Kindling Undergraduate Interests in Engineering Through Energy and Public Policy

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Abstract

When first-year students arrive on campus and declare engineering as the major of choice, she/he often does not understand the differences among disciplines (e.g., mechanical vs. industrial) within engineering. In the first two and one-half years of their college studies, most engineering students take theory-based courses. Often these courses weed out students more so than retain them. It is not until the final three or four semesters do undergraduate students experience the "fun" in engineering through team and individual projects where they create and engineer solutions to engineering problems. Would it not serve these students well if we can introduce such creative processes earlier? The answer is an emphatic "yes." However, in the first half of students' academic careers, they do not have the theory and engineering maturity to tackle many problems. This is truly a catch-22 problem.

Energy policy issues are all around us. From clean coal technology to electric utility restructuring, energy policy problems make the headlines everyday. Most students can read and understand the issues at hand. This is the channel the authors explored. Several students in the first two years of engineering experienced firsthand research methodologies and communication skills necessary in engineering through exploring energy policy issues. In simple terms, students were able to learn order of magnitude estimation, risk, cost and benefit analyses, and some systems modeling without upper-level courses in engineering. Students also gained hands-on experience in simulation through system dynamics feedback mechanisms. Students who participated in the first phase of this program are now entering their final year of undergraduate study. Two students in this group are now examining and modeling Oklahoma's power markets under the proposed utility restructuring. In short, the energy and public policy approach to recruitment and retention of students has worked well in this small-scale effort.

I. Issue

Why do students transfer out of engineering? Are engineering schools and faculty doing enough in recruitment and retention of highly qualified students? Several sociological studies identified root causes of student attrition in engineering [2,4]. Seymore [4] determined that institutional sources and career-related concerns influenced students to switch out of engineering rather than the common assumption of personal inadequacy. She went on to rank specific factors contributing to switching. At the very top of this list was lack or loss of interest in science.
Women tend to learn more passively than men [3]. Women students in engineering suffer additional loss of confidence in a male-dominated field. Although this difference existed long

before women arrived on college campuses, most women in high school experienced good teacher pedagogy and personal encouragement from their teachers [5]. At large land-grant institutions, many students are often lost in large lecture classes with harsh grading systems. Today's students are barely keeping their heads above water just to graduate under five years. Consequently, what mentoring once existed no longer seems possible for many gifted students, especially female students, in engineering. If these causes are indeed significant, then what can an individual or a small group of faculty members do to make a difference? The authors attempted an energy and public policy approach to kindle undergraduate interests in engineering, which has worked well on a small scale.

II. Energy and Public Policy Program

The authors addressed a part of this attrition issue by creating a small-scale research-based mentoring program at Oklahoma State University (OSU). Energy policy issues surround us. From clean coal technology to electric utility restructuring, energy policy problems make the headlines daily. Most students can read and understand the issues at hand. This is the channel the authors explored. Several students in the first two years of engineering experienced firsthand research methodologies and communication skills necessary in engineering through exploring energy policy issues. In simple terms, students were able to learn order of magnitude estimation, risk, cost and benefit analyses, and some systems modeling without the upper-level courses in engineering. Students also gained hands-on experience in simulation through system dynamics feedback mechanisms. Two students in this group are now examining and modeling Oklahoma's power markets under the proposed utility restructuring. In short, the energy and public policy approach to recruitment and retention of students has worked well in this small-scale effort.

III. Tools

A combination of traditional and Internet tools are used to engage students in engineering and public policy:

<u>A. Order of Magnitude Estimation:</u> In order to cool a steam turbine in a 1000-mega-watt coal-fired plant, how quickly must we run water through it? This problem and others like it are presented in *Consider a Spherical Cow* [1]. How much natural gas is needed to heat a 1700 sq-ft house? Do you know how to read your electric bill? How much energy is saved if everyone in the United States stops driving her/his personal automobile for just one day? Consequently, to what extent can greenhouse gases be reduced if all personal automobiles are parked for just one day in the U.S.? A common sense approach with an order of magnitude estimation skill can answer the above questions. First-year students understand risk and the environment, yet few understand the connection between energy and the environment. By posing questions that link energy and the environment, students can be initiated into solving in-depth problems.

<u>B. Internet and News Analysis:</u> Although the order of magnitude estimation is interesting at first, it is difficult to make a research problem out of it. Public policy takes this challenge one step further by establishing a critical link between energy and the environment. This linkage becomes more relevant and interesting as the student-faculty team probes real and societal

energy issues. Examine the front page of a major newspaper. Law suits, debates, hearings, business mergers, and accidents appear daily because the use of energy and the environment could not be controlled. If our society were not so dependent on energy, there would be fewer environmental problems.

National public policy debates about energy and the environment can be found from a variety of sources. The Internet site <http://thomas.loc.gov> of the Library of Congress is possibly the most comprehensive source to identify current and past legislation. Here students can read the actual text of bills and their status. Advocating the use of a primary source of information is of utmost importance as undergraduate students progress in research. Between primary sources and order of magnitude skills, undergraduate students can start work in energy policy. Apart from reading and critical thinking, students seldom need technical expertise at an advanced level.

