Emporium Based Redesign of Statics

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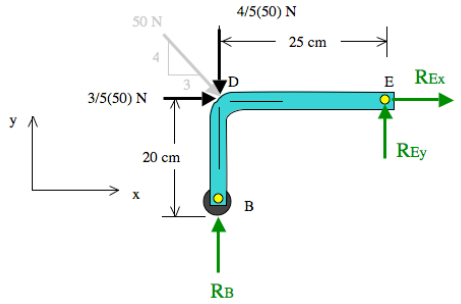
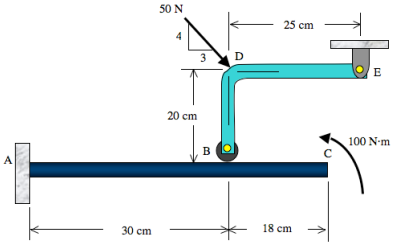
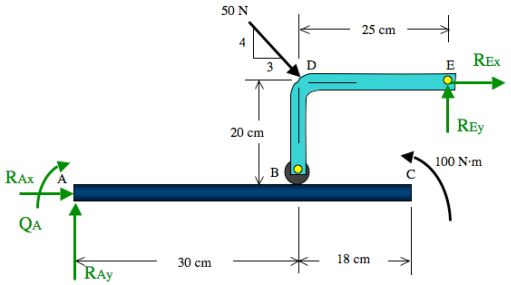
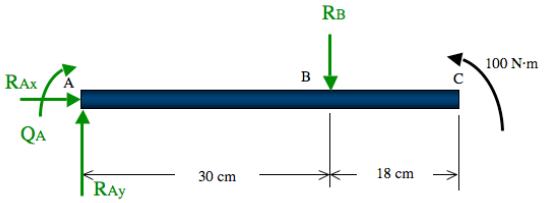








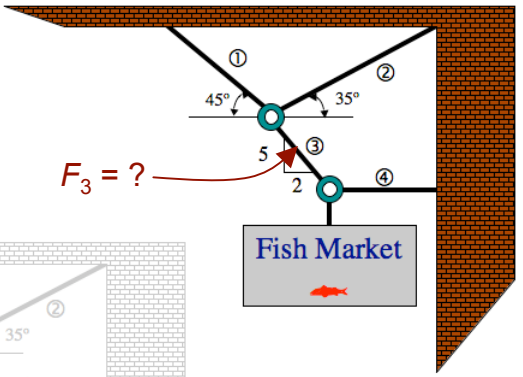
Disciplinary Showcase: Redesigning Science and Engineering
The Fourth Annual Redesign Alliance Conference
March 28-30, 2010

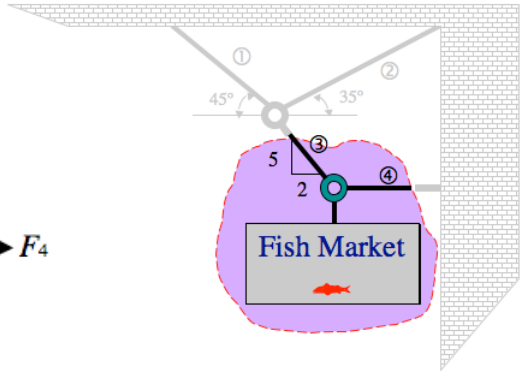
Background

- **Statics:** Sophomore-level engineering mechanics course
- **Course significance:** Fundamental course in engineering; prerequisite for advanced mechanics courses
- **Recent enrollment:** ~400 students in 14 sections per year with ~30 students per section
- **Traditional approach:** Lecture format, multiple instructors (3 hours/week)
- **Historical success rate:** ~74% (Grade of C or higher), 77% (W's omitted)
- **Current trend:** Rising enrollment + shrinking budgets
- **Redesign goals:** Improve learning & reduce instructional costs
- **Redesign team:** faculty experts & staff (assessment, technology, facilities)
- **Pilot phase:** Spring 2009 (parallel traditional & redesigned sections)
- **Full implementation phase:** Fall 2009 (7 redesigned sections)

