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Substitution of Lectures in Applied Statics Course With "Open Learning Initiative" Web Resources

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Introduction

Statics is considered a foundational course in the mechanics sequence of many engineering and engineering technology programs, including the fields of mechanical, civil, and aeronautical. It is the focus of much instructional development because students frequently struggle to master the content of this pivotal course. Among the many classroom innovations that have been explored in recent years for engineering education is online delivery. Since its beginning, moving engineering coursework online has had its challenges[1]. Yet these many efforts have seen some success, and the instructional development has increasingly focused on trialing and evaluating online approaches to engineering mechanics, including statics[2].

Purdue University's School of Engineering Technology has faculty at a number of locations around the state of Indiana, where it offers its degree programs. The faculty were charged with investigating possible distance delivery of department courses, to provide more flexible and effective instruction to their dispersed students. This effort identified lecture components of a number of offerings that might be coordinated and delivered online by faculty from any one of the sites. The three-credit Applied Statics course was seen as one that might be amenable to such an approach. Freshmen generally enroll in the course during their second semester. Its authorized, weekly formats are (1) three hours of lecture and (2) two hours of lecture with a two-hour problem-solving recitation session.

At the Richmond location, the Applied Statics course was targeted for transition toward online delivery. The course in Richmond has utilized the lecture-recitation structure. Students are assigned homework over the content and the homework solutions are provided the following week for rapid feedback. A take-home quiz follows that feedback, such that the students are typically working on homework while completing a quiz over the previous week's content. Tests over the material follow any related quizzes.

Applied Statics is offered only once per year in Richmond, with typical enrollment of ten to fifteen students. Thus, measuring and analyzing the effects of instructional changes can be quite challenging.

Approach

The review of support resources soon identified the Open Learning Initiative (OLI), established in 2002, at Carnegie Mellon University. Through grants from The William and Flora Hewlett Foundation, The Bill and Melinda Gates Foundation, The Kresge Foundation, The Lumina

Foundation, The National Science Foundation, The Spencer Foundation and The Walter S. Johnson Foundation; the OLI group developed a collection of online course materials based upon current learning science (http://oli.cmu.edu/get-to-know-oli/meet-our-sponsors/, viewed January 1, 2014).

The Engineering Statics course on OLI was developed by Dr. Anna Dollár (University of Miami–Ohio) and Dr. Paul Steif (Carnegie Mellon University), initially via a National Science Foundation grant[2]. The online course is available without cost to students and instructors.

The OLI-hosted statics content is currently organized into twenty modules, within seven units. Learning objectives are clearly defined for each portion. Modules include introduction and summary sections to help students process and retain the content. Concepts and problem-solving procedures are presented, along with example solutions and video clips. The course includes numerous opportunities for the students to practice their technique using well designed, interactive exercises and problems. The webpages provide instant feedback and multi-level hints to further assist those students who request it. The OLI statics course includes end-of-module quizzes for registered students and a personal dashboard for them to monitor their learning and performance. The faculty can monitor the class' scores on a similar dashboard, with the ability to quickly drill down into the performance data, to examine the details of a particular quiz problem or of a particular student.

The OLI statics online resources have been used in many different ways. Students have found and visited the free website as a tutorial or supplement to their course textbook. Often statics instructors will intentionally encourage their students to refer to it for additional assistance. Some instructors have chosen to replace the course textbook outright with OLI's interactive statics content. One well executed approach by S. A. Sorby and C. R. Vilmann at Michigan Technological University[3], fully replaced the lectures with OLI resources and a weekly, one-hour question and answer classroom session. Papadopoulos and Roman[4] have explored its potential use with bilingual students. OLI has proven to be a versatile learning resource for developing statics instruction.

After concluding that OLI incorporated excellent learning research and interactive features, we selected its Engineering Statics course for use within the Purdue course. It should be noted that the many years of investment in the OLI website by Dr. Anna Dollár and Dr. Paul Steif have provided an economical, yet credible, alternative to textbooks and video-recorded faculty lectures.

Course Design

Purdue's course was not planned as a typical "flipped" class, in which the content is delivered online and the full lecture time utilized for other purposes. In this initial use, OLI replaced the lecture component entirely. Thus, OLI then was primarily used to effectively teach the concepts of statics. The course planning identified two topics that were no longer in the current Purdue course requirements and they were deleted. This helped to fit the OLI modules into the semester calendar at Richmond, approximately two per week. The instructor personally completed the modules to get a sense of OLI from the students' perspective and of the relative times they might need to complete them. Some modules required much more time than others, and the walk through helped confirm a reasonable module schedule. Throughout the semester, the instructor monitored OLI usage and quiz scores. At the end of each OLI module, the students completed the online quiz and the online instructor feedback form.

