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Preliminary Assessment of the Emporium Model in a Redesigned Engineering Mechanics Course

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ABSTRACT

A lecture-based engineering mechanics course (Statics) is redesigned using the Emporium model. Whereas students study the material outside of class via asynchronous online delivery of the content and instructional videos, they do all the other activities (e.g., assignments, tests) either individually or in groups inside the classroom. Computer- and experiment-based assignments are used to engage students in active and collaborative learning. While supervising all the in-class activities, the course instructor and the learning assistants offer guidance to students as requested. Following a successful pilot study in spring 2009, all sections of the course were converted to the Emporium model and coordinated by the same instructor. The learning outcomes in the Emporium-based Statics and student grades in two subsequent courses are compared to those using the lecture-based approach. Details of the course redesign, learning outcomes, and student perceptions are presented to reveal opportunities and challenges in adoption of this model in other engineering courses.

Key Words: Course redesign; Emporium model; Engineering mechanics

INTRODUCTION

In an effort to enhance learning, many educators have successfully developed and integrated multimedia and computer technology in engineering education [1-7]. Some of these tools are used to enhance the traditional (face-to-face) lecture format whereas others provide a framework for fully Web-based (online) or blended delivery of the course content. Although these tools help to diversify the delivery of instructional materials, the pedagogical paradigm of lecture-based instruction (on campus or distance) remains the same. Studies have shown that adding active and collaborative activities can increase the conceptual learning of students in engineering courses [8].

Many studies suggest that Web-based instruction is as effective as traditional face-to-face lecture approach. Johnson et al. [9] concluded that even though students preferred their experience in the face-to-face course, there was no significant difference in the learning outcomes of the two methods of instruction. Another comparative study [10] showed a small increase in the students' performance in the Web-based class, but concluded that the improvement could be attributed to the slightly higher grade point average of the students in the Web-based course. Using a thorough survey of many comparative studies reported in the literature, Olson and Wisher [11] found that Web-based instruction can actually improve student performance. However, in terms of students' satisfaction with their educational experience, the face-to-face interaction gives the traditional approach a clear advantage over an online or distance instruction [12].

Recent innovations to replace the traditional class lectures with more effective interactive learning sessions have included the so-called flipped, inverted, or inside-out classroom [13-16]. The principal goal is to eliminate the delivery of the course content during the regular class periods in favor of using pre-recorded lecture videos to be viewed by the students before coming to class. This change allows the class period to be used for a multitude of learning activities including discussion sessions, collaborative exercises, mastery quizzes, homework assignments, and team problem-solving sessions among others.

Guided by the innovative approaches developed by the National Center for Academic Transformation (NCAT), several nation-wide initiatives have been implemented to redesign traditional lecture-based courses [17,18]. The *Supplemental*, *Replacement*, *Emporium*, *Online*, and *Buffet* models offer different methods of content delivery and learning assessment for greater flexibility in matching a redesign approach to the course subject. The suggested readiness criteria [17] help identify the course that is suitable for redesign with the highest chance of success. Each redesign effort consists of a pilot phase and a full implementation phase. The redesign initiatives at different institutions have so far targeted such subjects as biology, psychology, history, statistics, mathematics, chemistry, literature, and fine arts. To our knowledge, the present initiative represents the first effort at redesigning an engineering course according to NCAT guidelines.

After examination of the five redesign models, we concluded that the Emporium model is most suitable for application to an engineering course such as Engineering Mechanics I, Statics. The face-to-face communication retained in the Emporium model gives it an advantage over the fully online model when it comes to student satisfaction with the learning environment. As with all the previous redesign efforts, we are pursuing two goals: 1) enhance learning outcomes and 2) reduce instructional costs.

The NCAT recommended guiding principles for successful redesign are as follows: redesign the whole course; encourage active learning; provide students with individualized assistance; build in assessment with prompt (automated) feedback; and ensure sufficient time on task and monitor student progress. This redesign effort adhered to these guiding principles in the implementation of the Emporium model to Statics.

In this paper, we describe details of the redesign effort and the ensuing four-year experience with an Emporium style of teaching. While providing data on the course learning outcomes, grades in two higher-level mechanics courses, and student perceptions, a comparison is made with the historical data from lecture-based instruction of the course.

EMPORIUM MODEL

In the Emporium model, the entire course content is delivered asynchronously online or through other computer-based media outside the classroom. The advantage of computer-based content delivery is that students receive the instructional material on as-needed basis and can review a topic multiple times until they understand it. However, unlike the online model, students actually attend class, but instead of listening to lecture, they perform individual or group activities under the guidance of the course instructor. The principles of active and collaborative learning are reinforced while providing students with more frequent feedback on their learning outcomes assessments.

Another feature of the Emporium model is that a single instructor can teach multiple sections of the same course with relatively large enrollment. Of course, the role of the instructor is changed from one of delivering class lectures to one coordinating the delivery of course content, managing the Emporium activities, and responding to students' questions. As such, a more consistent learning experience is provided to the students in different sections of the same course as students work toward reaching the uniformly specified learning milestones.

