AC 2012-5180: TRANSFORMING A LARGE-ENROLLMENT, ENGINEERING STATICS COURSE INTO QUALITY ONLINE INSTRUCTION BY ADAPTING PROVEN INSTRUCTIONAL STRATEGIES

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Transforming Large-Enrollment, Introductory Engineering Classroom into Quality Online Instruction by Adapting Proven Instructional Strategies

Background

In recent years there have been growing interests of promoting quality learning in engineering. Engineering professors have increasingly shown presence in educational publications and conferences to demonstrate their efforts to improve teaching and to provide better educational values to their students. The attentions and efforts for quality education in academia have led higher-education administrators and professors to examine conventional engineering teaching.

Emerging technologies and a global movement toward outcomes-based program accreditation such as ABET (the U.S. Accreditation Board of Engineering and Technology) progressively mandate changes and improvements of the traditional engineering education design and delivery. However, frameworks that would advance engineering education are rarely found in practice. Research in other disciplines such as education and educational psychology indicates better teaching methods facilitate learning more successfully than the traditional lecturing approach that has been dominant in engineering education.

One of the prominent instructional practices in the STEM fields (Science, Technology, Engineering, and Mathematics) is the minimally guided approach that has been referenced by various names such as discovery learning, problem-based learning, inquiry learning, experiential learning, and constructivist learning. After conducting a thorough review of former studies and literature, Kirschner and others concluded “minimally-guided instruction is less effective and less efficient than instructional approaches that place a strong emphasis on guidance of the student learning process.” Especially the minimally guided instruction would not be well suited for those who need fundamental understanding of knowledge and application that are typically covered in the intro-level engineering curriculum.

Hall defined explicit instruction as “a systematic instructional approach that includes set of delivery and design procedures derived from effective schools research merged with behavior analysis.” Hall also addressed two essential components to well-designed explicit instruction:

(a) Visible delivery features are group instruction with a high level of teacher and student interactions
(b) The less observable, instructional design principles and assumptions that make up the content and strategies to be taught.
According to the teaching guide provided by Saskatoon Public School, explicit teaching enables teachers to direct student’s attention to specific learning in a highly structured environment. Students work on tasks for topics and contents organized in small portions and delivered in a logical order. They are guided to explain, demonstrate, and practice until they achieve mastery of learning.

Mastery learning is not a new instructional method. Davis and Sorrel stated that mastery learning is “based on the concept that all students can learn when provided with conditions appropriate to their situation.” In the mastery learning setting, learners are guided and encouraged to reach a predetermined level of mastery before progressing to the next.

**Challenges and Motivations**

The authors faced challenges with the introductory engineering statics and elementary strength of materials course in the traditional format. In a typical lecture-hall like classroom filled with over 200 students per semester, an instructor lectures with heavy scripting and drawing on a chalkboard and occasional demonstration of mechanical objects such as scaled-down models. Since the fundamental theories and applications of engineering statics and elementary mechanics must be covered within one semester, the instructor always rushes through a massive amount of content and a wide range of basic concepts in shallow depth. Even though the instructor is trying to interact with students more actively, it is very difficult to interact with the entire class. The students get bored and distracted easily and it is even more challenging for those who sit far from a podium to follow the instructor’s explanation of mechanical processes drawn on a chalkboard.

The instructor teamed up with an instructional designer and overcame the aforementioned challenges by adapting proven instructional strategies in transforming the large-enrollment, introductory engineering course design and delivery. Due to increasing enrollment rates of the introductory engineering courses and the growing global market for educating prospective engineering students, the team considered a flexible and expandable course delivery option.

During the spring of 2011, the authors developed an online course for the introductory-level engineering course, Statics and Elementary Strength of Materials that has been taught in a traditional lecturing format. As discussed in the literature review, there are no findings of a validated framework that can be well adapted in engineering education. However, the authors believe that proven instructional strategies applied in other disciplines can be applied in the engineering education as well. The strategies from explicit instruction and mastery learning were implemented in redesigning the course.

**Online Course Design and Development**
The redesigned introductory engineering course was offered fully online as a pilot section during the Fall 2011 semester. In a weekly-based structure, the course consisted of 15 main topics. The learning process is automated with a mastery-learning framework in which a predetermined level of success in each progressing stage precedes to the next.

Figure 1 illustrates how the learning process for the Fall 2011 semester is laid out. It starts with the instructor’s notes that provide an overview of the week by highlighting main concepts and important points. Following with learning objectives specific to the designated week, students work on learning materials such as chapter readings, basic concept demonstration videos, problem-solving demonstration videos, publisher’s resources, and web resources. The practice session through a reading quiz in Blackboard\textsuperscript{TM} and an assignment in the publisher’s homework system are setup with unlimited attempts and prompt feedback. In the newly developed test bank, the questions are sorted based on three difficulty levels (easy, intermediate, and difficult) and a randomly selected question set is generated for a weekly test. A weekly Q&A forum is setup so
that students can interact with each other any time and share common troubles they experience in the course.

Based on the feedback from the pilot period, the authors revised the course, as shown in Figure 2, to improve the learning process. The major revision includes excluding the use of publisher’s homework system and reorganizing learning activities to be more logically sequenced.

Figure 2. Revised Learning Process for Spring 2012
During the pilot phase, it was discovered that an independent execution for a problem-solving activity as an assignment using the publisher’s homework system created serious disconnection between learning contents and the problem-solving activity. Since the assignment was conducted separately, it was difficult to seamlessly include it in the mastery learning process. In addition, students expressed frustration with the problems of the publisher’s homework system in which the way the problems are setup is not as intuitive as students can do without additional help.

