Practicum in the Engineering Classroom- A Graduate Course

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***Abstract* – Development of a 1-credit graduate course "Practicum in the Engineering Classroom EngE5504," a required course for a new PhD program in engineering education and the existing graduate certificate in engineering education within the Engineering Education department in the USA, is discussed. The course syllabus, class project assignment, and results of end of semester course evaluation surveys are included and discussed. Examples of students' class projects, targeted to introduce freshmen to various disciplines of engineering, are included to demonstrate graduate students' awareness of developing course materials using active learning approaches.**

Index Terms – assessment, active learning, engineering practicum, engineering education, hands-on engineering activities.

INTRODUCTION

A large public university created a new Department of Engineering Education (EngE) within the College of Engineering (COE) in May 2004 to improve engineering pedagogy. EngE offers a common 1-year General Engineering (GE) program for initial preparation of ~1500 incoming engineering freshmen every year. EngE faculty is currently developing a PhD program in engineering education. Also, a graduate certificate program in engineering education is already in place. A number of graduate courses in engineering education have been developed in support of these graduate programs. One of the required courses for both certificate and Ph.D. programs is a 1-credit "Practicum in the Engineering Classroom EngE5504" course. This paper discusses evolution of this graduate course over the last 2 years. One of the major activities in the course is a 9-week long class project. In this project, graduate students are assigned to develop a 60-min long hands-on workshop targeted at introducing their respective engineering departments to engineering freshmen. This paper, first, discusses the course in general including syllabus. Then, examples of students' hands-on projects are presented. Finally, students' responses to an end of semester survey are summarized.

EngE5504 PRACTICUM IN THE ENGINEERING CLASSROOM

This is a 1-credit graduate course and has been offered every semester since fall 2005. Having successfully completed this course, the student will be able to and/or will have experienced:

- Articulate the relationship between a given set of course learning objectives and the design of the syllabus
- Use engineering education theory to prepare effective lesson plans
- Effectively conduct classes in a variety of formats (e.g., lecture, small group, discussion) appropriate to the material at hand and adaptive to different learning styles
- Design and conduct assignments and assessments appropriate to the course learning objectives
- Productively reflect on their teaching practices to enhance or improve the student learning environment
- Perform peer reviews of other students and faculty and discuss their performance

About 20 students, mostly pursuing Ph.D. program in different engineering disciplines, have taken the EngE5504 course since fall 2005. The students are expected to have a teaching assignment in order to enroll into the course. Course instructors, typically two, meet with the students for 50-min each week in an informal environment and discuss teaching related issues and share their teaching experiences. Table 1 gives the topics that were discussed in the course in its latest offering in spring 2007 [1].

Table 1
LIST OF TOPICS IN ENGE5504

Date	Topics
Week 1	General course introduction; Course policies Instructor's teaching experiences; First day in class
Week 2	Engineering education research - overview
Week 3	Developing course syllabus/ lesson plans
Week 4	Teaching portfolio
Week 5	Semester project assignment and discussion
Week 6	Student assessment / evaluation
Week 7	Student assessment / evaluation
Week 8	Faculty hiring and tenure process
Week 9	Presentations in different classroom settings
Week 10	Internationalization of engineering curriculum
Week 11	Appraisal of teaching
Week 12	Project presentation
Week 13	Class cancelled
Week 14	Project presentation
Week 15	Course wrap up

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The course grade is composed of four items as follows: Semester Project (50%), Weekly assignments (20%), Class Participation/Discussion (20%), and Journal/Teaching portfolio (10%). Students are provided with reference materials / articles from various sources from time to time and there are no required textbooks. However, following texts are recommended:

1. Davis, B., "Tools for Teaching," Jossey-Bass Publishers, 1993, 429 pages.
2. Chism, N., Menges, R., Svinicki, M., Weinstin, C.E., "Teaching Tips", 9th edition, D.C. Health and Company, Lexington, MA, 1994, 444 pages.
3. National Research Council, "Evaluating and Improving Undergraduate Teaching in Science, Technology, Engineering, and Mathematics," National Academies Press, Washington, D.C., 2003, 215 pages.

CLASS PROJECT

One of the major assignments in the course is a semester project. Students are assigned this project during the 5th week of the semester, and in-class presentations and a project report are due during last 2 weeks of the semester. This project, assigned for the first time in spring 2006, has evolved considerably. The main objective of this project is to give the graduate students the experience of creating curriculum material using hands-on learning approaches to expose engineering freshmen to different disciplines of engineering. The next section gives a description of the project that was assigned in spring 2007 [2].