The major cost reduction offered by the Emporium model is indeed due to having a single instructor assigned to all sections of the same course, regardless of the number of sections. The assumption is that the cost of a single faculty at the Instructor's or junior faculty rank is less than the total cost of multiple instructors (at different faculty ranks and pay scales) assigned to the same task. Although the Emporium requires the addition of multiple paid learning assistants, the cost is significantly less than that of salaried instructors. Therefore, depending on the number of sections offered in a given semester, the Emporium model could help reduce the instructional costs.

As with nearly all the engineering courses, Statics is traditionally taught as a lecture-based course. Besides introducing various topics, the instructor also works example problems that clarify mechanics concepts while describing the analysis procedure. Much of the learning, however, occurs outside of class as students master the material by working homework problems. This course redesign was based on three integrated activities that can be broadly categorized into pre-Emporium, Emporium, and post-Emporium, where the word "Emporium" refers to "regular class" in this case. While Emporium activities (i.e., working on assignments, taking quizzes) are conducted inside the classroom during the regularly scheduled class periods (50 to 75 minutes depending on the schedule), the pre-Emporium (i.e., studying the course content) and post-Emporium (i.e., working on unfinished assigned problems) tasks are performed before and after regular class periods.

Pre-Emporium Activities

All the course content is introduced via Web-based learning tools as part of the pre-Emporium activities. Since all engineering students at Mississippi State University are required to own laptops with free on-campus access to the Internet, no additional burden is placed on the students in this regard. With the course content divided into nearly two dozen modules, the amount of material students need to study in each pre-Emporium period would require about the same amount of time spent in class listening to a lecture. Pre-Emporium activities consist of reading a particular section of the e-textbook, following the specified hyperlinks to watch tutorial video clips describing each Statics concept and the solution to a number of example problems, and working one or more exercise (practice) problems prior to attending class (Emporium). If students have a question about a topic covered during the pre-Emporium, they have the opportunity to ask the course instructor during Emporium as well as the regular office hours. There is no discussion board or live chat as part of the pre-Emporium activities. However, the students can consult with the instructor during regular office hours or in class.

Since the likelihood of success in this course is rather low for those who do not comply with the pre-Emporium tasks, most students make a serious effort to understand the content before attending Emporium. To ensure compliance, all the students' pre-Emporium activities are initiated through links provided on the course management system Blackboard Vista®, *myCourses*, which makes it possible to record the date, time and duration of each student access.

With elimination of formal classroom lectures, the instructor's role has shifted from giving lectures to responding to questions and more direct interaction with the students in the Emporium setting. However, for various reasons, most students cannot fully understand the course content by simply reading the textbook. They need someone to explain the content, guide them through specific solution steps, and facilitate their understanding of important concepts. Therefore, if not through formal lectures, the explaining part has to be done through other means (e.g., watching recorded tutorials) as discussed below in the Instructional Materials section.

Emporium Activities

In the Emporium model, students are required to attend class as in a traditional course (150 minutes per week). However, instead of passively listening to a lecture, they work on assigned problems. To ensure sufficient time on task, students can only access and work on the assignments inside the Emporium, although they can work on practice problems outside the Emporium.

Computer-based assignments consist of a set of problems assigned to the students from the exercise set in each chapter of the textbook. Students solve these problems by hand (Figure 1) and submit their results online for a prompt feedback. While the same set of problems is assigned to all students, the numbers in each problem are algorithmically assigned (different) to encourage students to work on their own problems, although peer-to-peer interaction is allowed and encouraged. Students are given up to four attempts to submit the correct set of answers to each problem to earn full credit. With the course instructor and the learning assistants in the classroom, help is readily available to overcome frustration associated with a student's inability to solve the assigned problems. Of course, if a student has not done the pre-Emporium activities, he/she is less likely to work all the problems correctly in the specified timeframe.

Experiment-based problems using physical models (Figure 2) are assigned approximately once every two weeks to help reinforce concepts introduced in the course. For each experiment, students, in teams of three to four, are given one or two problems. They first solve each problem by hand and then set up a physical model, measure the unknown quantities and compare their experimental results with their calculated values. Each experiment and accompanying analysis is treated as a separate assignment and manually graded.

Figure 1. Students working on computer-based assignments.

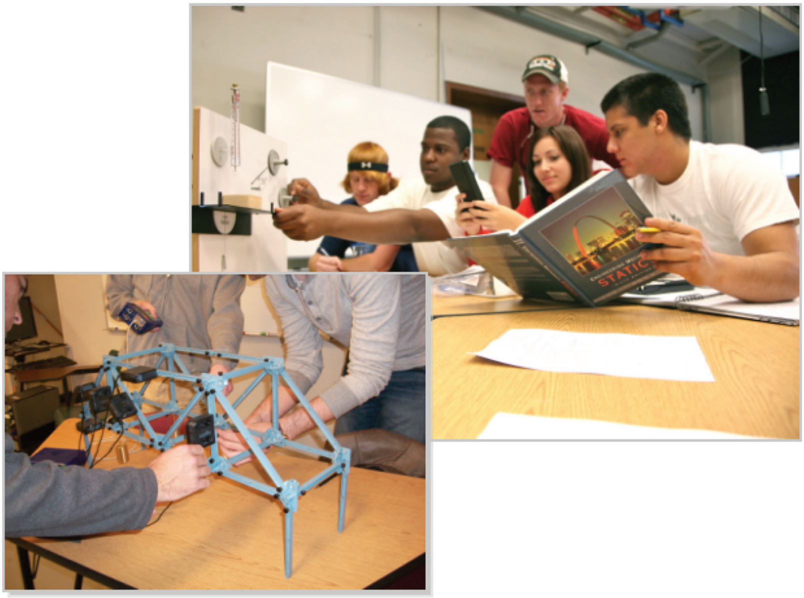

Figure 2. Students working on experiment-based assignments.

