

## **The Current Status and Uses of the General (Undesignated) Engineering Program with a Case Study**

**James Farison, Byron Newberry**

**Department of Engineering, Baylor University, Waco TX**

### Abstract

In this paper we discuss several important aspects of the category of engineering programs named simply Engineering (or General Engineering) or Engineering Science, in contrast to programs with a designated disciplinary focus, such as Electrical Engineering or Mechanical Engineering. Our purpose is to explore the role such undesignated, or *general*, engineering programs play in the overall scheme of engineering education. Our analysis of the *general* Engineering programs consists of two parts. First, we present a survey of the current status of these programs nationally. We then present a case study of the Baylor University *general* Engineering program, with which we will illustrate some of the trends found from the national survey.

### Introduction

There are currently 48 engineering programs offered at U.S. institutions with ABET/EAC accreditation under the name Engineering, General Engineering, Engineering Science, or Engineering Sciences. Such programs are often characterized by a more general or interdisciplinary nature, and are distinct from designated programs in not having to satisfy individual program criteria in addition to the basic criteria for ABET accreditation. The latter is also true of Engineering Physics programs, but these are not included here since the “Physics” designation is often significant; i.e., it represents a real program emphasis in the discipline of physics. The Engineering, General Engineering, Engineering Science and Engineering Sciences programs are hereinafter collectively referred to as “*general* Engineering” programs, while the lowercase use of “engineering” will refer to any or all types of engineering programs.

We can hypothesize that *general* Engineering programs exist primarily for one of two reasons. First, when an institution begins its initial program in engineering, the program may be small and more general than it is specialized, and fits naturally the *general* Engineering name; or, an institution, as a consequence of either its mission or its administrative structure, may choose to continue a *general* Engineering program as its only engineering program. Second, an institution may offer, for specific programmatic reasons, a *general* Engineering program alongside one or more designated engineering programs. Frequently this is to provide additional flexibility in the curriculum for students with unique career interests; or the *general* Engineering program may be used as an incubator for developing new designated engineering programs.

With these preliminary thoughts in mind, our goal is to assess and quantify the purposes for which *general* Engineering programs are used, and to look for trends in the evolution of these *general* Engineering programs.

### Survey of *General* Engineering Programs

The 48 ABET/EAC accredited *general* Engineering programs were identified from the listing of accredited programs maintained by ABET<sup>1</sup>. Data were collected from this source, the ASEE Directory of Engineering Colleges<sup>2</sup>, the U.S. News & World Report database<sup>3</sup>, and the websites of the various institutions. Additionally, an e-mail survey was sent to 33 schools with *general* Engineering programs, of which there were 13 respondents (the Engineering Science programs and one Engineering program were incorporated into the analysis after the e-mail survey). Table 1 gives an alphabetical list of the 48 programs, comprising 34 Engineering and General Engineering programs and 14 Engineering Science and Engineering Sciences programs.

Table 1: ABET/EAC Accredited Engineering and General Engineering (E) and Engineering Science and Engineering Sciences (ES) Programs.

Air Force Academy	ES	Harvey Mudd College	E	Roger Williams	E
Arkansas State	E	Hofstra	ES	Stevens Inst. of Tech.	E
Arkansas Tech	E	Hope College	E	SUNY Stony Brook	ES
Baylor	E	Idaho State	E	Swarthmore College	E
Cal State Northridge	E	Iowa State	ES	Texas Christian	E
Cal Tech	ES	John Brown	E	Trinity College	E
Calvin College	E	LeTourneau	E	Trinity University	ES
College of New Jersey	ES	Loyola College	ES	U. of Denver	E
College of Staten Island	ES	McNeese State	E	U. of Florida	ES
Colorado Sch. of Mines	E	Mercer	E	U. of Illinois UC	E
Colorado State	ES	Messiah College	E	U. of Maryland	E
Dartmouth	E	Michigan Tech	E	U. of Oklahoma	E
Dordt College	E	Montana Tech	E	U. of Tennessee	ES
Geneva College	E	Olivet Nazarene	E	U. of Tenn. Chattanooga	E
Grand Valley State	E	Oral Roberts	E	U. of Tenn. Martin	E
Harvard	ES	Penn State	ES	Walla Walla College	E

The list comprises 23 public and 25 private institutions. Of the latter, 16 are religiously affiliated. The institutions range in size, as measured by the total undergraduate enrollment, from 700 to 65,000, with an average size of 9761. The average size of the public institutions is 15,298, while that for the private institutions is 3983.