General Overview of Statics

- A required course for Aerospace, Biological, Chemical, Civil, & Mechanical Engineering majors, optional for others
- **Prerequisites:** Calculus II & Physics I
- **Contents:**
  - Rigid-body mechanics
  - Forces and moments in 2- and 3-dimensional spaces
  - Friction
  - Analysis of truss and frame structures
- Strong emphasis on analytical thinking & problem-solving skills



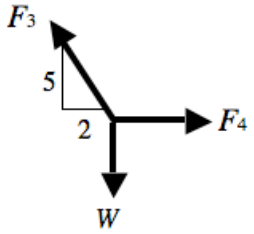


Force equilibrium:

$$W = 200 \text{ kg}$$

$$+\uparrow \sum F_y = 0 \quad \Rightarrow \quad F_3 \frac{5}{\sqrt{29}} - 200(9.81) = 0$$

$$\Rightarrow \quad F_3 = 2{,}113.14 \text{ N}$$



Free-body diagram

Redesign Process

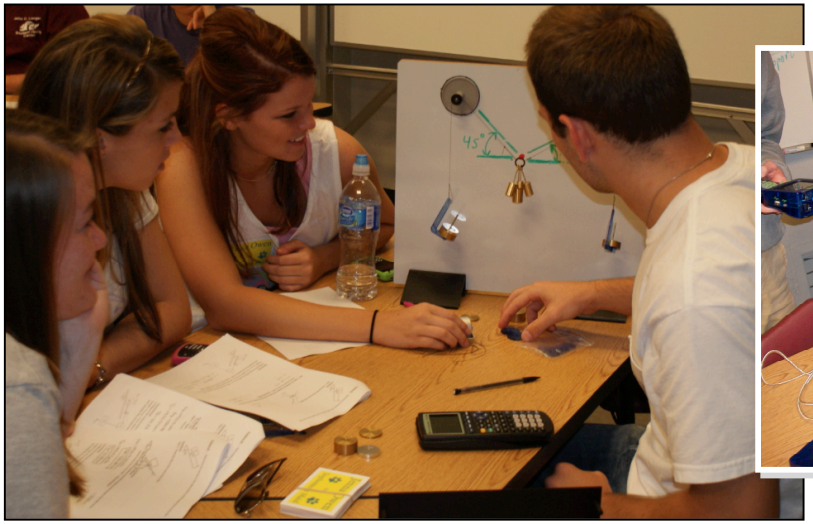
- **Motivation:**
  - Mississippi Course Redesign Initiative funded by Mississippi IHL
  - Success of redesign strategies and models developed by NCAT
- **Challenges:**
  - First redesign of an engineering course
  - Applying a nontraditional approach to teaching and learning
  - Availability and adequacy of computer based instructional resources
  - Implementation and management strategies
- **Approach:**
  - Adopt the Emporium model
  - Eliminate all classroom lectures in lieu of online delivery of content
  - Require assignments to be done inside the classroom (emporium hall)
  - Introduce hands-on activities (lab experiments) with physical models
  - Assign a single instructor to coordinate all sections