All the quizzes as well as the final exam are proctored and conducted inside the classroom. The questions on the quizzes and the exam entirely consist of working problems similar to what the students do for their assignments. Due to the limited capability of the online assessment tools, and the need to assign partial credit for the correct portion of each solution, the in-class quizzes and the final exam are manually graded. Students in all sections of the course are given common assignments, quizzes and final exam to ensure uniformity of assessment across multiple sections of the same course.

Post-Emporium Activities

Students who are unable to complete the computer-based Emporium assignments during the regular class period are allowed to return to the Emporium in the afternoons or weekends to complete the remaining problems while receiving help from only the on-site learning assistants. Although this was intended to alleviate pressure on the students, it created other challenges. As will be noted later, the post-Emporium option was eliminated in fall 2011 by reducing the number of assigned problems to be completed in a regular class period. While reducing the operation hours, the post-Emporium remained accessible to students who wished to work on practice problems with help readily available.

Instructional Materials

Recognizing the shortcomings of recording a live lecture, we made use of the technology offered by a commercial site *Your Other Teacher* (www.YourOtherTeacher.com) that specializes in online content delivery of math, physics, and engineering mechanics courses including Statics. They offer pre-recorded tutorials on various topics as well as step-by-step solutions to a number of example problems that are available for their users to access for a nominal fee. These tutorials are recordings of the instructor's voice and handwriting (Figure 3) on a whiteboard in a digital video format that can be downloaded and viewed on any computer. These videos offer greater utility than the video/audio recording of an actual lecture in a classroom setting. The technology is easy to use, and students can watch the videos at their own pace with opportunity to rewind or fast-forward. Another interesting aspect of these tutorials is that they come in multiple sets each matching the contents in the same order that appear in a given textbook currently on the market, adding flexibility in terms of textbook selection.

The *Virtual Laboratory for the Study of Mechanics* (VLSM), is another learning resource that is available online (www.ae.msstate.edu/vlsm). In addition to tutorial notes on individual topics, VLSM also contains a number of *LiveMath*® example problems and *Test Your Knowledge* exercises. The collection of Flash animation clips helps the student to better understand such topics as the parallelogram law, decomposition of a vector into its Cartesian components, and description of reaction forces and moments in 2- and 3-dimensional supports (Figure 4).

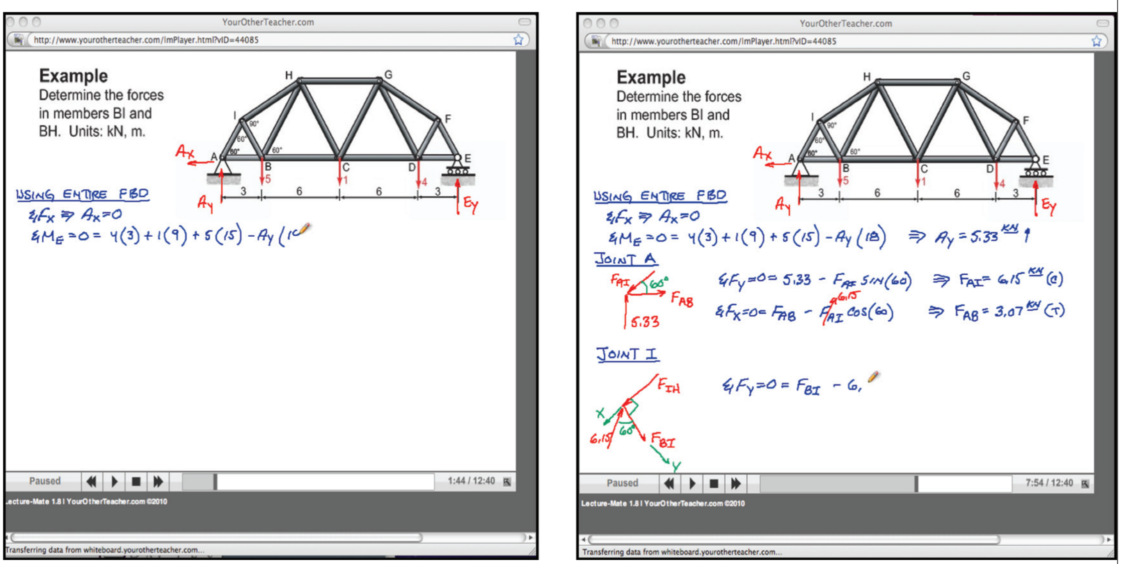

Figure 3. Snapshots of a tutorial example on truss analysis at yourotherteacher.com.