Spring 2007 EngE5504 Project Assignment: One of the objectives of the General Engineering (also called freshman engineering) program, conducted by EngE faculty, is to introduce engineering freshmen (~1500 every year) to various engineering disciplines within the College of Engineering. A number of hands-on activities are done in the freshman engineering courses like Engineering Exploration (EngE1024) to accomplish this objective. The objective of this semester project is to create a workshop for introducing engineering freshmen to your engineering department. You'll be provided with the spring 2007 syllabi of ENGE courses (e.g., EngE1024 and EngE1114) to help you choose the topic of your workshop and associated learning objectives. Prepare a report of the project using following guidelines:

1. Clearly state the title of the workshop.
2. List learning objectives (max. 3) for this 60-min. long workshop. Assume 32 students will participate in your workshop.
3. Create a pre-workshop assignment that includes 5 questions. These questions can be multiple choice or short workout and should be designed to assess the prior knowledge of freshmen related to the proposed activity. It can be assumed that this assignment will be assigned one week prior to the in-class workshop.
4. Describe workshop activities in detail including:
    a. Materials required with vendor list
    b. Estimated cost (in $ per kit) of materials needed for creating the proposed workshop. It is suggested that maximum cost be limited to $20 per unit.
    c. It can be assumed that this workshop will be done in groups (four students per group) but the workshop should have both individual and group components. Clearly state the individual and group parts.
    d. Protocol for workshop activities (instructor handout)
        i. Time estimate for workshop if multiple parts (max. time 60 min.)
        ii. Use CAD or hand sketches as needed to demonstrate ideas
        iii. Assume the entire workshop including pre-workshop activity, in-class activity, and follow–up assignment is worth 100 points. Suggest a grading rubric that will be used to grade this workshop.
    e. Instructions for students for both group and individual parts.
    f. A follow-up workshop assignment consisting of about 4 questions, again multiple choice or short workout, that emphasize the problem solving aspects of the activity. This will be assigned at the end of the in-class part of the workshop.
5. Create 4 multiple choice test questions appropriate for testing knowledge gained in the area related to the workshop. These questions should have 5 answer choices. Do mark the right answers.

You will make final presentation of your project to the class during week 12 and 13 of the semester. Presentations will be expected to be about 20 minutes long.

Note: I'll expect you to give a brief description of your progress on March 12 and March 26.

Examples of Student Projects

Since introduction of the class project in spring 2006, 15 graduate students have come up with a variety of hands-on projects aimed to introduce engineering disciplines to freshmen using active learning approaches. In fact, two of these projects (i.e., mechatronics and introduction to systems concepts using sustainable energy) have been implemented in a required freshman engineering course "Engineering Exploration EngE1024." Examples of some proposed hands-on activities include "mechatronics," "water for now and tomorrow," "chemical bond design," "introduction to trusses," "bridge building 101," and "tower construction," "assessing roof conditions in underground stone mines," "introduction to systems concept using sustainable energy," "Bernoulli's equation," etc. The following sections describe two such projects.

Human Factors and Ergonomics: Workstation Design: A PhD student in the Industrial and Systems Engineering department proposed this hands-on activity. The goal is to design an ideal student workstation for an undergraduate

engineering classroom. The main objectives are to introduce students to: i) Industrial Engineering, ii) Human Factors/Ergonomics, iii) Relevance of Human Factors in engineering design, and iv) Human factors tools for workstation design. As per the stipulated requirements, the author came up with five pre-workshop activities. For example, Question 1 of pre-workshop activity was on "Anthropometry" and reads as below:

1. Using the following diagram, please measure and record your (see Figure 1):

a. Item 1 - Stool height (cm): _____

b. Item 2 - Knee height (cm): _____

c. Item 3 - Elbow rest height (cm): _____

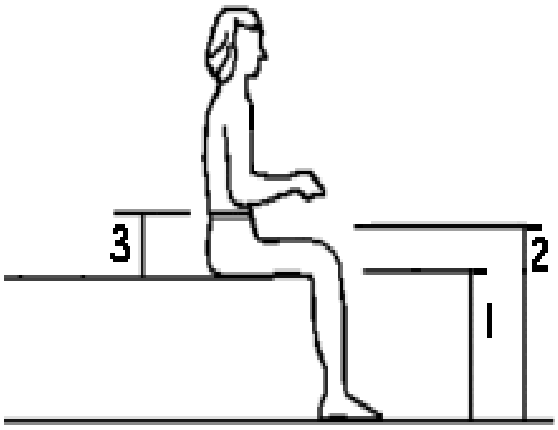

FIGURE 1
WORKSTATION DESIGN PROJECT

The project report included a complete description of workshop implementation details including instruction for instructors, list of items needed, post-workshop and test questions, etc. Details of this project are given in [3].

