AC 2010-1405: A GENERAL ENGINEERING MINOR AS A MEANS TO ENCOURAGE TECHNOLOGICAL LITERACY

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A General Engineering Minor as a Means to Encourage Technological Literacy

Abstract

Technological literacy can be increased by offering a minor in general engineering. A Minor in General Engineering was developed at Binghamton University. This minor was first available in the 2008-09 academic year. The description of the minor states this minor "enables students who are majoring in non-engineering fields to gain an introduction to the engineering design and analysis process." An outline of the requirements for the minor is presented. The experiences of the first students who participated in the program are described. Also, the challenges encountered in the approval process for this minor are described.

Introduction

The need for an educated citizenry is recognized as one of the basic requirements of a democratic society. In our increasingly human-built world, this entails a technologically literate citizenry. The goal of technological literacy "is to provide people with the tools to participate intelligently and thoughtfully in the world around them."[1] Included in this participation is an understanding of the human process of technological development: engineering analysis and design.

At the university level, literacy in the areas of reading, mathematics, science, or history is often mandated by "general education" or "distribution" requirements. Regarding technology, these requirements might include an introduction to computers course. Very rarely however is there a requirement for any more general introduction to the process of technology development or engineering. Nonetheless, many engineering schools at larger universities provide courses such as "An Introduction to Engineering" aimed specifically at non-engineering students. As with any course, this involves faculty and supporting resources. An alternative is to use existing courses and offer a minor in general engineering.

A minor in general engineering enables students who are majoring in non-engineering fields to gain an introduction to the engineering design and analysis process. In this paper, a description of the requirements for the minor at Binghamton University is presented. Some discussion of the rationale for the components of the curriculum is given. Next, a description of the experiences and a few comments by the first students who completed the minor are presented. In conclusion, a discussion of challenges to the establishment of the program and how they were dealt with are presented.

Description of the Requirements for the Minor in General Engineering

The minor in general engineering was proposed by faculty in the Engineering Design Division (Freshman Engineering Program) in the 2007-08 academic year. The original intent was to provide the opportunity for students who did not intend to major in one of the engineering disciplines available at the university (bioengineering, computer, electrical, industrial, and mechanical) to learn about engineering and, thus, increase their technological literacy. Three initiatives were considered: (1) institute a BA degree in General Engineering, (2) develop and

offer “Introduction to Engineering for Non-Engineers” courses, and (3) create a Minor in General Engineering. After review of the available resources, the Minor was pursued.

Benchmarking with similar minors at other universities was conducted. Included were Dartmouth, Lehigh and University of Minnesota. Other minor programs within the university (management, computer science, and liberal arts) were reviewed. It was decided that the minor would require a minimum of 17 credit hours (or five courses) to be comparable to other minors at Binghamton University.

It was also decided that students wishing to earn a minor in general engineering must first complete a set of prerequisite math and science courses. Following completion of the prerequisite courses, students would take the required engineering courses. The engineering courses that would be required would include courses from three categories: (1) engineering fundamentals, (2) advanced engineering, and (3) project work. With this mixture, students would be introduced to analysis in the engineering fundamentals courses and be exposed to the rigor of engineering in the advanced engineering courses. The inclusion of a required project insures that students participate in an engineering design.

Prerequisite Courses

It was decided that admission to the program for a minor would depend on the applying students GPA in a set of prerequisite courses. The minimum GPA was set at 2.7/4.0 Three prerequisite courses were identified. They are: Calculus I, Physics I, and Physics II. The calculus requirement can be satisfied by AP Calculus. A high percentage of students at the university arrive with this credit, enabling many non-engineering students to consider the minor. After debate, it was decided to accept AP Physics for the Physics I requirement. Students then have the option of taking either calculus-based Physics II or algebra-based Physics II to complete the course prerequisites. It is highly recommended that students take both of the calculus-based physics courses. One factor is that the algebra-based courses are not accepted as prerequisites for most of the engineering courses that are required. No special consideration is given to students pursuing the minor regarding individual course prerequisites.