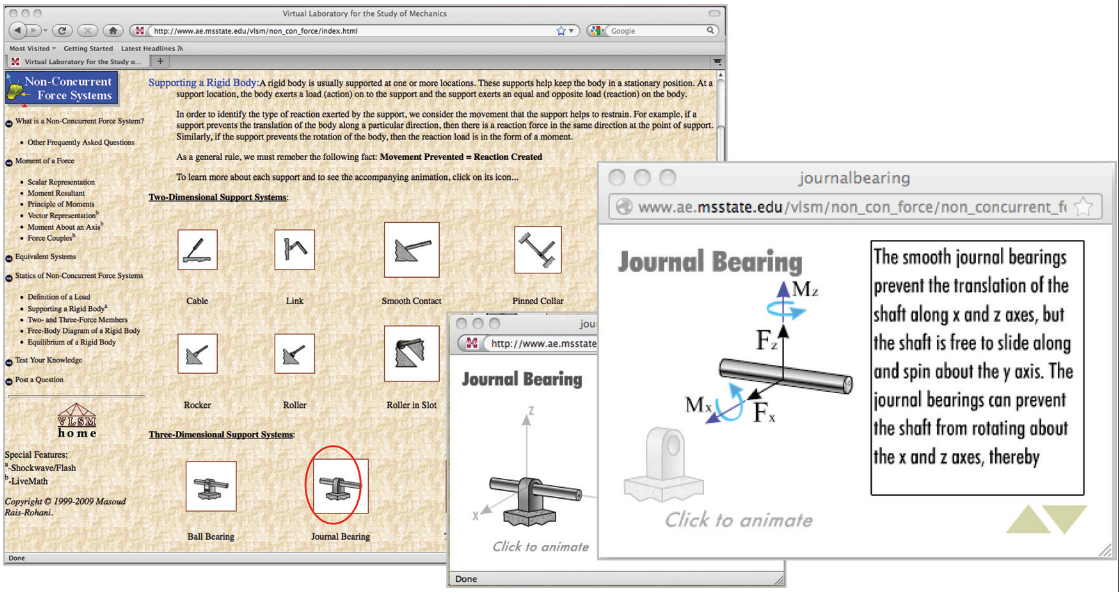

Figure 4. Animation and description of support reactions in VLSM.

The textbook initially used in this course was *Engineering Mechanics: Statics*, 6th ed., by Meriam and Kraige (John Wiley and Sons), and the 7th edition was used beginning with the fall 2012 semester. Students can purchase an electronic copy of the textbook and print the portions they wish to have on paper. The *WileyPlus* system also contains a large collection of exercise problems that can be assigned and graded online.

Research [19-25] shows that through interaction with physical models, students can significantly enhance their understanding and retention of topics presented in an engineering course such as Statics. Laboratory-style models (www.Pasco.com) are used to set up experiments that are consistent with the topics covered in the course. The experiments include resolution and addition of two-dimensional forces; moment about a point; equivalent loading systems; two-dimensional force equilibrium; centroid and center of mass; truss structures; and friction. All physical experiments are tied to particular problems, so students can verify and validate their hand calculations while gaining deeper understanding of the Statics related concepts.

RESULTS FROM THE PILOT PHASE

The pilot phase was conducted in the spring 2009 semester. Using the parallel-sections approach, two sections were selected as the control group and two as the experimental group, with each section consisting of approximately twenty-five to thirty students. All four sections were taught by the same instructor to maintain balance in the teaching style experienced by the students in each group. While all students received similar tests or quizzes, the problems were not identical for the two groups because of the difference in the class schedule with 50 or 75 minutes in duration. However, all students in both groups took a common final exam to facilitate a formative assessment.

Table 1 gives the summary of data for each group. The scores represent the mean values for each population with the standard deviations inside parentheses. The percentage of students making A, B, or C is shown in the last column. Although D is considered a passing grade, the subsequent engineering mechanics courses require a minimum grade of C in Statics. This requirement affects the majority of engineering students who need to take more advanced mechanics courses such as Dynamics and Mechanics of Materials. The grading system for each group is shown in the footnote with the numbers in parentheses indicating the quantity in each category. In the Emporium class, there were 24 computer-based assignments with two drop grades plus 6 experiment-based assignments. While the students in the traditional course took 3 tests with no drop grade, those in the Emporium took 7 quizzes with one drop grade.

A t-statistic of the two student populations assuming either equal or unequal variances showed an insignificant difference between the final exam scores while the differences in the assignment and in-class test scores were statistically significant at 95% confidence level. Given the students' performance in quizzes and assignments, a better performance was expected on the final exam by the Emporium group. However, it is not possible to have a fair letter-grade comparison due to differences in the credit assigned to the various activities between the two groups. Generally, there appears to be less scatter among the individual grades in the Emporium (experimental) group than the traditional group.

The total number used in the last column of Table 1 does not include those who withdrew from the course and received a grade of "W". Although the ratio of students making grades of A through C (success rate) in the experimental group was 86% higher than that in the control (traditional) group, the difference cannot be totally attributed to the Emporium approach. For reference, the success rate for students in the 2001-2005 time period (historical data) was approximately 77% (excluding the W's), which is a better indicator of students' performance in a traditional Statics course than

Approach	Student Population	Assignment Score	Test / Quiz Score	Final Exam Score	Overall Score	Success Rate
Traditional[a]	57	72.8 (22.7)	66.3 (17.6)	64.7 (19.6)	64.8 (19.5)	49%
Emporium[b]	53	90.1 (14.4)	79.4 (13.1)	67.7 (15.8)	80.6 (14.0)	91%

[a]Grading system: 15% assignments (8), 55% tests (3), 30% final exam.
[b]Grading system: 15% pre-Emporium tasks (32), 20% assignments (24+6), 40% quizzes (7), 25% final exam.

