"How Things Work": The Development of a New Course

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Abstract

The nation-wide crisis in K-12 science, math, engineering and technology (SMET) education has been addressed by several programs. One of these programs is the National Science Foundation's Collaborative for Excellence in Teacher Preparation (CETP), which strives to improve K-12 science education by enhancing the science education of pre-service teachers. A new science class, *The Science and Engineering of How Things Work*, was developed to teach scientific principles in a hands-on, inquiry-based learning style. This paper will address the challenges and rewards associated with the development and instruction of this class.

Introduction: The Problem

Several figures of merit are used to measure the quality and progress of mathematics and science education in the United States. The National Assessment of Education Progress (NAEP) has been administered to students in the United States since the late 1970's and the Third International Mathematics and Science Study (TIMSS) was recently used to compare the math and science eduction of students throughout the world. From these studies the following observations can be made:

- NEAP data show that students are performing better in science and math during the 1990's than in the 1970's. The rate of improvement may show signs of leveling off [1].
- U.S. student achievement in math and science, as compared world-wide, is good in elementary school and declines sharply towards high school [2].
- The performance of Blacks and Hispanics is below that of Whites [3].

It is interesting to note that the benchmarks used to compare students from the 1970's and 1990's have not changed, however the proficiency in SMET that is required for success in the job market has substantially increased over the past 25 years.

Several less formal surveys accentuate the SMET problems as they exist in New Mexico.

- 77% of the general public in New Mexico describe science and math as boring or hard.
- 60% of the elementary school teachers in New Mexico skip science sections because they don't feel comfortable teaching the material.

[1] National Center for Education Statistics (1997)

[2] Martin *et al.*(1997) *Science Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study*

[3] National Center for Education Statistics (1997)

EE 110: Part of the Solution .... I hope

The goal of the National Science Foundation's Collaborative for Excellence in Teacher Preparation (CETP) is to improve the science education of preservice teachers. In 1998, New Mexico was awarded a CETP grant. One of the primary goals of this program is to reform current science and math courses and to develop new courses that would improve the SMET literacy of Education majors. I was charged with the task of developing an engineering course for education majors.

Goals for EE 110

The following are a set of general goals that were established prior to the development of EE 110.

Make it fun. Perhaps the most important goal of this class is to show the preservice teachers that SMET can be fun, exciting and dynamic. If just a small amount of this enthusiasm for SMET can be passed on to their future classes, it will go a long way in building everyone's appreciation for science and math.

Teach the student how to *learn* science. Education majors are required to take 12 credits of science. This is far too few hours to learn everything that is needed to be a good teacher of science even at the K-6 levels. However, if the preservice teacher can learn science on his/her own, she/he will be able to gain the expertise needed to teach a wide variety of SMET topics.

Build the student's scientific intuition. I have noticed that scientific intuition is a quantity that is highly correlated to how well a person does in science (SMET). Most of the time, a student's scientific intuition is adequate, but it has not been developed. By using experiments/exercises that incorporate everyday phenomena, a student's scientific intuition can be developed.

Teach the class the way you want SMET taught to kids. Education majors spend many credit hours learning how to teach SMET. Why not just teach education majors SMET the way you want them teaching it to their students?

Structure of EE 110

At the introductory level, there is very little difference between science and engineering. I believe that the most concise definition of engineering is: *design under constraints.* Throughout this course I have tried to include this concept.

Hands-on learning There may be a debate on whether students learn physics, for example, better via a traditional lecture format or by the more modern *inquiry based method.* However, there is little debate over which one is more fun. All of the SMET principles in EE 110 are taught in a hands-on inquiry based method.

Integration of Lecture and Lab The lab and lecture for EE 110 are integrated. Often the class begins with 30-45 minutes of discussion followed by a lab portion. As questions arise during the lab, mini-discussion periods are integrated.

Modular design The subject matter of EE 110 is divided into modules where a specific problem is investigated in depth. The modular design allows for successful portions of the class to be continued and new modules to be added.

Science of the every-day All of the topics in EE 110 deal with every-day phenomena. This increases the student's *comfort level with the material* and provides a good starting point on which their scientific intuition may be strengthened.

Grading The students in EE 110 are graded on their lab work, homework, exams, and presentations.

Modules used during the Fall 2000 Semester

- Batteries:
  - Ohm's law and basic electricity; Concept of power
  - The chemistry of how batteries are made
  - Environmental issues
  - Economic issues
- Physics of the playground:
  - Rolling balls
  - Slides
  - Merry-go-round
  - Swing
- How to gamble:
  - Coins
  - Dice
  - Cards
  - Lotto
- Bridges:
  - Forces (review)
  - Tension
  - Compression
  - Construction principles
- Other Benefits: The course will also cover basic skills needed to perform science and engineering tasks:
  - Measurement skills (accuracy, error etc)
  - Graphing skills
  - Science research
  - Scientific instruments
  - Applied mathematics

Summary of the first four semesters of EE 110

EE 110 got off to a rough start with problems that included a conflict over the name of the course and a fight with the registrar's office about the number of credits and the meeting time of the class. These problems contributed to a low enrollment during the first two semesters. By the third

semester, the class was filled by the third day of registration and the course has remained full during the next two semesters.
Entrance and exit surveys show that the students' attitudes towards science have improved and that they feel they have learned from the class. During the last two semesters between 10% and 15% of the education students have changed their area of specialization to math or science, which seems to support the findings of the survey.