IV. Some Energy and Public Policy Topics

Energy policy topics are abundant. The recent restructuring of the electric utility industry has many issues. Electrical engineering students can address the power reliability issue. Industrial engineering students can examine the simulation of generation, transmission, and usage of electricity under the proposed management system of Independent System Operators. Civil, chemical, and environmental engineers can study the environmental impact as the industry is restructured. The possibilities are endless.

Other energy-related policy issues include nuclear fuels reprocessing, transportation of spent nuclear-fuel, alternate fuels and vehicles, environmental compliance such as the Project XL, global climate change, clean coal technology, to name a few. All of them were debated in the 105th Congress. Although they have begun their engineering study, students can learn to appreciate the interaction between science and politics at an early stage of their career.

V. Rationale

The rationale behind introducing energy policy topics for research is simply that no formal advanced-level engineering training is required to interest students. Students can enjoy engineering from the start. The process also forms a bond between the student and her/his mentor. Sociological studies have shown that individual attention, which once fostered women students' interest in engineering, was lacking in college [4]. This, combined with a harsh grading system in engineering, prompted many women to switch out of engineering. Energy policy study brings students in direct contact with faculty members from the first day on campus and establishes a long-term solution to the attrition problem.

VI. Peer-to-Peer Mentoring

One strategy that has worked well in the authors' program is peer-to-peer mentoring. In 1995 one female student was invited to work on a policy issue that was of mutual interest to the student and mentor. In the following year, another female student was chosen. Faculty-student mentoring continued. Moreover, the first student, who was then a sophomore, also helped in the mentoring process by sharing academic and personal experiences with the newcomer. The process continued in the following year. Now there are four students, one in each class passing the torch to the next.

Students participating in the program are not from the same background nor are they in the same program. Yet they are able to work together in a team environment. The authors attribute this success to a common thread that holds them together--engineering policy. Engineering policy is truly multi-disciplinary, with no boundary to separate one student from another.

VII. Starting Your Own Public Policy Program

Any faculty member can start a policy program. Most engineering societies (ASME, ASCE, AIChE, IEEE, SAE, ASEE, etc.) have a presence in Washington, DC, with their government relations office. Some offices are lobbying organizations; some are not. Regardless of their lobbying status, they want faculty and students to get involved in the public policy debate. Policy debates are found in engineering society newsletters and electronic messages. They contain many energy and environment issues that faculty-student teams can explore together. When the faculty member and student have identified an issue, contact the congressman or senator. Their local or Washington, DC, office can provide a wealth of information pertaining to the chosen topic. The Congressional Research Service publishes nonpartisan studies which only Congress and their staffers can request. Ask them for help. The U.S. Department of Energy also has excellent resources. There are associations, government and nongovernment agencies, and not-for-profit organizations in Washington, DC, and in your local area that your students can access.

Based on your work with students, possible external funding opportunities also arise. Your energy policy program can be sustained through external funding as well as internal research funding for students. The most worthwhile benefit to the program is its ability to retain talented young engineers interested in their chosen discipline from matriculation to graduation and beyond.

VIII. Internships/Fellowships

For students, there are excellent internship opportunities in public policy. One of the oldest and strongest public policy experiences for engineering students is the Washington Internships for Students of Engineering (WISE), a program in which the authors participated as an intern and Faculty-Member-in-Residence (FMR). Since 1980, the program has selected 15 to 18 students in a nationwide search. Funding comes from participating engineering societies and the National Science Foundation. Each intern works with her/his mentor at the society's government relations office and the FMR to see firsthand how policy is made. There is a policy paper requirement to the internship. Although students choose their own paper topic in consultation with mentors and the FMR, a majority of papers are energy-related. WISE is one of few internships in Washington, DC, where interns are provided with housing, transportation, and a stipend.

For faculty members, the WISE program actively seeks an FMR each year. The FMR is compensated for her/his work. The position provides opportunities for the faculty member to establish contacts in Washington, DC. Other energy policy opportunities for faculty members include Congressional and Executive Fellowships through the engineering societies, the White House Fellowship Program, and the AAAS Fellowship Programs.

IX. Conclusion

The added benefit to engaging in energy and public policy study is realized much later in a student's career. Most engineering curricula are packed with science, mathematics, and engineering fundamentals in the first two to three years; students will not write reports or engage in oral presentations until the final two years of their studies. Practitioners of engineering emphasize the importance of communication skills, yet many engineering curricula are not designed to address this need until late in one's study.

Critical reading, thinking, and writing skills can be developed and refined through public policy debates. Translating/interpreting policy with scientific understanding requires extensive reading, analysis, and writing. In addition, students learn to take a position and defend it. Since policy analysis does not have one right answer, students learn to weigh positives against negatives. This skill is also very beneficial in later years in design courses, where there is no one correct design but many acceptable designs.

Energy and public policy can be used to recruit and retain students in engineering. It works especially well to entice women engineering students interested in engineering and related areas. It fosters camaraderie among students, encouraging peer-to-peer mentoring. Students develop research methods and communications skills early in their college careers, which benefits them throughout their engineering careers. The setup allows mentoring to take place outside the classroom setting, and contacts and opportunities permit external funding possibilities for mentors.

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