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Abstract

A new program has started in our school. This is a true multidisciplinary program that includes the whole engineering college and all engineering fields. The major goal of the program is to provide technological awareness and understanding of the technical issues to non-engineering students. Since many managers, directors, and policymakers (all around the world) are making decisions on technological-based issues, it makes sense to provide them with a conceptual-based technology education. This paper covers the major premise of our efforts, the way it is planned, the way we include all majors in the college, and the way we work together to make it happen. This is a collegewide effort that includes all levels from the dean and the dean's office to the individual departments, as well as some of our graduate and undergraduate students. The big challenge is how to teach the classes—i.e., who the audience is. This paper shows the detailed planning, implementation, and early results and challenges of our first course developments and implementations. The paper provides examples of classes, the material that we cover in the first class for non-majors, and the approach of teaching such classes. The students in these classes are mainly in such fields as political science, business, environmental science, policy studies, and other parts of the social sciences. All of the classes in this minor program are designed with basic high school algebra as a prerequisite. The students will learn the concepts and even go through basic back-of-the-envelope calculations that will help them appreciate engineering solutions. The paper provides examples of such concepts as well as reactions of the students. Currently, we have the overwhelming support of the students. While the official start of the program is January 2007, students have shown great support and are working with the director of the program and the College of Engineering to take classes in advance to be a definite part of the program. This paper will address the main issues as to how we go about teaching technology and engineering appreciation to non-engineering students.

Introduction

The need for more technological literacy is one of the major items on today's national educational agenda.[1-4] This is a task that has been nationally advertised by many educational, political, social, and international organizations. Technological literacy is a strong component of the success of nations in the future. The global need for more understanding of technology, technology trends, and technological development is seen by all governments as well as humanitarian and cultural organizations.[1,2]

In the United States, a fundamental understanding of technology is becoming essential to many managers, directors, CEOs, and policymakers. It is important to note that most such key people do not have any engineering or technologically related education or training. However, they are in positions to make important decisions on technology-related items. To such individuals, a fundamental understanding of the basis and concepts of technology, engineering, and technological developments are essential[3,4].

The mission from the College of Engineering

The policymakers of the future will need a better understanding of engineering concepts to make prudent decisions, but there is no realistic prospect that a large fraction of these decision makers will hold engineering degrees. However, it would be possible for persons in a wide variety of occupations and educational backgrounds to acquire an understanding of basic engineering principles without completing an entire engineering degree program.[1]

The minor in engineering studies is proposed and is being designed by our College of Engineering to address this need. We believe this pioneer work by our faculty and staff is a worthwhile and challenging task with local, national, and possible international impact. Understanding the issues of technology, technical literacy, and technical competency are some key components that will define and shape the future success and achievement of nations.[1,5]

The program goals and details

The main goal for proposing the minor in engineering studies is to provide a technological education to non-engineering students with various backgrounds. The minor is not an engineering degree. This is not a minor in engineering but a minor in engineering studies. The student will not be trained as an engineer (and cannot compete for engineering jobs) but will have a good understanding of what engineering, engineering design process, technology, and technology-related concepts are. This program is trying to build basic literacy in the field, and the first goal is to provide a perspective for appreciating engineering and technological issues.

We are a school of science and technology as well as a land-grant university. This is an effort proposed, designed, and implemented by the College of Engineering. Initiated by the dean of the college, this is not a collegewide activity. The development and implementation of the program engages all members from the dean and associate deans to faculty and graduate students in various departments. The program is designed so that no student will be excluded due to insufficient prior preparation in mathematics or the sciences. The classes will only assume knowledge of high school algebra and high school basic sciences. No trigonometry or calculus is necessary. The required courses in the minor do not have any prerequisites. All non-engineering students are encouraged to take advantage of these classes. Many of the elective courses are specifically designed to require either no or very reasonable prerequisites, so that students from all majors will find coursework that supports an accessible and intellectually stimulating program of study.

Program requirements

Any student in a non-engineering major can declare a minor in engineering studies.