Table 1. Performance data from the Pilot Phase.

that in Table 1. While 85% of the course grade in the traditional group was based on performance on tests and the final exam, for the Emporium group that portion was reduced to 65%. Other factors contributing to the observed differences may include the overall students' attitude toward the course and their level of preparation in the prerequisite calculus and physics courses.

RESULTS FROM THE FULL IMPLEMENTATION PHASE

The results presented in this section span over the period from fall 2009 to fall 2012 for seven semesters. All of the sections of Statics in these semesters were coordinated by the same instructor using the Emporium model. Different editions of the same textbook were used in this time period. For greater accuracy, the results are split into two separate groups. Starting from fall 2011, student were required to complete the computer-based Emporium assignments during the regular class periods and the credit assigned to the pre-Emporium tasks was eliminated in favor of increasing credit assigned to the Emporium assignments, quizzes, and the final exam. While it was possible to track the date, time, and duration of each student's pre-Emporium activities, it was impossible to know if the student was actively following the pre-recorded tutorials in their entirety or studying the online content and assigned portion of the textbook.

Figure 5 presents the summary of average scores on pre-Emporium tasks, assignments, quizzes, and the final exam, as well as the overall course average and success rate in each semester from fall 2009 to spring 2011. The results are for twenty-three separate sections of the course with enrollment of 800+ students. The average success rate per semester varies from 69% to 74% while the average

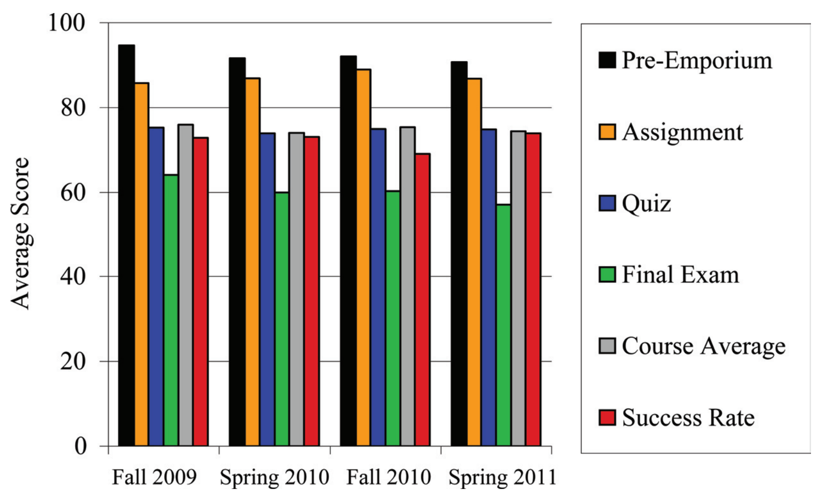

Figure 5. Comparison of average scores and success rates from fall 2009 to spring 2011.

success rate per section ranges from 52% to 97% for an overall average of 72%. It should be noted that the success rate is measured as the ratio of the number of students making A, B, or C compared to the total (A through F) excluding those who withdrew from the course with a grade of W. The grading system was based on 12% pre-Emporium, 18% assignments, 45% quizzes, and 25% final exam.

The breakdown of the average scores for one semester (fall 2009) is shown in Table 2 as an arbitrary sample. The last row also includes the standard deviation values inside parentheses. These results represent the average scores for 228 students. The overall success rate of 73% is very close to the historical trend at 77% (excluding the W's). However, if Sections 5 and 7 are treated as statistical outlier, the average success rate changes to 77%, which is essentially the same as the baseline performance.

Subsequent examination of the grades in the two prerequisite courses showed an average GPA of 3.1 (0.91) in Calculus II and 3.0 (0.80) in Physics I for the combined total of 228 students taking Statics in the fall 2009 semester. The parenthetical values represent the standard deviation associated with each average. A grade of C or better is required in the two prerequisites before students can take Statics. Among the total semester population, 20 students (~9%) were taking Statics for the second time, 25 had taken Calculus II more than once, and 38 had taken Physics I more than once. The population consisted of 186 (82%) male and 42 (18%) female students.

A closer look at the students in Sections 5 and 7 representing the best and the worst performance in Statics (Table 2) showed that those in Section 5 had an average GPA of 3.32 (0.91) in Calculus II and 3.32 (0.79) in Physics I whereas those in Section 7 had an average GPA of 2.81 (0.98) in Calculus II and 2.58 (0.85) in Physics I. The level of preparation in the prerequisite courses is clearly reflected in the students' success rate in Statics.

