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Benefits from Offerings to Non-Engineering or ET Majors: Integrating Colleges of Engineering into Their Institutions

Abstract

Colleges of engineering are very strong academic/research organizations but they usually offer courses only for their own majors. The sciences and mathematics typically offer extensive courses for non-majors. Often, these are required courses for the non-majors and the aggregate of the non-major courses may exceed those offered for their own undergraduates. The practice of colleges of engineering not to offer courses for non-engineers isolates engineering and deprives engineering colleges from allies in other colleges, cuts them off from sources of students in the very groups engineering would like to entice, and misses the opportunity to educate other majors about the contributions engineering has made and will make to society. Instances of engineering college courses offered for non-majors are discussed and the characteristics and topics for additional courses are presented.

Introduction and Motivation

In our country, where technology make access to information, data, statistics, and even opinions readily available, our citizens need to know a great deal more about engineering and technology so they can make intelligent decisions. These circumstances crop up everywhere and they are inherently highly multidisciplinary in nature. Colleges of engineering and/or engineering technology, herein after called E/ET colleges, are well-suited for the challenge to educate people about technical issues but, unfortunately, E/ET colleges often offer courses only for their own majors. This exclusivity precludes the access to very beneficial knowledge by individuals in other majors and it also isolates E/ET colleges from the other colleges within their own institutions. As a result, E/ET colleges need to take the initiative to introduce non-majors to the principles of engineering and technology by developing appropriate courses

The construct of these potential courses is very important to bridge this gap. They must contain sound technical principles, be objective and realistic, treat inherently interesting and timely topics, instill a recognition of the quantitative nature of technology, contain good case studies, provide hand-on experience if possible, and, most importantly, be well taught. Names for these courses are important and in this paper, they're called *Engineering Insights* or EI course for short. An example course might be *EI 101: Electric Energy Generation and Distribution.*

From the exposure they receive through taking EI courses, graduates of liberal arts, business, education and similar programs will better understand what will be involved to improve infrastructure systems and they will be more likely to appreciate the time and investments that are required. They will become skeptical of quick fixes, be able to spot unsound proposals, and will realize the importance of seeking well-founded advice on technical matters. Upon taking EI courses some students may find the E/ET fields so interesting that they switch to these curricula,

just as E/ET majors presently transfer to different programs that they find particularly interesting after taking introductory or elective courses. As a direct consequence of offering of EI courses E/ET colleges will, over time, become less isolated and more integrated into the cultures of their institutions. This will also translate to more well-rounded graduates of other colleges within their institution who will assimilate into society.

Integrating E/ET colleges into their institutions is not new. A long-time eloquent proponent is Dr. John Calhoun, professor emeritus of petroleum engineering at Texas A&M University and an ASEE past president. The National Academy of Engineering (NAE) reports often mention the importance of a citizenry that is more informed about technology. Industry and ABET have increased their emphasis on infusing teamwork experiences into E/ET curricula and this can transform into interactions with majors in disciplines outside of E/ET. Those who have taken EI courses would make good recruits for these interdisciplinary teams.

Even though the numbers of their own graduates may be modest, departments of chemistry, mathematics, and physics are regarded as essential not only because of the importance of their fields but also because they offer many courses for other majors. Not infrequently, these courses are required for graduation, including many E/ET majors. Indeed their non-major courses generate large quantities of student credit hours that further justify these departments and their courses for non majors provide support for a number of teaching assistants that comprise a good portion of their graduate students.

Members of ASEE's Multidisciplinary Division are the most likely faculty to develop EI courses because they inherently have wide interests and tend to be familiar with resources for such courses. Promising topics for EI courses are likely to span several E/ET departments and may well draw upon information outside E/ET colleges.

Prospects that the Concept of EI Courses Catch Hold

Fortunately, there are positive indications. Princeton University's Dr. David Billington's widely read book, ***The Innovators*** [1], evolved from well-received courses he developed for engineering majors and non-majors. The preface of this book is, in itself, a lesson on how such material is assembled and the amount of effort involved. A few years ago Dr. Billington presented a plenary session at an ASEE annual conference to a standing-room-only audience. With his son, David P. Billington, Jr., they have published a second excellent book, ***Power, Speed, and Form***[2].

Duke University's Henry Petroski is a prolific author of books[3,4,5] that are widely read by engineers and non engineers. Dr. Petroski writes incisive letters to editors about engineering; one of his most recent ones being to the *Washington Post*, commented on President Obama's emphasis on science and noted that it would be more effective to stimulate the economy through engineering. Dr. Petroski has addressed standing-room-only audiences at ASEE conferences.

Dr. John Lienhard of Houston University has written very interesting books on ingenuity[6, 7, 8] and he, too, has presented heavily attended sessions at ASEE conferences. Dr. Lienhard produces a 5-minute PBS radio program, *Engines of our Ingenuity* that is aired five days/week and carried

by an impressive array of stations. Begun in 1988, there have been over 2450 episodes. The University of Houston's web site[9] provides the texts for the broadcasts and many audio caches.

Another capacity crowd speaker at ASEE Annual Conferences is Dr. Woody Flowers of MIT whose involvement in robotic competitions have engaged significant numbers of young people into E/ET through what is virtually a spectator sport. He is well known for his abilities to inspire people who previously never found technology interesting.

These examples confirm the demand for EI courses. However, a good deal of promotion is required to raise the awareness of students, faculty and advisors.

Objectives, Outcomes, and Structures for EI Courses

The fundamental objective of EI courses is to enhance the critical ability of citizens to comprehend technological systems, to improve their abilities to make intelligent choices.

