members have editorial rights but can access only their respective group space. They may edit powerpoint-like presentations and spreadsheets within Google Docs and upload or export all types of multimedia files. In addition, free videoconferencing using DimDim [26]-[27] is available for each group. Class level videoconferencing is incorporated by using the proprietary videoconferencing software Adobe-Connect which is available at Wentworth. In the future, the required functionality of Blackboard may be integrated into the Google Docs site.
In principle, the class-level videoconferencing may be used to replace the face-to-face weekly lectures. Assessment so far, though limited, indicates student interest and satisfaction, as well as a perceived efficiency by the instructor in his own interaction with the groups. The above model will be fine-tuned based on student feedback. This model provides an integrated online infrastructure that may not only be used to enhance the design and student experience, but also to lay the foundations for possible future online or hybrid interdisciplinary project-based courses. It may also be used in the teaching of the capstone design course in the 5th year. The author, who is scheduled to teach a section of capstone electromechanical engineering design in Fall 2010, plans to use this model.

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