In the fall 2008 semester, six sections of Statics were taught by six adjunct and tenure-track faculty. While the instructional costs in fall 2008 included faculty salaries and hourly wages for three student

Section (Population)	Pre-Emporium Score	Assignment Score	Quiz Score	Final Exam Score	Overall Score	Success Rate
1 (36)	92.2	86.5	75.8	69.3	76.2	78%
2 (35)	95.8	90.1	76.5	67.2	78.5	74%
3 (35)	92.4	84.4	77.1	62.9	76.2	74%
4 (30)	94.8	85.3	75.0	64.7	76.1	70%
5 (32)	101.1	91.5	84.1	73.3	84.8	97%
6 (29)	94.2	83.9	67.4	53.2	69.1	59%
7 (31)	92.2	78.2	69.4	56.0	69.9	55%
Overall	94.6 (17.5)	86.0 (17.4)	75.2 (16.3)	64.1 (20.3)	76.0 (16.4)	73%

Activities: pre-Emporium tasks (32[a], 24[b]), assignments (24+6[a], 17+5[b]), quizzes (7[a], 5[b]), final exam (1).
[a]Monday-Wednesday-Friday Sections. [b]Tuesday-Thursday Sections.

Table 2. Performance data from fall 2009 semester during the Full Implementation Phase.

graders, those in fall 2009 included the full salary of a single instructor (course coordinator) together with hourly wages for 11 undergraduate learning assistants and one graduate teaching assistant. Comparison of the instruction costs in fall 2009 to the previous year showed a savings of 19%. The cost reduction estimates based on the NCAT's Course Planning Tool showed an expected average savings of 16%.

Figure 6 shows the summary of individual average scores as well as the overall course average and success rate in three semesters from fall 2011 to fall 2012. As a result of eliminating credit for the pre-Emporium tasks, the grading system changed to 20% assignments, 50% quizzes, and 30% final exam. The results for 17 sections with 634 students show an average success rate gradually increasing from 74% in fall 2011 to 78% in fall 2012. For the same time period, the final exam average per semester has also climbed from 64 to 69.6. Both of the final exam average and the success rate are higher than those in the prior years (Figure 5). Although the level of student preparedness can vary from one semester or section to another, the only other difference is the elimination of the pre-emporium and adjusting of the grade percentage associated with each activity. The results are encouraging and point to the likelihood of greater success in the future.

IMPACT OF COURSE REDESIGN ON SUBSEQUENT COURSES

One key consideration in the course redesign is the potential impact that it could have on the students' performance in the subsequent courses in the mechanics sequence, particularly Dynamics and Mechanics of Materials. With help from the information technology services, the Dynamics and Mechanics of

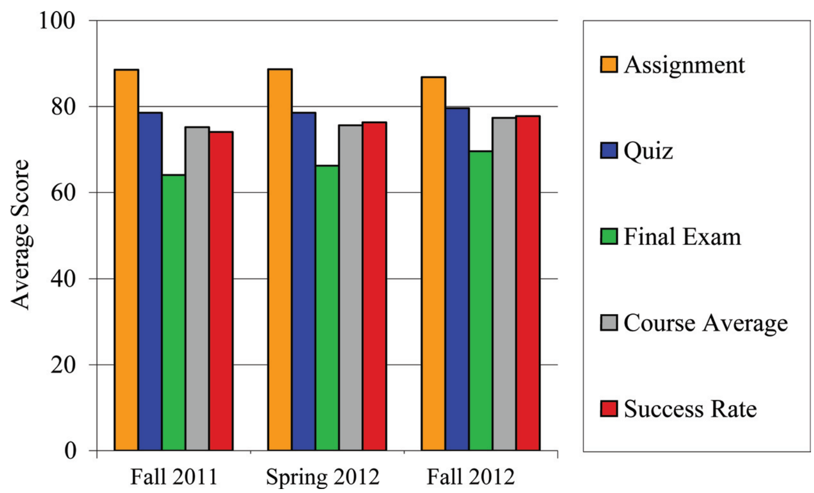

Figure 6. Comparison of average scores and success rates from fall 2011 to fall 2012.

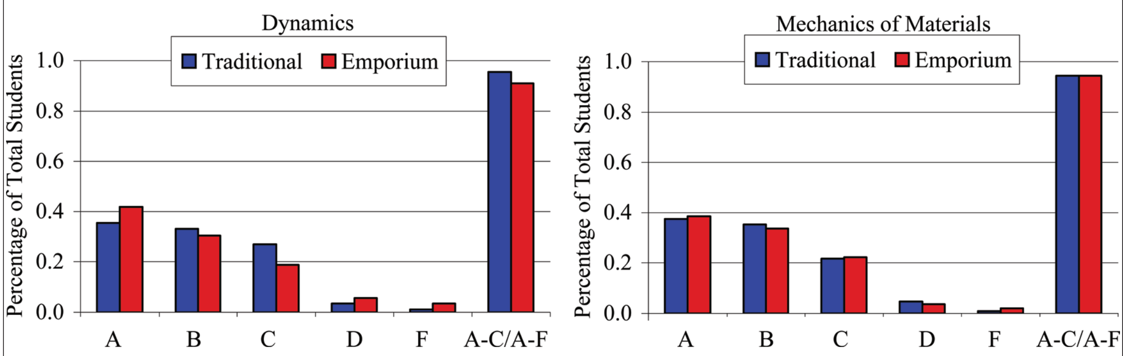

Figure 7. Comparison of Grades in Dynamics and Mechanics of Materials.