The Purdue course was deemed a hybrid, in that while the two-hour lecture was considered to be delivered online, we retained the weekly, in-class, problem-solving recitation sessions. Students generally learn to solve engineering mechanics problems best by personally working through them one by one. As in previous years, the students solved the assigned recitation problems in small groups, overseen and guided as needed by the instructor. The problems aligned with the most recent OLI modules the students had completed. The instructor reviewed the quiz scores and response forms from those modules prior to the recitation sessions. He then responded to specific questions raised, without re-presenting the OLI topics. Where possible, the instructor also incorporated clarifications into the guidance of the recitation problem solving.

The recitation sessions were scheduled on Thursdays. In previous years, the lectures would have been on Tuesdays. Those Tuesday slots were converted to "open office hours", in that the instructor would be available in the classroom, with OLI access, to answer questions. The OLI module quizzes (typically two each week) were scheduled to straddle the Tuesday Q&A and the Thursday recitation sessions. This provided convenient opportunities every week for the students to get answers to their questions shortly after each OLI quiz.

The students were required to buy the two textbooks used in previous years. One was a traditional statics textbook; the other was an economical book of distilled concepts and worked problems. The students had required readings from both books, aligned with each module. Assigned homework problems came from both textbooks as well.

As with others who have utilized OLI's Engineering Statics course for content delivery, there were required topics that OLI did not provide. For the Purdue statics course, these were internal loading and shear-moment diagrams. The instructor chose to move those to the end of the semester and provide them as traditional lectures, blending them with recitation activities in both the Tuesday and Thursday time slots.

The order and duration of the OLI topics and the amount of "module-time" associated with each required that the actual content of the tests and final exam be somewhat differently distributed, relative to previous years. The placement of the two traditional lectures at the semester end was another cause for this assessment redistribution. The content of these two lectures had been assessed in the third test and final exam previously, and with OLI were only addressed on the final exam.

Results

In reviewing the results of this adaptation of the Purdue course, one quickly notes that the implementation necessarily altered a number of important variables. Also, the most recent potential comparison group of previous students would be a full year earlier, before the decision to incorporate OLI resources. Few focused comparison measures were in place. Further, the number of students enrolled in Richmond statics sections does not enable dividing them into concurrent sections for comparative analysis. Even without splitting the section, the low enrollments do not support statistically valid conclusions. Such is the constraint of a degree program with small numbers of students and yet seeking continual improvement.

However, a review of the earned grades and student feedback may provide helpful information for those considering options in transitioning to online statics delivery using OLI. Indeed, the dynamics involving a smaller student cohort may be a greater factor for some institutions than a comparison with large-enrollment sections.

As noted previously, the overall course content varied slightly from earlier (non-OLI) offerings. The distribution of content among the three tests and final exam also changed with OLI. Table 1 shows the scores from the OLI course and the four previous statics classes. All course offerings had the same instructor and grader. Comparing the averages of the three tests, the use of OLI showed an average of 70.9%, within the range of recent scores and above the average of the four prior years (66.2%). The comprehensive final exam was 61.9% using OLI and 58.5% previously, again comparing favorably with the range of previous offerings. Averaging all four yielded similar results of 68.6% for the OLI class and 64.3% previously. It should be noted that other factors, including student quiz and homework grades, typically boost the final course grade calculation significantly.

This comparison indicates that the students who enrolled in this first Purdue statics course with OLI for their lecture component exited the course with understanding comparable to previous students. Just as important, the initial trial with OLI did not show significant decreases in assessment scores.

Applied Statics	Test 1	Test 2	Test 3	Final Exam		Avgs of Tests	Avgs of All
OLI 2013	**71.7**	**64.8**	**76.1**	**61.9**		**70.9**	**68.6**
Non-OLI 2012	66.8	79.4	72.4	65.6		72.9	71.1
Non-OLI 2011	67.2	80.1	50.4	59.3		65.9	64.2
Non-OLI 2010	44.7	68.1	39.3	38.9		50.7	47.8
Non-OLI 2009	73.3	83.9	68.6	70.3		75.3	74.0
Non-OLI Averages:	**63.0**	**77.9**	**57.7**	**58.5**		**66.2**	**64.3**

Table 1. Comparison of Proctored Assessment Averages (Percentages)
Applied Statics—Purdue SOET Richmond

Student feedback generally spoke of the same challenges previous statics students have had, yet some reflected the use of OLI to deliver content. Some feedback distilled from OLI's My Response component:

- Frustration with the variation in difficulty among the OLI modules. Sometimes feeling rushed to complete an unexpectedly long module.
- Differences between the instructor's approach/terminology and that of OLI (e.g., clarifying whether a force is on the truss pin or the member).
- Students occasionally thought that some OLI quizzes didn't align well with their modules.
- Students often related that OLI quiz scores didn't reflect what the students perceived as their level of understanding. [Often due to careless student errors.]
- Students reported that OLI helped them with the statics concepts, but they were much less confident about their corresponding problem-solving abilities.
- Students reported returning to and reviewing the material when their first pass through left them concerned about their comprehension.
- Students consistently stated that OLI's interactive components were very helpful.

