

Development of Engineering as a Liberal Arts Major

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Abstract

A major in engineering has been developed at a liberal arts college in conformance with other liberal arts majors. The major is designed to prepare students for direct entry into graduate programs in engineering. This paper describes the development process and some of the difficulties encountered.

Introduction

In recent years there has been a movement to increase the liberal arts component of engineering education. This is seen in the devotion of an entire issue of PRISM [1] to the relationship between Engineering and the Liberal Arts. There has also been a growing interest in introducing engineering to liberal arts students. Major programs in this area fall under the heading of Engineering and the New Liberal Arts[2]. In these, the approach has been to either add liberal arts to the standard engineering curriculum or to add literacy in engineering to the standard liberal arts curriculum. We have taken a different approach. We are attempting to construct a unified engineering major as a standard major at a liberal arts college. That is, the engineering major at Hope College is a liberal arts degree. The effort is being supported internally by Hope College and by the Fund for the Improvement of Postsecondary Education of the U.S. Department of Education.

Hope College has a total enrollment of 2900 undergraduate students. Approximately 40% of the freshmen indicate that a science is their intended major. The sciences include Biology, Chemistry, Computer Science, Geology, Mathematics, Nursing, Physics and Engineering. The sciences at Hope College have had a long history in preparing students for graduate and professional school. Undergraduate research is an important component of the science curriculum. The Department of Physics and Engineering has been awarded more than \$300,000 per year in externally funded grants since 1988.

The primary goal of the Engineering Major at Hope College is to prepare students for direct entry into graduate school in the engineering speciality of their choice. To enable the students to have adequate preparation in a four year program in which the engineering major must conform to the standards for all other liberal arts majors, significant curricular choices have been made. Guidance in these choices have been provided through: 1) advice from a consulting group of academic engineers, 2) visits to traditional and non-traditional engineering schools, and 3) discussion with graduate school faculty members as to the preparation really needed for graduate study. The program at Hope College is attracting more students every year which indicates student interest. The accept ability of the program .



to graduate schools is seen in that over the past ten years more the 80% of the graduates have gone directly into graduate study. This paper will explore the development of an engineering major at a liberal arts college and some of the problems that have arisen.

History

Hope College, like so many other liberal arts colleges, has participated for years in "3-2" arrangements with traditional engineering colleges. At Hope College this began before World War II. Many of its physics majors transferred to engineering colleges after their junior year. Upon graduating from the engineering college, the student received two baccalaureate degrees: one from the engineering college and one from Hope College. The primary component of the curriculum taught at the Hope College was the general education component including science and mathematics courses. The physics majors, who elected to complete their education at Hope College, enrolled directly into graduate programs for the most part.

In the early 1970's we began noticing that some of our 3-2 students were returning to Hope College to complete their degree after spending only a year at a traditional engineering school. The reason was not ability to compete but a discovery that engineering was not the career for them. We decided to begin teaching introductory engineering courses with the purpose of helping students make a more enlightened choice of a vocation. An engineer with a Ph.D. in mechanical engineering was recruited as a member of the Department of Physics and given the task of teaching two engineering courses a semester plus assisting in the programs of Mathematics and Physics.

A demand for additional courses arose almost immediately. With only one faculty member in engineering to teach many different courses, a decision was made to teach sophomore level courses (after a year of physics and calculus) every year and to place junior and senior level courses on an alternate year basis. By 1980 the teaching demands had increased to a high level, but as the college was not year ready to commit to a larger presence for engineering, the engineer resigned.

During the 1980's the teaching of mechanical engineering was performed by a series of visiting faculty members assisted by part-time faculty members. This proved unsatisfactory while at the same time there was a growing appreciation of the comparability of engineering with the other intellectual disciplines normally found at a liberal arts college. The acceptance was probably assisted by Hope College's tradition of viewing the liberal arts more broadly than is done at many other liberal arts colleges. In fact, there were already in place Departments of Economics and Business Administration, Sociology and Social Work, and Nursing.