Managing Conflict

This hands-on workshop, proposed by a PhD student in the ME department, is intended to help freshman engineering students adapt to the group work environment. Since the resolution of conflict and dependence on others are frequently among the most challenging elements of group work, the workshop activities and supporting material are specifically targeted to developing useful constructs and language to help students communicate effectively and professionally to resolve conflicting perspectives within the group. Students will be divided into *section teams* appropriate to the workshop size and material constraints. Each group will select a single member to also serve on a *resource team*. The class as a whole will be challenged with the task of constructing a device or structure to reliably move a marble from an elevated structure on one side of the room to a target area on the other. Each section team will be assigned a segment of the room and will be responsible for the design and construction of assemblies to communicate the marble from the previous team to the subsequent team. The entire class will have a common pool of resources: building materials from which their designs may be derived. It is the responsibility of the resource team to negotiate and ultimately decide how the resources will be distributed. (The competition for limited resources naturally introduces an element of conflict even if disagreements over design strategies do not occur.) The project report and presentation slides included all instructions, list of hands-on materials, time estimates, etc. needed for implementing the workshop. Figure 2 shows a schematic of the proposed activity. Details are given in [4].

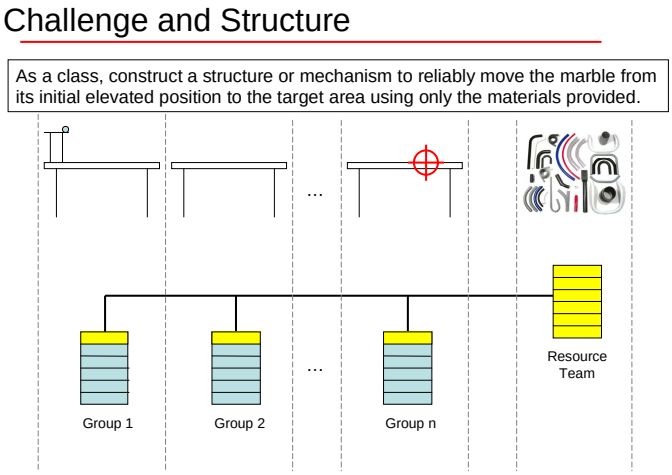

FIGURE 2
MANAGING CONFLICT SCHEMATIC

CLASS PROJECTS IMPLEMENTED IN A FRESHMAN ENGINEERING COURSE

The authors (first and the last) also coordinate a required freshman year engineering course "Engineering Exploration EngE1024" which is a required course for all engineering freshmen at this public university. Two EngE5504 class projects (i.e., mechatronics and introduction to systems concepts using sustainable energy) have been implemented in this course. A brief description follows.

Mechatronics workshop: In order to give meaningful experiences related to Electrical, Computer Science/ Engineering and Mechanical Engineering, a "mechatronics" workshop was developed by a Ph.D. student from the electrical and computer engineering (ECE) department under the guidance of a faculty from the ECE and the first author. This workshop was piloted in spring 2006 with ~180 students in EngE1024 and was implemented in the entire freshman class of 1200 students in fall 2006. The main objectives of this workshop are to: 1) Expose freshman engineering students to mechanical construction, electrical/electronic circuits, as well as digital circuits from computer engineering, and 2) Build and test a two-wheel driven mobile robot. The experiment involves building a robot using several mechanical (gears, wheels, shafts, etc.) and electrical parts (resistors, capacitors, motor driver integrated circuits, breadboard, battery, diodes, micro switches, etc.). Hands-on activities in the workshop included: (1) building a gear box, (2) attaching motors, wheels, battery, switches, and breadboard, (3) constructing a power supply for the robot, (4) creating circuits on the Breadboard, and (5) testing the robot. Figure 3 shows the 2-wheet robot that is built as part of this hands-on activity. It may be mentioned that in spring 2006, this activity was completed in one week

but starting fall 2006, the mechanical engineering part (i.e., gearbox assembly, etc.) is done in first week and the electrical and computer engineering part (i.e., breadboard circuiting, etc.) are done in 2nd week. Details of this workshop can be seen in [5, 6].

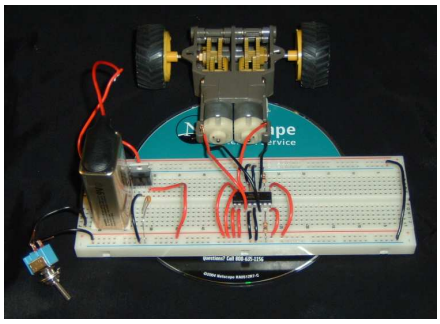

FIGURE 3
TWO WHEEL ROBOT- MECHTRONICS WORKSHOP

Introduction to Systems Concept using sustainable Energy: This workshop was designed by a PhD student in the biological systems engineering (BSE) department under the guidance of the lead author and a faculty member from the BSE department and was piloted in spring 2007 in EngE1024 with ~180 students. A systems model called Berkeley Madonna (BM) [7] was used to simulate impacts of two energy scenarios involving coal and biodiesel and CO_2 emission and sequestration were discussed using hands-on activities using BM model. Students were provided with BM model files for simulating the two energy scenarios using course web site. Data on population growth, energy usage, forest cover, etc. were collected from authentic sources. In order to introduce the main concepts associated with the systems activity, a pre-workshop assignment in the form of a flowcharting exercise was developed that involved comparison of CO_2 emission between coal and biodiesel energy resources. Details of the activities are given in [8].

