

Adding Mini-Labs to ENGR101, Tulane's Freshman Intro to Engineering Course

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Abstract

As part of the effort to improve the freshman engineering experience for the 2003-04 academic year, labs were added to our required fall semester "introduction" course. The experiments were primarily developed and conducted by graduate students in each of Tulane's five engineering departments.

The ultimate goal for these activities was three-fold: (1) get the freshmen into the research labs in small groups (2-3 students per session), (2) promote interaction with the graduate student population, and (3) enthuse the students about research and engineering. Although limited pay was available, the major plus for the instructors was the opportunity to create, lead, and modify (based on experience) a small teaching module. Students rated the lab sessions and could post comments visible both to the instructors and other students. Students used these ratings to help decide which labs in which to enroll.

Several aspects of this program differed from standard lab courses. Through an innovative course management website, instructors and students both had unprecedented scheduling flexibility both in the selection and attendance of lab sessions. There was typically great personal investment of the graduate student instructors in their lab modules. The targeted scope for the mini-labs was limited in comparison to standard labs. The breadth of topics was large; the 5 engineering departments offered 27 different topics with enough sessions to offer 496 seats, enough for each of the 218 students to participate in two labs.

There were some major hurdles to overcome in starting up this program. We encountered factors including (1) bias against the presence of undergraduate students (especially freshmen) in the research labs, (2) perceived overwhelming demands on faculty or graduate student time with no "obvious" payoff, and (3) the assertion that we should not "cater" to our Freshmen. Because initial appeals to graduate students did not fully populate all needed labs, most department chairs eventually mandated that mini-labs be generated and conducted by their personnel.

Student response to this program was favorable. For next year, we hope to offer additional topics and sessions so that each student can participate in three mini-labs.

Introduction

Tulane was experiencing a high attrition rate between its freshman and sophomore enrollees in engineering. A new budgeting system made it attractive for us to change the freshman curriculum in an attempt to stem this bleeding. As a part of the widespread redesign of Tulane's "Introduction to Engineering" course (really the only contact with the engineering school during the students' first semester on-campus), mini-labs designed for no more than three freshmen attendees per session were added to the requirements. An overview of all aspects of the changed freshman course may be found elsewhere.^[1]

We had three specific goals for the freshmen involved with mini-labs. First, we wanted to get the freshmen into the research labs in small, manageable groups (2-3 students per session) and provide some type of hands-on experience for them; we had been told by upperclass undergraduate students that this was something they would have appreciated early on in their studies, but departmental undergraduate research experience did not typically commence until the junior year. Second, we wanted to promote interaction with the graduate student population; undergraduate and graduate student populations rarely intermix until coenrolled in advanced coursework. Lastly, we hoped to enthuse them about research and engineering, and thereby positively affect retention in the engineering program.

An additional goal for the involved graduate student instructors was to provide the opportunity for them to individually create, lead, and modify (based on experience) a small teaching module; the limited scope and repeated offerings of the mini-labs provided an excellent microcosm for the instructors to learn about design and implementation of teaching in a manner not available through traditional graduate teaching assignments.

We also desired to implement the mini-labs in such a way that minimum direct administrative oversight was required. To this end, a comprehensive activities-management website was developed which handled instructor creation and modification of lab documentation, instructor offering of session times, student access of lab documentation, student signup for individual lab sessions, and instructor reporting of attendance.^[2] With this website, management of the mini-labs was not overwhelming for the two course administrators consisting of one faculty coordinator and one graduate student teaching assistant.

Creating lab topics

An initial e-mail invitation to participate was sent to all graduate students in the Engineering School (early Summer 2003). Detailed in this message were the basic guidelines: size (maximum 3 students per session), scope (1-2 hours of lab time with some kind of hands-on experience included), and specific information about how much the student instructors would be paid. Thanks to funding through the Tulane Interdisciplinary Studies (TIDES) Program, we were able to offer reimbursement for lab supplies plus \$25 labor pay for each offered lab session, with

an additional \$50 bonus for the first lab session to help pay for efforts expended in creating the lab and its documentation.