There are 21 required credits (semester system credits) for this program. Depending on the college and the specific department requirements, some of these classes can also be counted toward other requirements. So it is possible that a student can take 21 credits for this program and share some of those as other departmental requirements for graduation. The 21 required credits consist of three required engineering studies (ES) courses: ES 260, *Introduction to Engineering: From Thoughts to Things*; ES 265, *Survey of the Impacts of Engineering Activities*;

and ES 270, *Survey of How Things Work*. Each of these second-year classes is a 3-credit class. The students then will have to select 12 additional elective credits from the approved list of courses—6 credits of which must be from either other ES courses (designed for this program) or 200-level and higher (sophomore and higher) courses offered by any of the engineering departments. To meet the university minor requirement, the students need to select 6 credits at the 300-level from an approved list of classes. This approved list consists of technology-related classes that are offered on campus. We have a steering and advising committee for the program that needs to approve the classes, and once a class is approved by the committee it will be in the list.

Here are some examples of classes both in the ES and not in the ES programs as shown in the new course catalog.

ES 325. Survey of Changing Precepts in 21st Century Transportation (2 credits) [new course, 300-level]—New transportation technologies: maglev trains; hydrogen fuel cell automobiles; superjumbo, supersonic, hypersonic, ekranoplane, and personal aircraft; Segway and other personal conveyances. Fundamental principles of engines and motors (turbines, fuel cells, piston engines, electric motors); Carnot efficiency; aerodynamics and fluid dynamics; materials limitations on performance; societal limitations on performance. Support infrastructures (fuel distribution systems, roadways, ground and air traffic control). Environmental consequences.

ES 345. Survey of Sustainable Engineering (3 credits) [new course, 300-level]—An examination of engineering devices and systems for use in third-world nations; utilization of appropriate technologies to improve sanitation, energy utilization, and agriculture to improve the quality of life in third world communities; adaptation of existing engineering systems to environments where electrical power, potable water, and sewage treatment facilities are primitive or absent; sociological consequences of the introduction of new technologies to less-technologically developed cultures.

Phil 343. Philosophy of Technology (3 credits) [prereq: 6 credits of social science or T SC 341 and 3 credits of social science]—Conditions under which technological innovations contribute to human emancipation, relationship of technology and democracy, utility and limits of technical rationality, and problems of ensuring that benefits of technological advancement are communally shared. Issues discussed with reference to contemporary developments in microelectronics, technology transfer to the third world, etc. Nonmajor graduate credit.

Jl MC 474. Communication Technology and Social Change (3 credits) [Prereq: junior classification]—Examination of historical and current communication technologies, including how they shape and are shaped by the cultural and social practices into which they are introduced.

ME 484/584X. Technology, Globalization, and Culture (3 credits) [*Prereq: senior classification*]—Bernard, Rectanus. Cross-disciplinary examination of the present and future impact of globalization with a focus on preparing student for leadership roles in diverse professional, social, and cultural contexts. Facilitate an understanding of the threats and opportunities inherent in the globalization process as they are perceived by practicing

professionals and articulated in debates on globalization. Will use a digital forum for presenting and analyzing globalization issues by on-campus and off-campus specialists. Nonmajor graduate credit.

Who should consider it?

This proposed program is designed to help students who

- Are not engineering majors but are interested in understanding "how things work"
- Are looking at directorship, management, technical marketing, sales, and related careers in an industry that continues to involve more technology
- Are possibly interested in public policy—decisions impacting government, education, industry, religious institutions, health care
- Are thinking about working in bioengineering areas but not on the technical side

The engineering studies minor is designed to be an effective minor to supplement the student's non-engineering degree program.

Program objectives

Students who complete this program successfully will be able to

- Better understand the role of engineering in society and the interactions of engineering with their major field of study
- Perform simple calculations and estimations using the engineering method
- Make simple cost-benefit and risk-benefit analyses
- Appreciate the importance of the underlying assumptions used to produce the cost-benefit and risk-benefit analyses presented by engineers
- Make informed decisions about the desirability of engineering activities by weighing the benefits of those activities against their environmental risks
- Understand the interdependence of the economic, environmental, and sociological aspects of technological change
- Assess the validity and possible weaknesses in predictions of economic, environmental, and sociological consequences of technological change presented by others
- Attain a basic understanding of the engineering design process
- Achieve a survey-level understanding of why particular materials and processes are used to produce simple engineering devices and systems
- Understand the capabilities and limitations of basic manufacturing processes and engineering systems

All of our classes that are designed for this program (as well as the classes that are included as electives) should help advance the students toward the above-mentioned goals.

