AC 2009-603: LABORATORY PROJECTS APPROPRIATE FOR NONENGINEERS AND INTRODUCTION TO ENGINEERING

John Krupczak, Hope College
Professor of Engineering

Kate Disney, Mission College
Engineering Instructor

Scott VanderStoep, Hope College
Professor of Psychology

Laboratory Projects Appropriate for Non-Engineers and Introduction to Engineering

Abstract

A group from engineering programs at both four and two year colleges has developed laboratory modules with an emphasis on activities and perspectives shown to be successful in technological literacy courses for non-engineering students. To meet the needs of community college engineering programs, the logistical and commercial feasibility of shipping boxes or palettes of equipment was investigated. This will allow community colleges to borrow, rent, or lease rather than own the equipment. These laboratories are suitable for use in either introduction to engineering or technological literacy courses. The laboratories attempt to utilize insights from non-engineering students to determine themes that may enliven introduction to engineering courses. Beginning engineering students may have interests more closely aligned with their non-engineer peers than current engineering professionals. Technological literacy courses on a number of campuses have found that non-engineers respond positively to material that a focuses on technology familiar to the students in their everyday life, use extensive verbal and graphical explanations, and include useful information that helps to establish a sense of empowerment regarding technology. Eight laboratory projects are being created and tested both with non-engineering students and students enrolled in introduction to engineering classes. Projects include building and testing common technological devices such as speakers, amplifiers, motors, and a photovoltaic battery charger. Results from testing during the 2008-2009 academic year will be presented. The work is supported by the National Science Foundation under award: DUE-0633277.

Introduction

The National Academy of Engineering is advocating that all Americans need to better understand all types of technology not just computers and information technology [1]. While not yet common, some engineering departments offer service courses for non-engineers [2]. Many of these technological literacy courses have become successful when measured by sustained student interest and long-term sustainability [2,3]. In attempting to enliven introduction to engineering courses, these successful technological literacy courses represent a potential source for themes or topics.

In addition to capturing the interest of first year students, efforts to attract students to an engineering career must acknowledge that two-year institutions or community colleges represent the fastest growing segment of higher education [4]. Recent data shows that 40% of individuals earning bachelor or master's engineering degrees started higher education in a community college. The trend is higher in some states such as California for which more than 48% of graduates with science or engineering degrees started at a community college [5].

Despite this contribution to the nation's engineering workforce, engineering education in a community college environment presents formidable challenges for both students and instructors. Most community colleges have small engineering programs with only a few faculty, often only one or two. Each instructor has high teaching loads of four or more courses per semester. Faculty have little time for course or laboratory development. There is limited laboratory support staff and budgets to buy and maintain equipment. While many community colleges exist, the relentless teaching demands on the faculty, and geographic separation tend to result in community college engineering faculty working in a state of relative isolation. Any effort to attract students into engineering through community colleges must contend with these challenges.

Topics Cited as Appealing by Non-Engineering Students

Based on experience from technological literacy courses for non-engineers [2,3,6-8], particular topics or characteristics have been found to attract the interest of the non-engineering student. These are summarized in Table 1.

Table 1: Technological Themes Cited as Important to Non-Engineering Students.

Course Theme or Characteristic
Relevance of topics to familiar technological devices.
Practical applications and skills.
Hands-on experiences with technology.
Avoidance of entirely mathematical explanations.
Development of a sense of empowerment in relationship with technology.

In learning engineering or technological topics, non-engineers place a high value on knowledge relevant to familiar technological devices, seek practical applications and skills, and aspire to a sense of empowerment in their relationship with technology. While non-engineers are willing to pursue and even welcome developing in-depth understanding of technological principles, mathematical arguments alone are not sufficiently compelling in this regard. It should be possible to develop a self-contained explanation of the underlying principles of the device using only verbal descriptions and graphics. It might be noted that this is the approach followed in the popular “How Stuff Works” website [9], and the physics textbook [10].

Engineering educators might consider these preferences and priorities of non-engineering students as valuable data. Insights from non-engineers can help to identify the most compelling aspects of the field. The interests of first year engineering students may have more in common with their non-engineer peers than experienced working engineers. Themes borrowed from successful technological literacy course may help enliven the engineering curriculum.

Laboratory Development Process

Work is underway to create eight laboratory projects that meet the criteria outlined in Table 1. These projects will be suitable for use in either a technological literacy class for non-engineering students or for introduction to engineering. The activities will be piloted in both two-year and four-year institutions to establish suitability across a range of academic environments.

To address the problem of obtaining equipment, the projects will be created in such a manner that they can be completely contained in a box of 20-100 pounds and can be shared between schools or rented from a commercial supplier

Evaluation

In addition to assessment of topic-specific content knowledge, several scales of the Motivated Strategies for Learning Questionnaire—MSLQ [11] will be used with each activity. Specifically, data will be collected using these scales:

- **Intrinsic Motivation:** Intrinsic motivation measures the extent to which students are inspired to learn because of curiosity about the topic, or the joy that comes from understanding complex material.
- **Extrinsic Motivation:** Extrinsic motivation measures the extent to which students are inspired to learn because of rewards such as grades.
- **Task Value:** Task value measures the extent to which students feel that what they are learning is relevant, useful and personally meaningful.
- **Self-Efficacy:** If students feel competent and empowered to succeed they will have high scores on self-efficacy.