Materials grades of the students who had taken Statics using the Emporium model from spring 2009 to fall 2011 were retrieved for comparison with the traditional group (2001-2005 timeframe). The students who might have taken each course more than once were counted only once in this dataset.

Figure 7 compares the grade distributions in Dynamics and Mechanics of Materials for the two groups. The total numbers in the four datasets shown are fairly close from 515 to 550 students. The average success rates in Dynamics are 95% and 91% for traditional and Emporium, respectively, whereas they are approximately equal for Mechanics of Materials at 94%.

DISCUSSION

The results from eight consecutive semesters of Emporium Statics show that the blend of technology-assisted learning and in-class activities produces comparable learning outcomes to the traditional lecture approach. Although the average success rate in Statics is gradually increasing, the instructional costs have stayed noticeably below that of the traditional model.

As with any other non-traditional method of learning, the Emporium model also faces several challenges. For example, it is difficult to know for certain if the students are paying close attention to the pre-Emporium activities, dominated by watching the pre-recorded lectures.

A key aspect of the Emporium model as implemented in the Statics redesign has been the requirement for students to work on their assignments solely inside the classroom. Although the reason behind this requirement was made clear, the reaction from the students has been somewhat mixed. For instance, the post-Emporium option was instituted to alleviate pressure on the students, so they could return to the classroom at a later time to finish their assignments. However, this created an undue burden for some students. Without suggesting a direct correlation, it appears that the learning

Pre-Emporium Activities	Score
1. The pre-Emporium activities adequately prepared me to do the Emporium assignments.	3.62 (0.31)
2. The pre-Emporium activities helped me do well on quizzes.	3.36 (0.25)
3. Overall, the pre-Emporium activities helped me understand the topics covered in Statics.	3.58 (0.31)
Emporium Activities	
4. It was beneficial to work the assignments in the Emporium where help was available.	3.98 (0.23)
5. Working the assignments helped me learn the topics covered in Statics.	3.98 (0.24)
6. The hands-on laboratory exercises helped me more thoroughly understand the Static concepts.	3.62 (0.32)
Emporium Versus Traditional Lecture Approach	
7. The combined pre-Emporium activities were equally or more effective in teaching me the material in this course than the traditional lecture approach.	2.66 (0.29)
8. I devoted more time working problems than I would have if the course was taught using the traditional approach.	3.12 (0.29)
9. I liked the more frequent quizzes with each covering less material.	4.14 (0.25)
10. Overall, I like the Emporium approach better than the traditional lecture approach.	2.65 (0.35)

Table 3. Sample survey questions and responses during the Full Implementation Phase.

outcomes began to improve starting fall 2011 which coincided with removal of the post-Emporium requirement and elimination of credit for the pre-Emporium activities.

At the end of each semester, the students were asked to complete a survey with questions that were specific to the pre-Emporium and Emporium activities along with their general attitudes toward the Emporium model. Table 3 shows a list of sample questions along with average and standard deviation of the numerical responses given by the students on the scale of 1 (strongly disagree) to 5 (strongly agree).

The anecdotal information collected through the anonymous surveys revealed some of the reasons for the lukewarm reception of the Emporium model by a portion of the students in this study. These students prefer to be taught by an instructor inside a classroom than to watch the recorded tutorials and study the online course content on their own. For others, the availability of lecture videos and the self-paced format of the pre-Emporium activities were very appealing. The Emporium model required the students to follow a well-defined schedule of activities before coming to class to work on the assigned problems. For some students, this is a bit more stringent than what they would do if the course was taught using the traditional lecture format. We also found that some students would have preferred to work on the assignments outside of the classroom, whereas others liked the fact that they could get guidance while working on the assignments during the regular class periods. Clearly, there is more work to be done for the non-traditional teaching method adopted here to receive more favorable ratings from the students.

Besides the survey questions, the students were also asked to comment on their overall impressions of the Emporium approach as well as its individual components. A random sample of the students' comments is shown in Table 4.

Favorable comments:

"I really like the idea and it was a rude awakening for me to see how bad my study habits have become because in this teaching style I am responsible for my grade. And for that reason I say it is very important and will probably change my future college courses and how I approach them."

"I loved the approach. I have a very difficult time remembering everything a professor teaches. I loved how I could go back and replay the assigned videos if I didn't understand. Plus great test preparation."

"I feel as though I would have done well with either approach. The approach this semester was nice because it was somewhat of a change of pace from traditional lecture."

"For information classes, I prefer traditional lecture but for a math/physics based class, the emporium approach I believe, is best. The best reason I have for my opinion is that I didn't have to pay a tutor to help me with my homework, spend hours trying to figure out the homework, or spend hours looking for a classmate's help who understood. Somebody was there to answer my questions and I was better able to understand."

"I really enjoyed the emporium set up, I loved being able to watch lectures at my own pace (helped me focus on material better). Also, I probably wouldn't have worked example problems if this were a traditional class."

"I learned a lot from coming in during the afternoon labs. The TAs were very helpful."

"I liked the fact that we worked problems in the class because some teachers don't work enough examples for students to really understand the concepts."