The reaction of the students

We have had a great reaction from students in a wide variety of majors. The main body of interested students is in all programs in the College of Business as well as the political science, music, liberal arts, and education fields. As we work with other departments outside the College of Engineering, we are finding out that there are many students from a wider variety of backgrounds who are interested. Many interested students are very hesitant to take classes that are designed and taught by the engineering college. They are afraid of the mathematics requirements of engineering. To help the students understand what these classes are, the college is constantly working on the following:

- Presentations to all freshman-level students in non-engineering fields explaining the requirements and the type of classes they will see
- Having an active and dynamic Web site that will emphasize the philosophy of the program and the classes; on this Web site we are in the process of including sample lectures and activities so students will see what they will be facing

As expected, many students who started in engineering and, in one way or the other after taking a few classes, decided not to stay in engineering are some of our most enthusiastic students. That is why ES 260 can be replaced by a freshman engineering class. In addition, all engineering classes for the 2nd, 3rd, and 4th years would also be accepted as technical electives. This way those who started in engineering may easily return as a minor in engineering studies student, especially when they realize that the introduction to engineering classes they took could count as one of the required classes. The current students who are signing up for the program mainly consist of junior students in different areas of the College of Business. These students would like to take this opportunity to learn about engineering, since they believe in the future they would be working with or managing engineering groups. In addition, we are seeing a healthy interest in students in policymaking and political science disciplines. In particular, there seems to be a great interest among the 3rd-year students in public policy studies in the political science department. Finally, we have also been approached by a good number of freshman students in business who would like to plan their careers in technological-related areas such as construction management, high-tech management, and entrepreneurial studies. There has also been some interest among 2nd-year students in music and art. As the program is starting to grow and the classes are being offered, we are seeing a wide variety of interested groups who are contacting us to get information about the program.

The challenges for our faculty and future perspective

The main challenge for the faculty is the process of teaching engineering concepts to non-engineering students. In the College of Engineering, we are lucky to have many great enthusiastic faculty who are fascinated to teach engineering concepts to engineering students. Most, if not all, of the students that we have are strong in mathematics (calculus is required). Consequently, all of our professors and instructors have, until now, only taught students who

- Have decided to major in engineering
- Have a strong interest and background in mathematics and physics

However, the challenge of the classes for this minor is to incorporate the basic concepts but not necessarily the mathematical concepts. Some basic skills can be taught by the professors if needed, but those are very limited. The instructor needs to convey the message to students who

- Have decided they are not going to be in engineering
- Have very little mathematics knowledge (and no interest to know the right math)
- Would like to know more about technology but would not like to study as a technologist

Interestingly, this is neither the focus nor the interest of most of the engineering faculty. Some of us are interested and have limited experience but have not been involved in teaching technology to the student who is not pursuing an engineering career.

This has been one of the major challenges in our program. At first glance, a class in electrical engineering sounds great!

ES 305. Introduction to Electrical and Computer Engineering (3 credits) [new course, 300-level]—An overview of electrical and computer components of different electrical systems such as radios, phones, and microprocessors, and their basic operation. Basic design and testing of circuits; principles of thinking about the engineering process; an "under the cover" look at such systems. Practice with basic control and basics of analog-to-digital conversion and digital-to-analog conversion; interconnection among various subsystems.

While the above is really interesting and fun, one should note that it is meant for non-engineering students. The focus should be on concepts, perhaps hands-on laboratories that are rich in discovery but not in typical engineering challenges. The purpose of the labs is for the students to get to know the concepts and know the essence of the ideas and application and not to design nor be in testing and measurement. This is a good example of the type of classes that we are planning to offer and are designing for this program.

Conclusions

The minor in engineering studies is an attempt designed, initiated, and implemented by the College of Engineering to offer engineering concept classes and provide technological literacy to non-engineering students. This program started in January 2007, and the first group of students is currently taking advantage of the program. In this paper we introduced the motivation, the design, the objectives, and some of the challenges of the program. Based on initial student reaction, non-engineering departmental students and advisers comment that it is going to be a very popular program. The challenge of engineering faculty teaching engineering classes to non-engineering students was discussed. Since this program is not meant to train engineers and is instead meant to instill an appreciation of engineering concepts in future policymakers and those who will work with engineers or work with technology, it offers both great potential and very interesting challenges in the design and implementation of the classes.

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