STUDENT FEEDBACK

Since spring 2006, the authors have administered a survey to assess the effectiveness of various learning activities in this course. About 10 students have participated in this survey. A list of questions and samples of students' responses are given below.

What was the most valuable part of the course during the semester? Why?

-Learning and sharing the experiences of all the 3 course instructors was the most valuable part of the course for me.

-The most valuable part is being able to share teaching experiences with faculty members.

-I learned both teaching techniques and their enthusiasm to improve teaching practice and help students in a more interactive manner.

-The most valuable part of the course was discussing teaching experiences and issues with fellow graduate students. Hearing what other graduate instructors are doing and learning from their experiences (sometimes mistakes) is very helpful because it is easy to relate to fellow graduate students in the classroom.

-The interaction with other programs. We had a very diverse group and it was nice to hear there perspectives on teaching.
-It was very useful to learn about the tenure and hiring process. I think it really gives us an advantage in that process. I also enjoyed the opportunity to get feedback on various situations that i have or may encounter with students in the classroom.

-Several topics were addressed about college education in general, and Engineering education for freshman students in particular. These discussions ad talks broadened my knowledge about these subjects.

What was the least valuable part?

-Honestly, I learnt a lot from each class and don't really think any part was least valuable.

-The least valuable part is the topic of Students assessment/evaluation. I feel it less valuable not because it is not important, but that we haven't got into its details. We are provided with some sample evaluation sheet, but we didn't discuss very much on how to analyze the results and improve the course accordingly. Sometimes the open-ended discussions were also the least valuable part of the semester. There is a fine balance between sharing ideas, lessons-learned, and general teaching experiences and focusing too much on one person's very specific question or concern. Occasionally some of the discussions related to EngE research in the freshman courses also dragged on too much. The answer to this question depends largely on what the primary focus of this course is really supposed to be. Since I have limited knowledge of what constitutes EngE research, some information about what types of questions or research methods are addressed in this field would be interesting but it does not need to be solely related to the freshman courses (1024 and 1114).

-The sometimes straight teaching we got. I would have much preferred a round table discussion of topics. I don't know if this is because lack of time or style.

-The case studies from research. I am more interested in learning specific techniques for explaining difficult aspects of engineering rather than looking at a bunch of data that may only apply to freshman level courses.

What suggestions do you have for improving this course?

-I would like this course to be even more interactive. If students could get to discuss more about their teaching problems and deficiencies with each other and the instructor that would be really beneficial.

-I think instead of giving off handouts in class, we could do some pre-class reading, then discuss a few interesting aspects of a given topic.

-Defining the purpose of the course at the beginning and also clearly explaining what assignments will be expected would make the course better. Also, really trying to keep discussions focused would be nice. Perhaps asking the students in the course what areas of teaching and EngE research they are most interested in at the beginning would help to make the course more useful and relevant to students from semester to semester.

-Open a discussion board and maybe spear head some topics for the students to discuss from their perspective or experience.

-Focus more on teaching techniques and how to develop courese (general template) and less on data.

Based on your experiences in classroom, suggest one or two engineering education research questions.
-How do you teach design? Does completing a total design project each semester of the freshman year make sense or would it be better to break up the design process and really focus on a few phases in each semester?

-How has pedagogy changed for freshmen in the last 10 years?

-What is the role of the professor/teacher in helping individuals with documented learning impairments? Research of young minority engineers (practicing).- What made them become engineers, what made them successful students/professionals?

-What is the change of retention in Engineering for the last 15 years. What is the change of the percentage of college students who enroll in Engineering over the last 15 years?

SUMMARY

The authors have had a very positive experience in developing/teaching the Practicum in the Engineering Classroom course. Students' feedback has been generally very positive and constructive. In the past engineering faculty hasn't done a good job of training graduate students to be future educators with knowledge of the various aspects of teaching. Courses like this one help to fill this critical need. Based on the survey data, it was found that students, on an average, spent ~15 hours in completing the class project. Also, majority of students expressed that two instructors should co-teach this course so that they will have an opportunity to learn teaching experiences of multiple instructors. In addition to provide teaching experiences to graduate students, the course is providing a unique opportunity to develop hands-on activities, created by doctoral students, for educating engineering freshmen. Based on the engineering education research questions, generated by students (see previous section), it can be said that developing and teaching a course like EngE5504 may inspire graduate students to pursue research in the area of engineering education in conjunction with traditional engineering disciplines.

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