Mixed Comments:

"It would have been nice if the teacher also did a small 10-15 minute lecture on the topics when we first enter. The pre-emp are nice, but we can't ask specific questions on specific problems."

"The emporium approach was helpful on the material at the beginning and end of the course (easy stuff) because I didn't have to watch the videos to get A's. So basically I saved time. A traditional teacher would have been helpful on the harder parts."

"Working the problems with help was beneficial. However, I believe it is easier to understand a concept when someone explains it, rather than watching a video."

"I learned a lot and had an A average on my tests, but the EMP-score was a D (from lack of time and tries)."

Unfavorable Comments:

"The book didn't often logically follow through with how it arrived at an answer or equation. Also, the examples worked in the videos were too easy."

"Some assignments took too long for the period."

"I felt that I often had to "gamble" with the assignments. If I spent 20 minutes on a problem and was wrong, I had to decide whether to try and fix the problem or devote the rest of the time hoping to get the second question right."

"TA's for certain tables, it seemed like some tables were always getting all the help."

"Have someone do the video that isn't monotone."

"If I am paying for a class and a professor to teach me, then I <u>do not</u> want to teach myself for homework and have homework for class."

"I feel that by changing the traditional system to something that we don't experience normally, it has had a negative impact on my ability to learn. I <u>had</u> to devote more time than usual because I wasn't given the option to learn as I normally do and choose to."

"Allow for Emporium work to be done at home/outside of class. No time limit on assignments."

"I would recommend another time to come in and finish the same amount of work."

Table 4. Sample of students' written comments.

Method	Advantages	Disadvantages
Traditional	• Live delivery of the course content • Similarity with how most courses are taught • Opportunity to ask questions during lectures • No need for computer or advanced technology • Requires a basic classroom • Fewer sets of tests and assignments to grade by one instructor	• Over reliance on the instructor to instill knowledge • Missing a lecture can negatively impact learning • Fewer tests to avoid loss of lecture periods • Few or no hands-on activities • No guided assistance on assignments • Teaching and grading inconsistencies in different sections of the course • Multiple salaried instructors at different pay scales
Emporium	• Diversified presentation of course content with computer technology • Alleviates the note taking pressure • Ability to watch pre-recorded instructional videos once or multiple times • Assignments done in class with guidance of the instructor and learning assistants • Frequent quizzes with less content in each • Hands-on experiments with physical models • Increased opportunities for active, interactive, and collaborative learning • Reduction in instructional costs	• Need for computer access inside & outside of class • Need to adjust to a new method of learning • Need for a classroom with a seating arrangement to accommodate student group activities along with Internet access • Unavailability of diverse and comprehensive online content for a specific course • Monitoring and management of pre-Emporium and Emporium activities • Increased effort in manual grading of larger sets of quizzes and hands-on experiments • Acquisition of multiple physical models for hands-on experiments

Table 5. Comparison of the traditional and Emporium models of teaching.

Based on this redesign experience and the anecdotal evidence gathered from the students, a list of advantages and disadvantages of the Emporium and traditional models for teaching and learning an engineering course is compiled in Table 5. In our interpretation of the traditional approach, we are considering multiple sections of the same course taught by different instructors; each section is totally based on the lecture format with minimal or no use of technology or hands-on activities.

CONCLUSIONS

Following the recommended guiding principles for successful course redesign, an engineering mechanics course (Statics) was converted from lecture-based to Emporium model. In the new format, students study the course material asynchronously outside of classroom using a variety of online contents, and do all the other activities including assignments and quizzes inside the classroom. The course coordinator and learning assistants provide individualized assistance on assignments and are available to answer questions outside of class. Both computer- and experiment-based assignments in individual and group settings are used to promote the learning outcomes. The Emporium model provided opportunities to significantly increase both the assessment and feedback frequencies while enforcing sufficient time on task, monitoring progress, and providing students in different sections a uniform learning experience.

The results from the one-semester pilot and seven-semester full implementation phases of the redesign showed that while the learning outcomes and average success rates in Statics were comparable with those from the traditional approach, the instruction costs were reduced by as much as 19%. Longitudinal assessment of the average success rates in the more advanced engineering mechanics courses (i.e., Dynamics and Mechanics of Materials) showed that there is no significant difference between the students who studied Statics using the Emporium model and those using the traditional lecture-based format.

Among the students who took Statics using the Emporim model, the opinion is mixed; some like the diversity of the instructional materials and the self-paced learning process, whereas others prefer the traditional lecture format and the flexibility of doing the assignments in a less structured setting.

The four-year experience with the Emporium Statics indicates that motivating students in new ways of learning is not an easy task. There is considerable resistance on the part of the students to take ownership of their learning. Although students have greater opportunities to do much better, as some do, under the Emporium model, over reliance on the teacher as the conveyer of knowledge through classroom lectures continues to be a challenge.

In an engineering course such as Statics, where true learning occurs when students actively work on solving problems of varying complexity, the practice and drill elements need more emphasis.

Work on fine-tuning the Emporium model for Statics continues by considering various pedagogically sound elements that can promote learning while improving the students' attitudes and the overall success rates. This includes consideration of developing in-house tutorial videos with a more diverse set of example problems and presentation of the course materials as well as having both in-class and out-of-class homework assignments.

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