From this initial contact, ten proposed lab topics resulted. But our freshman enrollment is about 220 students, so the number of topics needed was much greater than this. 220 students requiring two sessions each at three students per session demanded at least 150 lab sections; it was unfair to expect more than six to ten offerings (sections) per lab topic, so this indicated that around 25 topics were required. Thus, further solicitation was needed.

Departmental buy-in

Department chairs were approached and asked for help in creating additional mini-lab topics. Each department approached the project differently, with the realization that in some respects they were competing with each other for enrollment not only in the labs but also eventually as selected student majors. Mechanical Engineering (MCEN) interpreted creation and running of mini-labs as part of the duties of their Teaching Assistants (TA's), with the departmental laboratory coordinator designated as the point of contact for the ENGR101 course administrators. Civil & Environmental Engineering (CVEN) created a TA position to run two freshman mini-lab topics. Chemical Engineering (CENG) discussed labs at their faculty meeting and generated ideas there. Electrical Engineering & Computer Science (EECS) and Biomedical Engineering (BMEN) made no formal departmental effort to generate labs; since the course administrators were from BMEN, potential lab topics were explored individually with likely instructors.

Faculty resistance to this program was intense at times. Although the intention was to have the graduate student instructors do most of the creation, teaching, and grading of the labs, faculty interpretation was that most of the work would fall upon their already overburdened shoulders. In a few cases, faculty were the primary authors of the lab instructions, but most were written by grad students. Some faculty refused to allow undergraduates, let alone freshmen, into their laboratory facilities for fear that other research work would be contaminated and/or destroyed; in such cases, those facilities were not involved in the program. In other cases, interested graduate students were directed by their research advisors not to "waste" their time teaching freshmen but instead to focus solely on their research. One prospective instructor switched funding from a TA to a Research Assistantship and was pulled from the freshman program in the process. Some faculty also expressed pessimism that mini-labs could be created at a knowledge level that would be of any value to the freshmen.

Offered lab topics

Figure 1 lists all lab topics offered in ENGR101 for Fall, 2003 along with the descriptions which were displayed to the students on the website created to manage student enrollment in the lab sessions.^[2] A total of 27 topics were developed and offered to the freshmen during the Fall semester, with 178 lab sessions attended at various times through the day and week.

