Self-Directed Learning to Empower a More Creative and Diverse Engineering Workforce

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Background

Abstract

My approach is to employ open-ended problems as topics for semester-long group projects in a diverse set of engineering courses. These projects serve as a thematic framework for self-directed learning. The rationale for using self-directed learning is to enhance creative problem solving through promoting the independence, persistence, self-confidence, versatility, resourcefulness, and open-mindedness of student learners. Further, the project topics deliberately highlight specific social benefits of engineering innovation. By directly addressing the many social benefits of engineering innovation, we may persuade a more diverse group of students to prepare for, enroll in, and endure the challenges of a rigorous engineering education.

Active/Self-Directed Learning Community (LC3)

- **Objective:** *Strengthen the engineering workforce of the future promoting creativity and diversity of engineering students.*

Motivation

- **The Need for Innovation**. Addressing the Grand Challenges and maintaining competitiveness requires continued technological innovation (NAE, 2007).
- **Creativity in Engineering Education**. Engineering students usually apply facts to find a specific correct answer. Students are seldom presented open-ended tasks requiring creativity (Kazerounian & Foley, 2007).

Figure 1. Engineering students are often tasked with quickly finding the sole correct solution to a problem.

- **Training in Creativity.** Empirical evidence indicates that university students who receive some training in creative problem solving demonstrate higher creativity (Davis & Bull, 1978) are better able to employ practical applications (Cropley & Cropley, 2000), and display higher creative performance (Scott et al, 2007).
- **Diversity in Engineering Education**. Young people and their parents typically identify engineering with a challenging curriculum or practical benefits. Greater emphasis on the teamwork, creativity, and society benefits may help promote diversity of undergraduate engineering students.
  - Inspirational messages are especially appealing to women and other under-represented minorities [NAE, 2008].
  - In our own surveys, we have found female students identify the potential to help people as a significantly more important reason for their choice of a major or field of study than male students (p=0.03).

Learning Activities and Materials

Developmental History of Innovation

1. "Waterslide Design Project"
Vanderbilt University, Fall 2007
Department of Civil & Environmental Engineering
Course: Fluid Mechanics (Junior core, 46 students)

Task: Groups of 3-4 design an original waterslide for Nashville Shores, a local water park.
Students Provided:
- Technical drawings of park infrastructure
- Park visit, meeting, and lunch with park President
- Feedback from park President, PE's, TA & instructor

Deliverables:
- Prelim: AutoCAD drawing and summary (1 page)
- Final: Poster, "pitch," and written report

Evaluation: Judging by panel (instructor, park President, area PE) and a peer evaluation. Nashville Shores built the winning slide the next year.

Figure 2. Undergraduates, Nashville Shores park president M. Strobel, and the instructor.

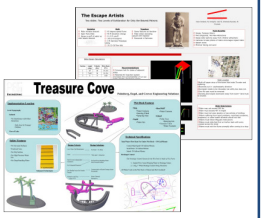

Figure 3. Examples of student final posters for the Waterslide design project.

2. "Informing Public Policy Using Chemical Engineering Principles"
University of Connecticut , Fall 2010
Department of Chemical, Materials, and Biomolecular Engineering
Course: Mass & Energy Balances (Sophomore core, 90 students)

Task: Groups of 3-4 write a position paper on a controversial public policy based on a quantitative mass balance and parameter values taken from peer-reviewed journals.
Students Provided:
- 1-page description with suggested topics
- Bi-weekly instructor feedback

Deliverables:
- Biweekly graded interim reports
- Final paper

Evaluation: Grading by instructor

Figure 4. Public policy project description and grading rubric.

3. "Development of a Novel Microfluidic Device"
University of Connecticut , Spring 2011
Department of Chemical, Materials, and Biomolecular Engineering
Course: Microfluidics & BioMEMS (Juniors, Seniors & Grad Students, 24 students)

Task: Groups of 3-4 design, model, build, and test a microfluidic device to solve a specific engineering problem.
Students Provided:
- "Just in time" techniques, theory, & skills (AutoCAD, COMSOL, microfabrication).
- Bi-weekly instructor feedback

Deliverables:
- Bi-weekly interim project components
- Final oral presentation

Evaluation: Instructor and peer evaluation

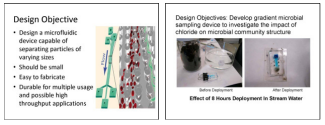

Figure 5. Examples of student-designed microfluidic devices: cell sorter (left) and microbe sampler (right).

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Major Issues to Resolve

Discussion

Student Expectations

- Engineering students are accustomed to solving clearly-defined problems with clear solutions.
- Students find self-directed learning frustrating and scary. Anxiety can result in lower teaching and course evaluations.

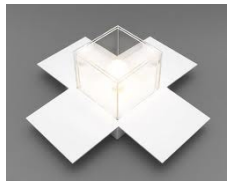

Figure 6. Developing effective innovators may require students and faculty alike to abandon pre-conceived expectations.

Implementation and Scale-up

- Self-directed assignments require increased effort per student.
- Engineering students do not have experience working effectively in groups. Group conflicts can over shadow other learning goals.
- Expectations for tenure and promotion seldom reward implementation of self-directed assignments.
- Instructor effort per student does not decline significantly with class size or with the number of times the class is taught.

Strategies for Success

- Explicitly acknowledge uncertainty to mitigate student anxiety. Manage grade anxiety with graded examples and detailed rubrics.
- Excellent course planning and organization reduces perceptions that the instructor is passively involved.
- End-of-semester reflection essays help students realize how much they have learned, and promote greater feelings of satisfaction.
- These methods may work best in an upper-level technical elective, and other situations where small groups can opt in.

Acknowledgments

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