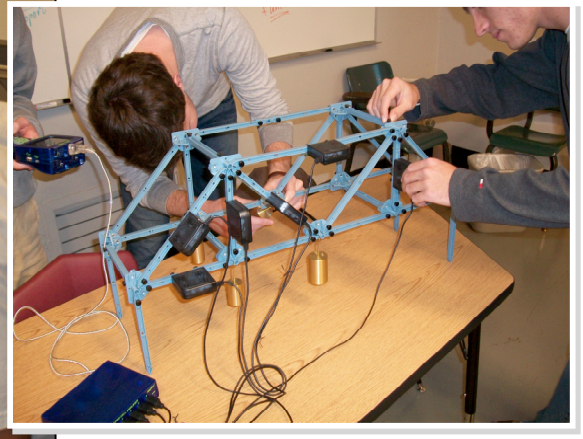
Redesigned Course Structure

- **Pre-emporium:** Activities performed outside the classroom in lieu of traditional lectures
  - Watch prerecorded tutorial videos online (www.YourOtherTeacher.com)
  - Study interactive content at *Virtual Laboratory for the Study of Mechanics*
  - Study select sections of e-textbook (www.wiley.com)
  - Work exercise problems in textbook and VLSM (www.ae.msstate.edu/vlsm)
- **Emporium:** Activities during regularly scheduled class periods
  - Work assignment problems by hand and submit answers online
  - Receive individualized assistance
  - Perform experiments with physical models to verify hand calculations
  - Take frequent quizzes
- **Post-emporium:** Afternoon sessions
  - Return to emporium hall to finish incomplete assignment problems
- **Course management:** Pre-emporium tasks & emporium assignments
  - Blackboard Vista (*myCourses*®) and *WileyPlus*®

Active Learning in Statics Emporium

Students working on assignment problems

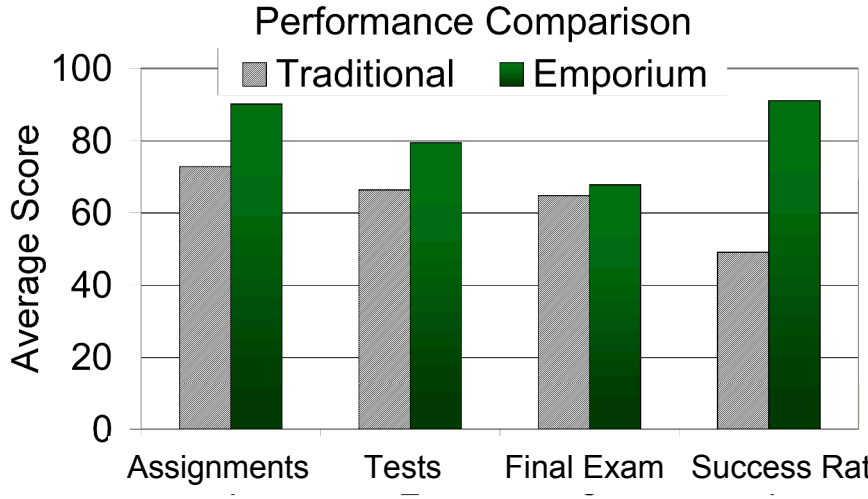




Students experimenting with physical models

Pilot Phase

- **Parallel sections:**
  - Control group: 2 traditional sections (57 students, 19% female)
  - Experimental group: 2 emporium sections (53 students,19% female)
  - All four sections taught by the same instructor
- Number of assignments:
  - Traditional (8)
  - Emporium (24 + 6 with experiments)
- Number of tests/quizzes:
  - Traditional (3)
  - Emporium (7), one drop grade
- Success Rate (Grade of C or higher):
  - Traditional[a] (49%)
  - Emporium[b] (91%)



[a]Grading system: 15% assignments, 55% tests, 30% final exam

[b]Grading system: 15% pre-emporium, 20% assignments, 40% quizzes, 25% final exam

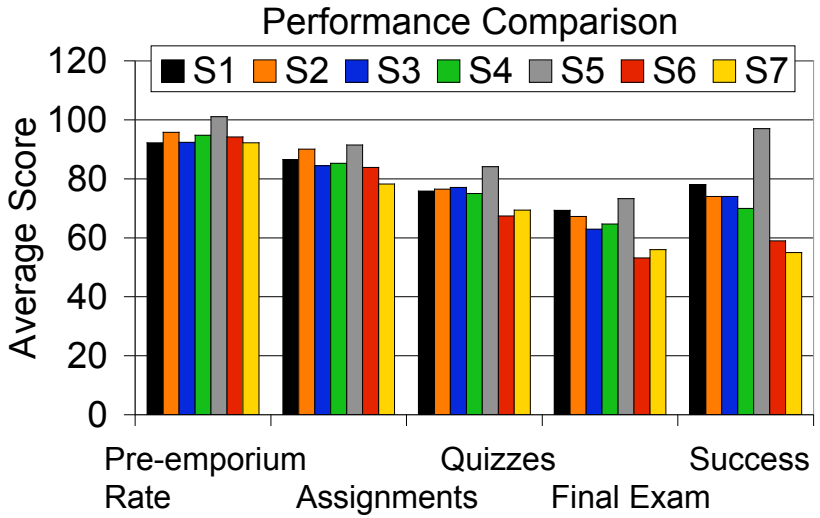
- **Assessment:**
  - Significant differences in assignment and test scores
  - Insignificant difference in final exam scores
  - Difference in success rates significant but influenced by grading system
  - Differences in prerequisite knowledge an important factor