These three course requirements insure that students entering the minor have the science and mathematics ability to successfully complete the engineering courses required for the minor. Admission to the minor requires the submission of an “Intent Form” that includes review of completion of the prerequisites.

Required Engineering Courses

The five courses required to earn the Minor in General Engineering are divided into the three categories listed above. These courses must be selected from approved lists of courses for each category. The lists are reviewed and updated annually. Students must take one course from the advanced engineering list and they must take a capstone design two-course sequence. The remaining course can be either another engineering fundamentals course or another advanced engineering course. As expected, it has been the case that most students take two of the courses from fundamentals course list and only one from the advanced engineering list.

(A) Engineering Fundamentals

These courses were selected to include courses from each department in the engineering school. They are all first- or second-year engineering or computer science courses. Many of the courses on the list have no prerequisites other than those required for admission to the minor program, if the calculus-based prerequisites are taken. Among these are Engineering Economics, Probabilistic Systems Analysis, Engineering Computing, Statics, and Digital Logic. At this time, fifteen courses are included on the list. Several of the courses on this list of engineering fundamentals courses have other courses from the fundamentals list as prerequisites. For example, Dynamics and Solid Mechanics are on this list. Both of these courses have Statics as a prerequisite.

(B) Advanced Engineering

These courses are all third- or fourth-year engineering or computer science courses. These courses were also selected to include courses from each department in the engineering school. At this time, there are sixteen courses approved as advanced engineering courses for students in the minor. The prerequisites for several of these courses can be satisfied by courses from the engineering fundamentals list. For example, Computer-Aided Engineering is an advanced engineering course for which the prerequisite is Solid Mechanics. Other courses on the list have prerequisites that many non-engineering students might already have fulfilled, e.g. Introduction to Materials Science requires Chemistry I. However, many of the courses require additional mathematics courses, such as Ordinary Differential Equations, as prerequisites.

(C) Integrated Engineering and Design Projects

Students must participate in two semesters of an integrated engineering and design project (capstone design courses). The capstone experience at Binghamton University is a two semester sequence that typically involves a design and build project. These projects are team projects and typically involve students from several of the engineering and computer science departments on a team. Many of the projects have industrial sponsors. Other projects include professional society competitions, such as the SAE Mini-Baha competition.

Students in the program for the minor must have senior standing and have completed all of, or be enrolled in, the fundamentals and advanced engineering courses. Due to course designations between departments, students may elect to participate in this capstone experience on a team in the bioengineering or systems science and industrial engineering departments or in the multi-disciplinary capstone course including both the electrical and mechanical engineering departments.

The combination of engineering fundamentals, advanced engineering, and project work gives students completing the minor in general engineering a basic introduction to engineering. This introduction to engineering provides the student a glimpse of the process of developing technology. It also gives students an appreciation of the constraints of devising technological solutions. As with all literacies, this awareness of critical thinking is necessary, no less for technological literacy than reading or mathematical literacy.

Experiences of the First Students Who Received a Minor in General Engineering

The first year the minor in general engineering was offered was the 2008-09 academic year. Three students applied for the program hoping to graduate in the first year. Two students completed the requirements for the minor that year.

A curious "unintended-consequence" of establishing the minor in general engineering has been that students who began their undergraduate studies as engineering students but who withdrew from the program have elected to earn the minor. These students have a head-start on the engineering fundamentals courses and often have completed an advanced engineering course.

Of the two students completing the minor the first year, one had been an engineering major then became an economics major and the other was a biology major. Both students commented positively on their experiences in the project course. The former engineering student participated on a project team that designed an alternative energy source, a windmill, to provide power for the university gymnasium. This team won the award that is given each year for the best project presentation. Students who worked with the student noted that he was a valuable member of the team. The comment made by the student working toward the minor was: "I am really happy the engineering school offers this. I had a great experience."