Figure 2 shows how the learning process is revised for the Spring 2012 semester. Beginning with learning objectives of the week, students start working on the main concept related learning materials such as chapter readings, basic concept demonstration videos, and web resources. And then, they reflect on their understanding of main concepts by trying out a reading quiz that has been revised to focus on main concepts of the week. When they complete the reading quiz with 100% success, the access to an assignment is released. The second part of learning materials such as instructor’s notes about important points, problem-solving demonstration videos, and publisher’s resources is tied into a problem-solving activity through an assignment in Blackboard™. When students achieve at least 50% of success on the assignment, the access to a weekly test is released. The 50% success on the weekly assignment is determined so that a moderate level of understanding is accomplished without making it prohibitive for students to get to take a weekly test, which carries a large weight of the total grade. The weekly test is timed and available only during a certain period of time every week in order to encourage students to stay on task in a timely manner.

In order to improve facilitating students’ coursework better, help sessions are setup daily by assigning a designated teaching assistant in each day to check on a weekly Q&A forum and respond to posted questions within 24 hours. The instructor regularly uses the early warning notification tool available in Blackboard™ to monitor students’ current status and provide early intervention accordingly.

**Online Students’ Performance Improvement at Mid-Point**

The redesigned course has been offered fully online only for the first time during the Spring 2012 semester. This study is currently in the mid-point of the Spring 2012 semester and a proctored midterm exam has been conducted during the second week of March in 2012 which is the 8th week of the 16-week academic calendar. According to the comparison of midterm grades between the face-to-face section of the Fall 2011 semester (n = 213) and the fully online course of the current semester (n = 191), the online students (M = 172.29, SD = 30.14) performed better than the in-class students (M = 163.39, SD = 36.20), t (400) = -2.70, p = 0.007, two-tail.

**Student Feedback from Pilot during Fall 2011**
During the Fall 2011 semester, students in both a face-to-face section and a pilot section were asked to participate in the study that reflects on their experience of the course delivery. An anonymous survey was disseminated and the participants received extra credits for their submission. The purpose of the survey administrated in both sections was two-fold. First, the responses from a face-to-face section will be referenced to compare with those from a current online course of the Spring 2012 semester. Second, the feedback from a pilot section was reflected on improving the online course delivery. In this paper, the authors discuss the students’ feedback considered for improvement as is summarized in the following.

The number of total responses from the pilot section were 23 consisting of 95.652% of males and 4.348% of females. The participants were fairly distributed in three class years: sophomore (39.13%), junior (34.783%), and senior (26.087%). The majority graded their computer literacy to be either good (34.783%) or excellent (43.478%) as well as Internet literacy to be either good (26.087%) or excellent (52.174%). 69.565% of students took an online course for the first time.

The survey was designed with open-ended questions intentionally to receive comprehensive feedback. The participants were encouraged to freely express their opinions based on guided questions (see Appendix A).

Overall, students spent 3-13 hours per week (Monday to Sunday) on the course. Most students perceived their time spent on the coursework was valuable and they learned a lot. Interestingly, some students commented on the better quality of the course comparing to other face-to-face classes they took concurrently. The majority liked the clear/straightforward framework of the course as well as instructor’s problem-solving demonstration videos. They expressed that the weekly Q&A forums were useful, but also complained of delayed responses. They liked flexibility on schedules they can manage by themselves, but it also surprised them how hard it was to stay on task in a timely manner every week.

The major problem that most students got frustrated was technical misconduct in a weekly test. It seemed the tests setup in Blackboard™ generated frequent errors on inputs for a calculated formula-based type of questions.

**Conclusion**

The online course is currently being implemented in the Spring 2012 semester. It is planned to conduct the same survey that will be disseminated at the end of the semester. The responses will be referenced to compare with the students’ experience from the face-to-face class in the Fall 2011 semester and will also be considered for future improvement. One of the revisions currently in-progress based on the student feedback from the Fall 2011 semester that is not addressed in this paper in detail is changing the setup in a weekly test. However, due to a limitation for
modification on a proprietary system like Blackboard™, the authors have been considering an open-source option such as Sakai for an alternative course management system.

The continual study discussing the comparison of in-class and online students’ experience and the further analysis on student performance improvement using both midterm and final exam grades of face-to-face and online courses will follow up later on.

Building best practices of quality online instruction in engineering education is relatively new. The authors perceive the value on promoting new ways of better teaching in engineering and intend to contribute the lessons learned from their own practices to the community.

**Appendix A: Guided Questions for Course Evaluation Survey**

Q: Describe your time commitment for this course considering the following questions:
   • What was the (average) amount of time you spent on this course per week (from Monday to Sunday)?
   • Was the time you were spending in the course valuable?

Q: Describe your opinion of the course content considering the following questions:
   • Whether or not you were interested in the material, did you learn something in this course?
   • Was there anything more you wanted to learn about [main topic of the course] related topics?
   • What part of the course did you find most useful/interesting?
   • Was the course delivered in a clear and understandable direction?

Q: Describe your experience of help/support considering the following questions:
   • How useful was the weekly discussion board for answering questions?
   • Have you participated in virtual office? If so, was it useful? If not, why didn’t you consider using virtual office hours?

Q: What were the biggest/most frustrating technical problems which you encountered during the course? Any suggestions for ways in which you might become more familiar and comfortable with the technology used for the delivery of this course?

Q: What did you like about the course?

Q: What did you dislike about the course?

Q: Any other comments for improving the course delivery?
References