In 1990 the college decided to create a new tenure track position in the Department of Physics to be held by an engineer. At the same time, a physicist who had already been teaching primarily electrical engineering courses was transferred to the engineering group. These two developed a research program in biomechanical engineering as well began to develop a more unified engineering curriculum. The research is supported by external agencies[3].

In 1993 the Department was awarded a grant [4] from the Fund for the Improvement of Postsecondary Education of the U.S. Department of Education (FIP SE). The grant enabled addition of another engineer on a tenure track and provided the opportunity to develop an engineering curriculum which conformed to the standard of other liberal arts majors at the college. The college responded to the awarding of the grant by adding a fourth engineer so that the engineering program at Hope College now has a faculty of three mechanical engineers and one electrical engineer all with Ph.D. 's.



Constraints on a Major

Any major program at a liberal arts college is subject to constraints imposed by the institution. These are usually expressed in a large general education requirement and limitations on the number of courses which can be required for a major. The requirements at Hope College are similar to those found at other Category I liberal arts colleges and include:

- 46 semester hours outside of the sciences.
- A maximum of 32 semesters hours for a bachelor of science major.
- A maximum of 24 semesters hours in cognate sciences for a bachelor of science major.
- A graduation requirement of 126 semester hours.

These limit what can be required for a major however Hope's requirements allow 24 semester hours of electives which can be directed toward enriching the major. In addition, many students enroll with advanced placement status or elect to take courses outside the normal semester periods all of which provides them with opportunities to broaden their studies both within and outside the major.

Graduate School Requirements

Under the auspices of our FIPSE Grant, visits were made to many undergraduate and graduate schools of engineering. As our program is designed to prepare students for direct entry into graduate schools of engineering, a critical component in its development was to determine what graduate schools expect their beginning students to know. It was surprising to discover that, in general, few highly specialized courses are deemed essential. This was true even in schools where specialized courses were required for an undergraduate degree. This can be explained by recognizing that most undergraduate degrees in engineering are a professional degree at the undergraduate level while graduate schools are preparing students professionally at the graduate level.

Examples of the expectations of graduate schools beyond introductory courses are:

Mechanical Engineering

- A course in thermodynamics.
- A course in fluid mechanics.
- A course in mechanisms.
- A course in dynamics.
- A capstone design experience.

Electrical Engineering

- A course in electricity and magnetism.



• A course in linear systems.

• A course in sampled data systems.

• A course in signals and systems.

• A course in digital signal processing.

Also of importance to graduate schools was the amount of experience students had in research as many of the financial support mechanisms for graduate students are derived from externally funded research grants. Laboratory teaching experience was also considered a benefit.

Curricular Overview

While it is clearly not possible for a liberal arts college to replicate the extensive course requirements found at traditional colleges of engineering, the curriculum in place at many non-traditional colleges of engineering is readily adaptable. The unified curriculum as found at Swarthmore or at Harvey Mudd are good examples of a strong engineering program coupled with an extensive general education requirement. The experience of these institutions demonstrates that it is possible to establish an intellectually honest engineering major at a traditional liberal arts college.

The engineering curriculum at Hope College is in its formative stages. The fundamental courses in mechanical engineering expected by graduate schools are in place including some additional electives. In electrical engineering, several courses must be added to provide a more adequate program. Chemical engineering is serviced through having students combine courses in engineering with those from an exceptionally strong Department of Chemistry. At present four faculty members are teaching the engineering courses and a course in engineering for non-science majors. The engineering program is a second, separate major within the Department of Physics and Engineering. It is expected that the engineering program will continue to grow and require additional staff. At some point it might be a separate department.

Benefits to Institution

Besides educating engineers with a broad understanding of our society, the establishment of engineering as a major has opened new avenues for the education of non-science students about engineering. Each semester approximately 50 non-science students elect to enroll in a one semester course on science and technology taught by engineers. The course is so popular that it is always oversubscribed. In it students not only learn about how everyday things work but also build and operate many devices.