Full Implementation Phase

- **Seven emporium sections:** S1 through S7
  - 228 students (18% female)
  - 20 students taking Statics for the second time
  - 25 had taken Calculus II while 38 had taken Physics I more than once
  - All sections taught by the same instructor

- Success Rate (Grade of C or higher):
  - Best (97%)
  - Average (73%)
  - Worst (55%)
  - Adjusted Average* (77%)
  - Historical Average (77%)

*Ignoring the best and worst sections



Grading system: 12% pre-emporium, 18% assignments, 45% quizzes, 25% final exam

- **Assessment:**
  - Large scatter in the final exam scores and success rates
  - Differences in prerequisite knowledge an important factor
  - No statistically significant difference with historical success rate

Impact on Instructional Costs

- **Fall 2008:** Traditional method of instruction
  - Enrollment = 210
  - Six sections of Statics taught by 6 adjunct and tenure-track faculty
  - Assistance provided by 3 undergraduate students
  - Total cost = $67,747
  - Cost per student = $323
- **Fall 2009:** Emporium method of instruction
  - Enrollment = 228
  - Seven sections of Statics taught by a single instructor
  - Assistance provided by one graduate TA and 11 undergraduate LAs
  - Total cost = $55,101
  - Cost per student = $242
- **Cost savings:** ~19% on total cost and ~25% on cost per student

Student Feedback

- **Pilot Phase:** agree or strongly agree
  - Overall, I like the emporium approach better than the traditional lecture approach. **77.1%**

- **Full Implementation Phase*:** 1- strongly disagree to 5 - strongly agree
  - Pre-emporium activities helped me better understand Statics. **3.27 (1.2)**
  - It was beneficial to work assignments in the emporium where help was available. **3.53 (1.2)**
  - Hands-on lab exercises helped me better understand the Statics concepts. **3.61 (1.1)**
  - I devoted more time working problems than I would have if the course was taught using the traditional approach. **3.17 (1.4)**
  - I liked the more frequent quizzes with each covering less material. **4.05 (1.1)**
  - Overall, I like the emporium approach better than the traditional lecture approach. **2.49 (1.3)**

* 79% of 228 students responded to a multi-part survey.

- **General observation:**
  - Students in the pilot phase preferred the emporium to traditional approach by a 3 to 1 ratio
  - Diversity of students in the full implementation phase led to mixed views on the redesigned approach
  - Some aspects of redesigned course more popular than others, but the overall popularity on the rise

Lessons Learned & Future Plans

- **Pedagogical Improvement Techniques:**
  - Asynchronous technology-based presentation of diversified course content
  - Enhanced active learning opportunities with physical models
  - Greater emphasis on problem-solving skills and sufficient time on task
  - Providing individualized assistance when it can have the most impact
  - More frequent assessment of learning
- **Cost Reduction and Resource Allocation:**
  - A single versus multiple instructors in charge of multiple sections of Statics
  - Reassigned faculty to teach more advanced undergraduate or graduate courses
- **Challenges:**
  - Adjusting to a new student-centered approach to learning
  - Manual review of each student's record of pre-emporium activities and manual assigning and recording of corresponding grades
- **Future Plans:**
  - Continue Statics emporium and track success rates in advanced mechanics courses
  - Apply the emporium model to other multi-section mechanics courses