### Program Classification Terminology

To facilitate this analysis, we identify two broad categories of *general* Engineering programs.

The term “*primary program*” designates a *general* Engineering program that is the only engineering program at an institution. *Primary* programs can be further partitioned into “*philosophical*” and “*instrumental*” programs. A “*primary-philosophical*” program is a *primary* program that maintains a truly general or interdisciplinary character by virtue of the fact that it is the institution’s overall philosophy that offering such a program has intrinsic merit. This is in contrast to a school for which the *general* Engineering program is primarily an instrument through which one or more designated disciplinary options or concentrations are offered and hence, while general in name, the emphasis is on disciplinary concentrations. Programs at such schools will be designated as “*primary-instrumental*”.

The term “*secondary program*” designates a *general* Engineering program at an institution that has one or more discipline-specific engineering programs in addition to the *general* Engineering program. *Secondary* programs can also be partitioned into one of two subtypes. In some schools, the *general* Engineering program exists primarily to facilitate interdisciplinary study within engineering, allowing students to combine courses from two or more engineering majors. At other institutions, the *general* Engineering program provides designated options or concentrations for which there are not (yet, perhaps) designated programs. For example, future disciplinary programs may be developed under the *general* Engineering title until they reach the point at which independent accreditation can be pursued. In either of these cases, the students would complete a curriculum comparable to a traditional disciplinary curriculum with respect to the number and level of engineering courses taken. Because these usages parallel that of *primary-instrumental* programs, such programs will be denoted as “*secondary-instrumental*”. In other schools with traditional disciplinary programs, the *general* Engineering program allows a subset of students, students who perhaps have unique career interests, the latitude to pursue course concentrations in areas outside of engineering. These concentrations could be in the humanities, the sciences, a business field, or in the arts. Because in this case a student has potentially a wide range of options for study, such a program will be designated as “*secondary-flexible*”. Of course, we can expect that there are some institutions whose programs will defy definitive classification.

### Program Classification

We classified each program into one of these four classification categories on the basis of information contained in the ABET database (for *primary/secondary* classification) and the institution websites (for *philosophical/instrumental* and *instrumental/flexible* classifications). For convenient reference, these classifications are summarized in Table 2. For confirmation of the accuracy of our classifications, a subsequent email survey (of the Engineering and General Engineering programs but not the Engineering Science programs) asked the respondents to self-classify with respect to the categories. Twelve of the 13 respondents’ self-classifications matched our classifications. The remaining one classified its program as *secondary-instrumental* (interdisciplinary – within engineering). We had classified it as *secondary-flexible* (programs allowing students to combine engineering with non-engineering study). The website for the institution indicated that both possibilities are offered, with the former being emphasized and, we suspect, being most utilized in practice. Therefore, this institution logically fits into both categories. We prefer to place such a program into *secondary-flexible*, since the possibility for combining engineering study with non-engineering study is somewhat unique, although perhaps

not utilized in practice. We therefore believe that our classification of programs is accurate. The distribution of programs according to classification is given in Table 3.

Table 2. Summary of Program Classification Terminology

Classification	Description
Primary	a <i>general</i> Engineering program at an institution in which it is the only engineering program offered
primary-philosophical	a primary program that is truly general or interdisciplinary, based on an institutions overall philosophy of its intrinsic merit
primary-instrumental	a primary program used as an instrument through which one or more designated disciplinary options or concentrations are offered
Secondary	a <i>general</i> Engineering program at an institution that also offers one or more discipline-specific engineering programs
secondary-instrumental	a secondary program used as an instrument to provide designated options or concentrations, perhaps until they reach separate program maturity, or for interdisciplinary study within engineering
secondary-flexible	a secondary program that facilitates interdisciplinary study in areas outside of engineering for students with unique career interests

Table 3. Profiles of *General* Engineering Program Types.