Lab#	Dept*	Participants	Title	Description
101	BMEN	11	Zapping Drugs	Apply electrical current across samples of eye drugs, measure pH and resistance, and observe response in order to determine whether the drug is stable under such usage.
102	ENGR	16	Intro to Humidity	You've already experienced humidity in New Orleans - now learn how to quantify it. Determine relative humidity & dewpoint, calculate heat index, and compare to broadcast values.
103	ENGR	11	Old-Fashioned Calculating	Ever wanted to perform complex calculations in the absence of any electronic equipment? Make your own slide rule, learn how to use it, and compare answers to those obtained by other methods.
104	ENGR	15	Principles of Controlled Flight	Construct & modify paper airplanes and pilot a computer simulation to demonstrate the basic principles which govern controlled flight.
105	BMEN	17	Intro to Computer Numerical Control (CNC) Machining	Design & fabricate a personalized keychain using a CNC milling machine.
106	CVEN	6	Measurements of Fluid Physical Properties that affect "Water Quality"	This lab is designed to measure the fundamental physical properties of the fluids that are related with contamination of the water. We will measure 3 important physical properties of liquid environmental contaminants known as nonaqueous phase liquids (NAPLs).
107	CVEN	8	Intro to Concrete Chemistry & Properties	Mix up a batch of concrete and form a cylinder at the first visit, then return 4 weeks later and strength test your cured cylinder.
110	MCEN	10	Tensile Testing	Run tensile tests of various materials on the Instron.
112	MCEN	9	Mechatronics: Robotic & Control System Lab	Program an arm manipulator, or tune an industrial emulator.
113	MCEN	13	The Hands-On of Fabrication	Be introduced to several types of fabrication equipment (lathes, mills, welders, saws, grinders, etc.) and operate some, under supervision of the instructor.
115	MCEN	14	Wind Tunnel Experiment	Estimate wind velocity in the wind tunnel, then test and compare various objects to predict their performance relative to the effects of wind.
116	BMEN	14	Secrets of the Amazon - Electrophysiology Simulation	Use SimBioSys to understand basic electrophysiology of excitable cells, and apply this to explain how neurotoxins work. Some pre-lab reading material has been added. Please familiarize yourself with it. You do not need to understand everything in the material but rather get a general sense of how cell membranes are constructed and what they can do.
117	CENG	11	Flow Properties of Food Thickeners	Use a Bohlin Visco 99 concentric cylinder viscometer to compare flow properties of water and two concentrations of carboxymethyl cellulose, a common food thickener.
120	E ECS	18	Lego Line-Follower	Build a functioning remote car using Lego, then program it using Lego Mindstorm's Graphical User Interface.
122	BMEN	20	Totally Hip Replacement Modeling	Use laboratory instruments and Computer-Aided Engineering (CAE) software to reverse-engineer a simple biomedical implant to produce a computer model suitable for device replication or structural analysis.
123	CENG	8	Intro to Experimental Design	Use high-energy ball milling to create nanoparticles and illustrate factorial analysis, a technique of experimental design, to determine the most important factors on particle size.
125	CENG	10	Effect of Antibiotics Upon Bacterial Growth	Mix up various concentrations of antibiotics (ampicillin & kanamycin) and add to samples of e. coli at 5:00 p.m. on the first visit; culture overnight, and return the next morning at 9:00 a.m. to assess the effects.
127	BMEN	4	Intro to Computational Modeling in Engineering	Learn how to use the finite difference method (a simple way to discretize a system into a finite number of points arranged in a regular grid) to model problems in Matlab involving heat flux, diffusion, stress/strain, etc.
129	CENG	20	Gas Hydrates - Ice that burns!	Adjusting pressure and temperature in the lab, simulate the conditions in nature that form gas hydrates.
130	CENG	10	Using gas chromatography to follow a catalytic reaction	Isomerize n-butane to i-butane over a solid acid catalyst, use the i-butane to increase the octane rating of gasoline, and use a gas chromatograph to assess the rate at which the catalyst deactivates.
132	CENG	15	Brewing Coffee	Use the brewing of coffee as a model of a chemical engineering process and learn how to analyze a system.
133	CENG	7	Hydrogels - Soft and Wet Material	Perform swelling experiments of hydrogels in distilled water.
134	CVEN	14	Impact Tests of Steel, Cast Iron, and Aluminum	Observe and compare the behavior of different materials under impact loading.
135	CVEN	51	Rocks, Soil, & Foundations - A Pile-Driving Simulation	Liked playing in the dirt as a kid??? We still do! Discuss the effects of structural loads on a variety of soil conditions. Perform a soil investigation and preselect a foundation. Use a pile-driving device to analyze soil resistance on single pile structures.
136	CVEN	5	Geotechnical Topics	Examine the behavior and effects of water in soil.
137	CVEN	11	The Versatility of Ozone: Preventing Cryptosporidiosis As Well As Sunburn	Learn about ozone for water treatment in a simplified bench scale experiment. Session times scheduled to coordinate well with Uptown-Downtown Shuttle service.
138	CVEN	8	Waterlines of the future - Is your drinking water secure?	Obtain material properties of polymeric liners using the universal mechanical testing machine, flexure testing machine and durometer.

*BMEN = Biomedical Engineering, CENG = Chemical & Biological Engineering, CVEN = Civil & Environmental Engineering, E ECS = Electrical Engineering & Computer Science, ENGR = Engineering (General), MCEN = Mechanical Engineering

Figure 1 – ENGR101 mini-labs as offered during Fall 2003 (as displayed to students)

Managing the labs

Lab enrollment and process tracking was handled with a custom-written website which allowed individual registration of students into lab sessions as space allowed. On this site, lab descriptions were displayed along with scheduled sessions days/times and lab documentation (mini-syllabus, pre-lab reading & problems). Details on the website may be found elsewhere.^[2]

Using the website, instructors could upload documentation, change lab titles/descriptions, check enrollment, and track student progress at will. Occasional prodding/pleading by the administrators encouraged instructors to add sessions during the semester.