These MSLQ scales have been used on hundreds of campuses. The psychometric properties are reliable and predict achievement [12].

Preliminary results from an initial test at Hope College are shown in Figure 1.
The results are highly encouraging—after completing just one series of the initial version of the laboratory activities in a technological literacy course for non-engineering majors, these students demonstrated increased intrinsic motivation, increased task value, and improved self-efficacy about science and technology. Self-efficacy increased by more than 10% and test anxiety about technological topics decreased by almost 15% in one semester. All results are statistically significant ($p<0.05$). These results are encouraging for the prospect of technological literacy for all Americans.

It is particularly notable that nearly 60% of the students taking the course at Hope College were women and 24% of the students were pre-service elementary teachers who will be teaching science in their classrooms. These results demonstrate that it is possible to lower anxiety, increase perceived value, and increase motivation for engineering and technology among those who will have influence on K-6 students.

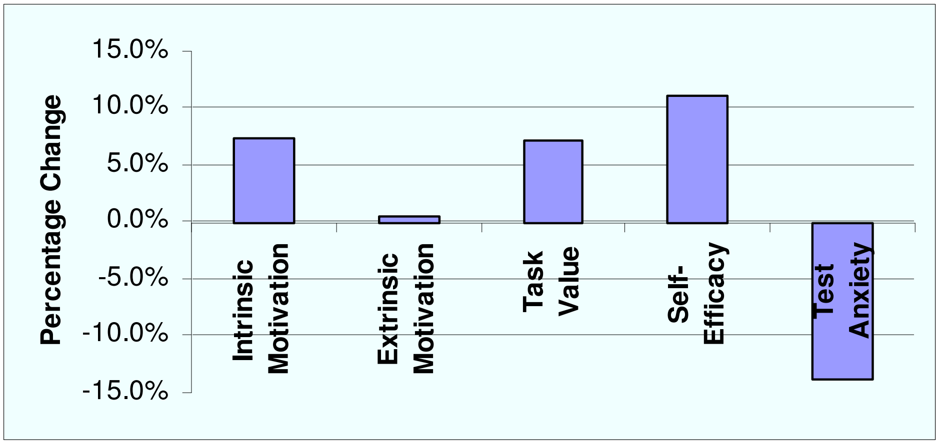

Figure 1: MSLQ Preliminary Results —48 Students, Spring 08.

Acknowledgement

The work was supported by the National Science Foundation under award: DUE-0633277. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Bibliography

1. Pearson G., and A.T. Young, editors, *Technically speaking: Why all Americans need to know more about technology*, National Academies Press, (2002).
2. Krupczak, J.J., D. Ollis, “Technological Literacy and Engineering for Non-Engineers: Lessons from Successful Courses,” *Proceeding of the 2006 American Society for Engineering Education Annual Conference* (2006).
3. Kuc, R.,” Teaching the non-science major: EE101 - The most popular course at Yale.” *Proceedings of the 1997 American Society for Engineering Education Annual Conference* (1997).
4. National Science Foundation, Science and Engineering Indicators, http://www.nsf.gov/statistics/seind04/., Accessed March 15, 2008.
5. *Committee on Enhancing the Community College Pathway to Engineering Careers, National Academy of Engineering and National Research Council* “Educating America's Engineers: The Vital Role of Community Colleges,” The National Academies in Focus, Vol 5, No 3 (2005).
6. Krupczak, J.J and C. Green “The Perspective of Non-Engineers on Technological Literacy," *Proceedings of the 1999 American Society for Engineering Education Annual Conference (1999).*
7. Sarfaraz, A.R., and T.A. Shraibati, “Responding to the Expectations of Non-Technical Students,” *Proceedings of the 2004 American Society for Engineering Education Annual Conference (2004).*
8. Ollis, D. “Installing A New "Technology Literacy" Course: Trials and Tribulations,” *Proceedings of the 2004 American Society for Engineering Education Annual Conference* (2004).
9. HowStuffWorks.com, One Capital City Plaza, 3350 Peachtree Road, Suite 1500,Atlanta, GA 30326, www.howstuffworks.com.
10. Bloomfield, L., *How Things Work: The Physics of Everyday Life*, 2nd Edition, Wiley, New York, (2001).

11. Pintrich, P.R., Smith, D., Garcia, T., and McKeachie, W. *A Manual for the Use of the Motivated Strategies for Learning Questionnaire.* Technical Report No. 91B-004. National Center for the Improvement of Postsecondary Teaching and Learning, (1991).

12. VanderStoep, S.W., Pintrich, P.R., and Fagerlin, Disciplinary differences in self-regulated learning in college students. *Contemporary Educational Psychology*, 21,(1996) p 345-362.