Category	No. of Programs in Category	Institution Average UG Enrollment	Avg. No. of All Engineering Graduates in 2001*	Avg. No. of General Engineering Graduates Program in 2001*	Avg. Date of Initial Engineering Program Accreditation
<i>Primary-philosophical</i>	5	3240	36	36	1973 †
<i>Primary-instrumental</i>	19	4731	36	36	1985 ‡
<i>Secondary-instrumental</i>	17	15307	376	33	1975
<i>Secondary-flexible</i>	7	15404	405	19	1971

\* No data available for 6 schools; 2001 data not available for 5 schools, so 2000 data used.

† This value is misleading. For two schools, the average start date is 2000; for the remaining three, 1956.

‡ If just two schools are excluded (with average inception date of 1949), this value becomes 1990.

It is interesting to note that there is a preponderance of programs in the *primary-instrumental* (40%) and *secondary-instrumental* (35%) categories. For schools with *primary* programs, the majority has designated discipline-specific options or concentrations from which students choose. One might say these are “general” programs that have “specialized”, but choose to retain their global status as undesignated. On the other hand, for schools with designated engineering programs in addition to a *general* Engineering program, the majority uses the *general* Engineering

program for interdisciplinary engineering study, or perhaps as an incubator for nascent designated programs. In other words, these institutions primarily offer “specialized” programs, but choose to allow students an option to “generalize” within engineering or to pursue as-yet-undesigned engineering specialties.

Only five *primary* programs are explicitly general in nature, and only seven *secondary* programs explicitly allow students to pursue a degree combining engineering with a non-engineering discipline (although other institutions may have alternate avenues for allowing students to do so). Furthermore, of the seven *secondary-flexible* programs, four reported no graduates from the general Engineering program in 2001, and a fifth was one of the programs that self-classified as *secondary-instrumental*, an indication perhaps that the non-engineering studies option is utilized little, if at all.

As can be seen from the average undergraduate enrollment and average total engineering graduates statistics, and as would be expected, the schools with *secondary* programs – those with multiple accredited programs – tend to be the larger institutions, and are predominantly public. The *primary* program schools tend to be smaller and predominantly private. However, the average number of graduates from a *general* Engineering program is relatively uniform across institution type.

#### Evolution of *General* Engineering Programs

We can hypothesize that the temporal trend is for an institution’s program to progress from *primary-philosophical* to *primary-instrumental* (from its inception as a general program toward increasing disciplinary coherence in one or more disciplines), and then from *primary-instrumental* to *secondary-instrumental* or *secondary-flexible* (an undesigned program with disciplinary options transforming those options into separately accredited designated programs). After the latter transition, the *general* Engineering program may be retained for one of the reasons previously discussed, or it may disappear altogether. Seven of the thirteen respondents to our survey indicated that their institutions were, or were considering, using the *general* Engineering program to grow future discipline-specific programs.

This evolutionary scenario does not preclude an institution purposely maintaining its *general* Engineering program as a certain type for the long term. For three of the *primary-philosophical* programs, the average initial accreditation date is 1956. Clearly it is part of their institutional mission to maintain a single general engineering program. For two of the *primary-instrumental* schools, the average initial accreditation date is 1949. Again, these schools almost certainly have an institutional culture that warrants maintaining disciplinary options within a single *general* Engineering program. In fact, the six *primary*-type programs responding to the survey all indicated that a holistic, broad-based education, facilitated by the flexibility of a single program, was a key institutional value. (However, two of those schools also indicated plans to move toward separately accredited discipline-specific programs.)

These exceptions aside, the trend supports the hypothesis. The remaining two *primary-philosophical* schools have an average initial accreditation date of 2000. The remaining 17

*primary-instrumental* schools have an average initial accreditation date of 1990. And the *secondary*-type programs have an average initial accreditation date for their *general* Engineering programs of 1974. We thus have a snapshot of the various stages in the life of the typical *general* Engineering program.