As with the use of most any content delivery supplement, OLI resources did not perfectly align with local instructional preferences. Most of these were deemed unimportant, while some were addressed by the instructor. Similar to textbooks, these issues fell into familiar categories:

- ***Concept Emphasis.*** The extensive OLI modules included a variety of information on each of the topics. The inherent limitations of web pages made it somewhat difficult for the instructor to de-emphasize subtopics of lesser importance to the students. For example, in the particular Purdue course, the students could have invested somewhat less OLI module time in the following subtopics: full versus static equivalence, validity of 2-D analysis, nonuniform distributed loading, join pin analysis, and parametric analysis. Then again, the students could have benefited from additional OLI content in centroids of composite areas.

- ***Terminology and Labeling.*** Instructors may have course conventions that differ from or supersede those of the textbook, or website in this regard. For example, OLI uses "AB" to designate both a truss member and its internal load, and uses "S" to designate a force from a spring,
- ***Process Details.*** OLI incorporates approaches that effectively serve a multitude of users. And yet it is difficult to meet everyone's needs. For example, while OLI generally uses scalar analysis it only occasionally utilizes vector analysis or calculus. On the other hand, there is no acknowledgement or use of the classic g_c constant, important to some instructors. Expectations for students regarding starting equations and solution formatting vary among instructors, and thus potential users may want to review OLI's problem-solving details.

Student feedback consistently noted the challenges in reconciling OLI and instructor approaches. As noted, these issues of instructional preference are also seen with the use of course textbooks. However, to the extent that online statics resources are used in lieu of classroom time, there may be fewer opportunities with the students to respond to these issues or compensate for them.

Conclusions

In a low-enrollment statics course, we successfully substituted a lecture component with the OLI Engineering Statics resources, while retaining in-class recitation sessions for problem-solving. In this first trial with limited enrollment, the proctored test score averages were comparable to previous classes. Given the limited data and lack of a concurrent control section, the results are understandably mostly qualitative.

Student reactions to the online OLI content were generally positive. The steady flow of student feedback mostly reflected the same frustrations of past students as they learned statics concepts and applications. Yet the perspectives of students who completed the OLI-based course did point out some important issues that instructors should keep in mind:

- Scheduling of the course content should reflect the large variations in time required to complete the OLI modules.
- Instructors use different terminology and techniques. Provision should be made to minimize issues related to differences between the instructor's and OLI's approaches.
- OLI is effective in statics concept instruction, but less so in developing problem-solving skills. Students still need to practice such skills, preferably in interactive settings, such as study groups or class recitation sessions.

The OLI Engineering Statics course is a valuable asset in developing statics instruction. Its interactive design is an effective means of instructing statics concepts. With time- and cost-conscious faculty looking for ways to "flip" courses by moving content delivery online, OLI's free resources become an attractive alternative to developing online materials in-house. Students see reduced costs too when OLI serves as the course "textbook". It is clear from the author's experience that with repeated use, instructors will find ways to make use of the OLI statics resources increasingly effective.

References

1. Ibrahim, W., & Morsi, R. (n.d.). Online Engineering Education: A Comprehensive Review. *"Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition.* American Society for Engineering Education.
2. Dannenhoffer, J., & Dannenhoffer, J. (2009). An Online System to Help Students Successfully Solve Statics Problems. *Proceedings of the 2009 American Society for Engineering Education Annual Conference & Exposition.* Austin, Texas: American Society for Engineering Education.
3. Dollár, A., & Steif, P. (2009). Web-Based Statics Course Used in an Inverted Classroom. *Proceedings of the 2009 American Society for Engineering Education Annual Conference & Exposition.* Austin, Texas: American Society for Engineering Education.
4. Sorby, S. A., & Vilmann, C. R. (2011). Going Online with Statics. *Proceedings of the 2011 American Society for Engineering Education Annual Conference & Exposition.* Vancouver, British Columbia: American Society for Engineering Education.
5. Papadopoulos, C., & Roman, A. S. (2010). Implementing an Inverted Classroom Model in Engineering Statics: Initial Results. *Proceedings of the 2010 American Society for Engineering Education Annual Conference & Exposition.* Louisville, Kentucky: American Society for Engineering Education.