Managing the instructors

In total, 25 instructors conducted freshman mini-labs during the Fall semester, 2003.

Payroll for the instructors was processed on a special fortnightly payroll at the rate discussed earlier. Pay was not processed until student lab reports were received, so there was sometimes a delay between session offering and instructor pay. This ensured that the instructors had an interest in encouraging students to complete their paperwork. All pay was successfully delivered by the end of the semester.

Some administrator effort was spent with the instructors in refining the idea and implementation of their lab topics. Since the administrators were not necessarily experts in each topic area, most of this help was directed towards marketing the labs; technical questions were deferred to appropriate faculty. Most of the administrative effort with the instructors dealt with student completion reports. Instructors were asked to deliver either a list of students completing each session (if no report was required) or the graded reports for each session (graded simply as \checkmark , $\checkmark+$, or $\checkmark-$), but sometimes either the students or the instructors did not deliver in a timely fashion.

Managing the students

The most difficult aspect of managing the freshmen was getting them to go ahead and sign up for lab sessions early in the semester. A portion of the student population was diligent and got their lab requirements out of the way early, but most waited until later in the semester. By that time, several scheduled lab sessions had passed with zero enrollment.

The website allowed students to register for lab sessions, unenroll if necessary, and monitor their schedule of events. In rare instances students sought assistance from the course administrators to sign up for a lab.

Instructors performed the bulk of student management once their lab session had been attended. If the lab required generation of a lab report, instructors maintained a list of completed/uncompleted efforts and passed these along to the administrators. If no report was

required, the instructor would notify the administrators of student completion and be done with the process.

Results

Of the 218 enrolled freshmen, 203 (93.1%) attended at least one lab; 154 (70.6%) attended two labs. Considering that the class was offered pass/fail, this is an acceptable compliance rate.

In a survey administered at the end of the semester, only 15.4% of the responding population (208 students) felt that the mini-labs were not a valuable use of their time.

Benefits

This program attempted to pair interested instructors with interested students, promote interaction between the graduate and undergraduate populations, and allow freshmen access to engineering research facilities far earlier than afforded to previous freshman classes.

For students

By allowing students to select individual lab sessions, those who did not wait until the last minute to sign up were allowed to choose labs of interest. The procrastinators did not always find open lab sections closely aligned with their interests.

Students were able to rate lab visits on a 1-5 star scale, and comment if desired. These ratings and comments were available for viewing during student selection of lab sessions to attend.

During the lab sessions themselves, students had access to the lab instructor for 1-2 hours in a small group setting. Most instructors reported talking to the freshmen about their interests and intentions, so the students had a great opportunity to form at least a minimal mentor-mentee relationship with a more advanced engineering student. Whether these relationships continue into the future will be interesting to see.

For instructors

Instructors were given the opportunity to teach a subject in which they were interested. For many of them, it was a first opportunity to develop and implement a curriculum of their own design. For the most part, even for the instructors essentially drafted into the program, this held true.

Moreover, since sessions were repeated for each topic, instructors could rapidly modify their learning module based on teaching experience, and they could learn from this quick turnaround. Instructors could view student comments and ratings, and incorporate them into their modifications. Instructors were given great latitude in setting requirements for their lab; for instance, requiring student generation of a short lab report was left to the instructor's preference.

A basic template for lab documentation was provided by the administrators, but in general the only similarity enforced was format for the 1-2 page lab syllabus.