### Impact of *General* Engineering Programs

The total number of graduates reported from *general* Engineering programs in 2001 (for six schools, 2000) is 1329. The total number of engineering graduates of all types for 1999-2000 was 67,300<sup>4</sup>. Though this latter number may be slightly higher for 2000-2001 (for which we did not have composite data), it still serves to indicate that *general* Engineering programs account for only 2% of all engineering graduates. The 48 institutions with *general* Engineering programs account for only 13% of all institutions offering accredited engineering programs, and account for only 14% of all engineering graduates. These figures indicate that *general* Engineering programs fill a relatively small niche in the overall scheme of engineering education.

Considering that the *primary-instrumental* programs tend to educate students within discipline-specific options or concentrations, though without corresponding explicit program designations, then the number of students receiving a truly “general” or interdisciplinary (within or without engineering) education falls to approximately 1% of all engineering graduates. This is not to say that the *primary-instrumental* schools have no interdisciplinary or broad-based educational qualities, since in these programs students often take a set – larger than at multi-program schools – of courses common to all option/concentrations, including in many cases design courses. The point is simply that there is a definite disciplinary focus to the options/concentrations.

### Case Study of a *General* Engineering Program

The engineering program at Baylor University represents an interesting example, where an (undesignated) *general* Engineering major is now offered alongside more “traditional” (designated) majors in Electrical and Computer Engineering (ECE) and Mechanical Engineering (ME). When Baylor initiated its *general* Engineering major under the Institute of Engineering Science in the College of Arts and Sciences (A&S) in 1978-79, it was the first engineering program on a campus with an historically strong liberal arts tradition. With no history or reputation in engineering and with the limited resources (laboratories, faculty, student body and tradition) available to a start-up technical program on a largely liberal arts campus, it was virtually essential that it began as a broad (rather than specialized) program. According to our current classification scheme, it would have been of the *primary-philosophical* type.

The program came under the newly formed Department of Engineering and Computer Science in 1980, still in A&S. The 1982-83 Catalog describes the program: “The Bachelor of Science in Engineering Sciences ... program does not attempt to duplicate traditional engineering programs but prepares graduates to work in one of the following areas: engineering electronics, computer engineering, engineering geology, engineering physics.” Mechanical engineering was added to this list in the 1983-84 catalog. By the 1985-86 catalog, engineering geology and engineering physics were dropped from the list of areas. In 1987-88, the Division of Engineering was

formalized within the Department of Engineering and Computer Science. The degree title of the program was changed to Bachelor of Science in Engineering (BSE), described in the 1988-89 catalog as “a general engineering program with options in the Computer, Electrical, and Mechanical areas.” The three options differed in only 29 hours of a total curriculum of 136 hours. The Engineering program was accredited by ABET under the general engineering program criteria in 1989. Thus, approximately ten years after its inception, the *general* Engineering program was accredited and had evolved into the *primary-instrumental* type.

The computer option was merged into the electrical option in 1993-94, providing a single BSE degree program with electrical (with “emphasis” in electronic systems or computer systems) and mechanical options. In 1995, the Department of Engineering and Computer Science in the College of Arts and Sciences became an independent School of Engineering and Computer Science (outside of A&S) and including the Department of Engineering. In 1999-2000, the electrical option with two emphases became the electrical and computer option.

All of this program development was under a single engineering program and, from 1989 on, under a single “general engineering” program accreditation. This single program format for its first twenty years had several strengths, including curricular efficiency and faculty and student unity. Further, the faculty developed a considerable belief in, and loyalty to, the concept of a broader engineering education, in contrast to the more specialized programs typically offered at larger institutions, both on the grounds of its own inherent value and as an alternative to the more specialized programs. Thus, it provided an alternative for students in a niche market. Yet, as already indicated, from the beginning there was the flirtation with the terminology of the more traditional designators.