Currently (2009-10), there are three students in the capstone design courses who have been admitted to the minor in engineering. While the number of students seeking the minor is not large, the program is considered an asset to the engineering school. There remains the belief among non-engineering students that the rewards of earning a bachelor's degree in engineering are not worth the effort involved.[2] It is hoped that this alternative will attract those student who do not plan to spend the effort needed for an engineering degree but who nonetheless are interested in technology. Currently the minor in general engineering is still new and not well-advertised. With new advertising circulars and posters, we hope that the popularity of earning the minor increases.

Challenges

Many challenges were encountered during the process of establishing the program for a minor in general engineering. These included both philosophical and administrative issues.

A conceptual question arose early in the approval process for the minor. It became apparent that the notion of what constitutes a "minor" varied greatly. The question was encountered: what competencies should a person receiving a minor in engineering possess? Several members of the approval committee believed that a list of desired outcomes should be associated with the minor. This position reflects the perspective of ABET accreditation. It was noted that minor programs are not accredited and, while specifying outcomes might be valuable criteria, it is not necessary for a minor. The analogy mentioned was with a minor in art: it is not generally expected that a student who earns a minor in art be an artist. Similarly with engineering: a minor in engineering does not identify a student as an engineer. It was concluded that a minor demonstrated a student's interest in a subject area but did not necessarily indicate that a skill was developed.

In addition, several bureaucratic difficulties were encountered. One issue involved the oversight and administration of the program. The general oversight of the minor was delegated to the Undergraduate Studies Committee of the Watson School of Engineering. This committee reviews the requirements for the minor, is responsible for approval of any changes, and updates the list of approved courses.

Two specific administrative duties are required for the program. The first is the review and approval of the applications for admission to the program, the "Intent Form." The Director of the Engineering Design Division has been designated as the person responsible for the approval of applicants' records for admission to the program.

The second administrative duty arose following a concern regarding the capstone design project. The prerequisites for engineering students for the capstone courses are extensive. To maintain the rule that no special consideration regarding prerequisites would be given to students pursuing the minor, a new sequence of course numbers was created. Students in the minor enroll in the newly numbered courses, yet participate fully in the existing capstone design course and on the project teams. The grading responsibility for these newly-numbered courses is assigned to the Chair or Undergraduate Director of the academic department of the capstone course in which the student is participating. The faculty advisor on the individual project teams evaluates the student in the minor based on the division of labor for each project and submits his or her evaluation to the appropriate Chair or Undergraduate Director. Recall that students can participate in the capstone course through any one of the engineering departments: bioengineering, systems science and industrial engineering, electrical and computer, or mechanical engineering.

Since the establishment of the minor, one change has been suggested. Many university students take AP Biology instead of AP Physics during their high school years. It has been proposed to change to the prerequisites to include the introductory biology course sequence OR the physics sequence. Students who would like a minor in general engineering but whose area of interest is bioengineering would be the most to benefit from this change.

Conclusion

The Minor in General Engineering is an opportunity for students outside engineering to observe and participate in the solution of technological problems. This program provides a vehicle for improving the technological literacy of students. In addition, the involvement of non-engineers on the capstone design project teams increases the multi-disciplinary nature of the work. It is hoped that the program will grow and increase the technological literacy of our graduates: "Like literacy in reading, mathematics, science, or history, the goal of technological literacy is to provide people with the tools to participate intelligently and thoughtfully in the world around them."[1]

References

[1] Technically Speaking: Why All Americans Need to Know More About Technology, Committee on Technological Literacy, National Academy of Engineering; National Research Council; Greg Pearson and A. Thomas Young, Editors (2002), p. 3.

[2] Linda S. Hirsch, Siobhán J. Gibbons, Howard Kimmel, Ronald Rockland, and Joel Bloom, "High School Students' Attitudes To And Knowledge About Engineering," 33rd ASEE/IEEE Frontiers in Education Conference, 2003. Paper #1145