Rewards were not only pedagogical, but also financial. For instructors with the time to do so, additional demand for well-rated labs allowed the opportunity to offer more sessions and earn more money. Scheduling was also an aspect of this equation, since instructors determined the days and times that their sessions would be offered; administrators supplied an overall weekly schedule indicating the times of many standard freshman core courses, but actual determination of session times was left to the instructors. The more appealing, interesting, and accessible an instructor made the topic, the better the economic outlook.

Two lab instructor awards were given at the end of the semester. Recognition for “highest body count” was given to the lab instructor with the most attending students, and “highest rated lab” went to the lab instructor with the highest average student rating. Both awards included a framed certificate presented by the Engineering Dean, and the highest rated lab warranted a \$50 bonus to the instructor. All lab instructors were invited to an awards luncheon held off-campus; individual framed certificates of appreciation were handed out by the Dean to every lab instructor present at that event.

Costs

Adding mini-labs to ENGR101 definitely had its costs. Effort was expended by the course administrators to encourage generation of lab topics and scheduling of lab sessions, by departmental faculty in varying degrees for generation of lab topics, by instructors to create and offer labs, and by students to attend and fulfill the requirements of the labs. In addition, payroll and lab supply costs had to be met.

Monetary costs

Overall payroll to instructors for all ENGR101 mini-labs was \$5,675. Lab supply reimbursements were approximately \$250, and awards cost approximately \$300.

These expenditures yielded a per-attendee lab payroll cost of \$15.90, and overall cost of \$17.44 per attendee. For the entire class, the overall lab cost came to \$28.56 per freshman.

Non-monetary costs

Time was the major non-monetary cost for the labs: for administrators to cajole people into participating as instructors, for instructors to generate labs and get permission to run them, for students to participate and perform required reporting.

No-shows by the students turned out to be a high unanticipated cost for the course. Instructors expressed great frustration at preparing to teach a lab, only to have none of the registered students

show up (or fewer than anticipated); this often resulted in a waste not only of time but also of materials. 99 seats were no-shows during the course of the semester, out of the 456 registered for, resulting in a no-show rate of 21.7%. We paid the instructors if students were registered for a session, so this also drove up the per-attende lab cost.

Future plans

Based on the experiences from the first offering, we have a few ideas for improvement.

First, we must convince students to sign up for lab sessions offered earlier in the semester. There were over twenty empty sessions toward the beginning of the semester in 2003. If we are successful, this will also reduce student panic at the end of the semester. This year, several sessions increased maximum session size to four students to accommodate needed enrollment.

Second, we must implement some kind of disincentive for no-shows and reduce the 21.7% rate. One-fifth of attended sessions' seats were empty due to no-shows. We will send automated reminder e-mails to enrolled students the day before a scheduled lab; this should reduce forgetfulness, at least. More drastic grading consequences are being discussed.

Third, we need to automate as much of the grading as possible to minimize the workload on the administrators. We will incorporate more of the grade accounting and lab completion reporting by the lab instructors to the administrators into the course website, a task currently handled in Blackboard™.

Fourth, we hope to increase the number of offered lab topics and sessions so that students may elect to attend a third lab session if they so choose.

Conclusions

Student completion rate of at least one mini-lab was 93.1%. Student satisfaction, as demonstrated by an online anonymous survey with 95% participation, was high for the mini-labs indicating that useful topics were both possible and achieved.

Instructors perceived valuable experience in teaching the labs, and a majority have expressed enthusiastic interest in participating in the program again next year.

One major indicator of overall program success will not be evident until next year, when retention of current freshmen in the sophomore class is known.

Overall, the level of effort and cost required to add mini-labs to the freshman engineering curriculum at Tulane seems to have been worthwhile.

REFERENCES

1. Mullenax CA, Walker CF. Increasing Freshman Contact with Engineers - A Revamp of ENGR101, Tulane's Freshman Intro to Engineering Course. *2004 ASEE Annual Conference Proceedings*. 2004.
2. Orth Wright L, Robinson DE, Mullenax CA. A Comprehensive Activities Management Website for Tulane's Freshman Intro to Engineering Course. *2004 ASEE Annual Conference Proceedings*. 2004.

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