As a major, Engineering is attracting some of the very best students on campus. This benefits other programs in that engineering students are often the leaders in classes outside the sciences. In addition, students initially electing engineering as a career sometimes decide that another area is really the one for them. Our loss is their gain but the option to change direction on the basis of experience is one of the advantages for students at a liberal arts college. We are also seeing students electing dual majors in areas as diverse as engineering and dance, engineering and art, and engineering and English. There are also engineering majors becoming certified as secondary teachers.



Institutional Problems

Acceptance of engineering as a legitimate discipline within the liberal arts was not immediate and universal. The objections occurred at three levels:

1. The level of the administration.
 - 1 Faculty members outside the sciences.
 - 1 Within the Department of Physics.

The administration at Hope College now finds that engineering can be attractive to good students and is an area of interest of potential donors. The scholarly activities of the engineering faculty have dispelled doubts about engineering as an intellectual activity. There are concerns about the fact that the discipline is equipment intensive and the large capital requirements for an effective teaching program. Some of these concerns have been allayed through the success of the department in raising external funds to support its research with students and to equip laboratories.

In the past most faculty members agreed that it was important for engineers be liberally educated however the thought of teaching engineering at a liberal arts college seemed somehow inappropriate. The intellectual quality of engineering students has dispelled the usual stereotyping of engineers as simply mechanics. Our students' contributions to the arts, music, theatre, and the student literary journals has help greatly. Our students have demonstrated that one can be analytical, practical and artistic simultaneously.

There is some question on the whether the degree from Hope College should be a Bachelor of Science in Engineering or a Bachelor of Science in Engineering Physics. The latter is the degree name at present. It clear however, from comparisons of our program with those at unified engineering schools and with those at traditional engineering schools, that our curriculum is definitely not an engineering physics curriculum but follows closely those found at schools with unified engineering degrees.

Our greatest difficulties in getting acceptance has been inside our own department. Some of this stems from that fact that students who formerly would have been physics majors are now engineering majors. This in turn affects the mix of physicists and engineers within the department. The response of some of the physicists has been to ask for more rigor in the physics courses and more rigidity in the physics curriculum as a way of decreasing the growth of the engineering student body. In this manner, they hope to insure the survival of an active physics program. The engineering faculty are concerned that physics could become an inappropriate filter in deciding which students can be successful engineers. They believe that the health of programs can be insured through recruiting excellent students.

The differences in the teaching methods between engineers and physicists have also caused some difficulty. Engineers tend to support team approaches to learning and the acceptance of alternative solutions. Physicists tend to look for closure on a problem while engineers tend to be more tolerant of ambiguity. Physicists tend to be discriminating while engineers tend to be accepting. It is not surprising that these differences exist. Certainly biologist, chemists, and physicist also look at the world in different ways.

Possibilities for the Future

Engineering appears to be established permanently at Hope College. The number of students continues to rise and the goal of preparing students for graduate study is in concert with many suggestion from



within profession[5]. There are approximately 40 freshman enrolled in the program and the total enrollment for all class levels is approximately 85. The decision on whether or not engineering will become a--separate department depends on reaching accommodations among the departmental faculty. Current thinking is that a separate department would probably be better as the number of engineering faculty members must continue to grow with the student population.

The curriculum will be further refined during the 1996-1997 school year. We will probably elect to apply for ABET accreditation under the new guidelines. The absence of ABET accreditation has not been a hindrance for our students in gaining admission to graduate school. The absence is sometimes a consideration for prospective students. Employers do not seem concerned that our program is not ABET accredited and are impressed with the educational breadth and abilities of our students.

It appears from our experience that a liberal arts college can establish a viable engineering major if its goal is to prepare students for graduate school. It also appears that there are excellent students looking for such a program. If it is possible to generalize from our results, one can conclude that an undergraduate engineering program with a significant research component offers strong encouragement for students to continue their education at the graduate level in the same way that traditional science programs at liberal arts colleges have done in the past. If more liberal arts colleges adopted a program similar to ours, they could become a significant source of engineering graduate students.

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