The EI courses should include most of the following characteristics:

- Contain well-founded engineering principles;
- Relate to engineered systems with which students readily identify,
- Involve good science, introductory-level analysis, economics, societal/environmental impact, and such topics as global engagement, ethics, and cultural aspects;
- Provide, as appropriate, hands-on laboratory experiences;
- Require well-conceived reports based on literature and database searches that include critical assessments and elements of analysis; and
- Include basic engineering design instruction.

These characteristics readily comprise the outcomes that can be assessed at the end of the semester.

Role of ASEE Multidisciplinary Division Members

Multidisciplinary Division members are excellent prospects for initiating the development of EI courses because they have broad views and are well qualified in technology. They are the most logical people to prepare EI course outlines, draft example classes, propose student assignments, and indicate sources of resource materials. The Multidisciplinary Division might evolve as a clearinghouse for sharing syllabi for EI courses.

Multidisciplinary division members are excellent champions for E/ET college administrators who will need them to lead the development of EI courses. When administrators are presented a compelling case that includes estimates of enrollments and the resources needed to develop a potential course, as well as plans to seek external funding for course development, they will be more inclined to provide seed money and/or released time to start the project.

Examples of Potential EI Courses

EI 101: Electric Energy Generation and Distribution. Systems and their efficiencies for generating electric power by steam-driven generators; hydroelectric, wind, and solar collector

electric power generation. Components of electric power grids. Costs of electric power generation. Data on the consumption of electric power by different industries, municipalities, and domestic residences. Environmental impact of different electric power generation systems. Safety, regulation, reliability, and the processes for approval of power plant construction.

EI 102: Urban Transportation of People and Goods. Efficiencies of automobiles, busses, trucks, and light rail. Urban road systems and traffic control. Costs of construction and maintenance of roadways, bridges, and their control systems. Costs of operation and construction of subways and surface mass transportation systems. Energy sources for personal transportation vehicles, their efficiencies and environmental impact. Traffic control systems, including static and dynamic signing, and their impact on safety, energy consumption, and travel time reduction.

EI 103: Inter Urban Transportation of People and Goods: Efficiencies of aircraft, automobiles, trains, and trucks. Costs of construction and maintenance of interstate highways. Comparisons of energy consumption, travel time, and environmental impact of different transportation systems. Trends in the movement of people and goods. Safety and reliability records of different transportation systems.

EI 104: Water Supply Systems: Requirements for potable water. Systems for processing potable water from various sources. Costs of water, reliability and safety requirements of water supply systems. History of potable water consumption. Availability of water input sources for potable water systems. Methods and costs of desalination. Water conservation systems.

EI 105: Waste Water Treatment: Domestic waste water - sanitary and storm water sewers. Characteristics of and methods for treating domestic waste water and the requirements to be met in its discharge. Industrial waste water treatment and the requirements of industry to be met in the discharge of its waste water. Inspection and monitoring of waste water. Problems of non-point source water pollution.

There is an abundance of other topics for potential EI courses. Some of them are: Solid Waste Disposal and Recycling; Manufacture of Pharmaceuticals; Food Processing; Development of the Internet; Technology of Hospitals and Health Care Systems; and Development of Satellite Communication Systems.

These strongly multidisciplinary courses are enhanced if they involve people with extensive experience in the field. Consequently, they are fertile grounds for lectures by experts from industry, government, and private practice who bring practical aspects of professionals working on these challenges and it gives students chances to ask penetrating questions.

While there are relatively few text books suitable to serve as texts for EI courses, there is a very large number of valuable resource books. Some particularly good ones are listed at the end of the references. An incentive for potential authors might is that the circulation of books for EI courses is likely to be much larger than engineering texts, regardless of whether they are adopted as texts. The flexibility of publishers to incorporate sections of different books into one text may make it possible to assemble customized texts for some EI courses.

Assessment of EI Courses

The established assessment practices of E/ET colleges can be applied directly to EI courses but some aspects merit special mention. Large numbers of non engineering majors are unlikely to enroll in EI courses without effective publicity about the courses so evaluating the effectiveness of the advertising is essential. To grow the enrollment in succeeding terms, the courses need to be well taught and favorably received by the students. The assessment program for EI courses must focus on what motivated students to enroll, whether their expectations were met, did they find the course intellectually stimulating, did they master the engineering and science principles presented, and did they find the course beneficial. They should also be asked to suggest improvements. Essay questions are particularly good indicators for a newly offered course and offer good guidance for course modifications, even though they are time consuming to process.

Benefits for E/ET Colleges

E/ET colleges have much to gain by offering EI courses. Colleges of veterinary medicine, agriculture, and business are usually considered integral parts of their institutions. Fifty years ago, veterinary medicine colleges enrolled almost no women but today, however, women account for over 50% of their enrollments in many cases. Veterinary colleagues claim this is because veterinarians are viewed as providing a caring service. It may also have come about because veterinary colleges offer courses for students with no intention of becoming veterinarians. As a consequence, veterinary colleges are less likely to be viewed as isolationists.

Colleges of Agriculture are similar to E/ET colleges in that they offer specialized academic programs but they offer a considerable number of other courses that are open to non-majors. Colleges of Business usually contend with AACSB accreditation which is similar to ABET but can be even more stringent. None the less, business colleges offer a considerable slate of courses for non-majors, some being popular among E/ET students.

As the number of E/ET colleges that offer viable EI courses grows, it will be possible to get some of these EI courses approved to fulfill general requirements in undergraduate curricula. This helps strengthen EI course enrollments and, over time, some of the perceived barriers between E/ET colleges and the other colleges will become less formidable.

The most important contribution arising from substantially more EI courses offered by E/ET colleges will be many more citizens who are better able to make informed, intelligent choices about technological issues.

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Resource Books

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