In late Spring 1999, with an accreditation visit coming in Fall 2000, the faculty began consideration of the question, “Should we seek separate program accreditation for our two options?” On the “con” side was the concern that we would lose the unique and positive character of the program and its attributes that had served Baylor very well for over twenty years. As the question was explored, several important “pros” were identified. There had been some “awkwardness” in our describing the current program to prospective students (Was it one program or two? Did we have EE and ME, or didn’t we?), and perhaps a greater “awkwardness” for our graduates in seeking employment (What is the BSE degree? What does “that” mean?). When we asked our industrial Advisory Board (now called Board of Advocates), they were quite direct: “Change to separate accreditation and to separate degree titles (BSEE, BSME).” One of them said that when he called his HR department and asked if they interviewed at Baylor, he was told that Baylor did not have the engineering programs (meaning degree titles) from which they recruit. That is, the professional structure and terminology in the engineering profession seemed to be putting our programs and students at a disadvantage. Still, the faculty liked having the undesignated engineering major. We also wondered about the accreditation of programs for our graduates during such a transition.

By Fall 1999, a simple idea arose that seemed to combine most of the advantages of the general program and the designated programs and to eliminate or reduce the disadvantages of such a change. That idea was adopted as the answer. Do both! That is, present the Electrical and

Computer option and the Mechanical option as two separate (designated) ECE and ME majors for their respective program accreditation and maintain the (undesigned) Engineering major. With only slight modification, the curricula of the two established options met the criteria for their respective program accreditation. And, the *general* Engineering major was freed from its role of delivering the two rather structured options to take on its own unique function.

The continuing *general* Engineering major name was now freed to become a new more flexible program, having to meet (at that time) only the non-traditional program criteria under the (now expired) ABET Conventional criteria (and, in the future, only the general criteria under the new ABET EC2000 criteria in which there are no program criteria for *general* Engineering programs). Thus the previous single program in *general* Engineering could now provide two important and (it was decided) desirable functions. It could be a general engineering program in which students could develop their own blend of the available engineering courses and programs. It could also provide the flexibility for engineering students to develop a “concentration” outside of engineering, provided that their plan still met all departmental and accreditation requirements. The new program draws exclusively upon courses already available at the university. For our program, this gave the *general* Engineering major a total of 18 hours of flexibility, compared to the other two majors for which those hours are specified. *General* Engineering students can use these hours to develop a program for their own career plan.

Students who chose to continue under the *general* Engineering program were in an accredited program and could graduate from it. And, since the previous *general* Engineering major options had been so similar to the “new” ECE and ME program accreditation requirements, there were upper division students who could change to the new majors and provide graduates for the accreditation visit in Fall 2000. So, the three majors (ECE, ME and Engineering) were presented and accredited by ABET in 2000-01. With the timing, all engineering graduates graduated from accredited programs. And it was the three “new” program descriptions that were accredited. Therefore, Baylor’s *general* Engineering program has now moved to the *secondary* category and has attributes of both *secondary-instrumental* and *secondary-flexible* programs.

The (new) *general* Engineering major has had modest enrollment, which was neither surprising nor disappointing. Our overall *general* Engineering enrollment numbers are not available, because many undecided lower-division engineering students declare the Engineering program as their major. However, considering only upper-division students, the enrollment numbers for *general* Engineering program majors compared to all engineering majors, since the change in Spring 2002, have been 7 of 103 for Fall 2000, 9 of 113 for Fall 2001, and 7 of 106 for Fall 2002. There have been 6 *general* Engineering graduates from Fall 2000 through Fall 2002, and 4 more are anticipated for Spring 2003. The program’s flexibility has already allowed individual *general* Engineering majors to prepare for engineering careers with “concentrations” in business (management, information systems), computer science, music/acoustics, and pre-med.

## Conclusion

*General* Engineering programs account for only a small percentage (~2%) of the total number of engineering graduates nationally. This naturally raises the question: What significance do these



programs have in the overall scheme of engineering education? This has three apparent answers. First, a small number of institutions, because of some unique quality of their institutional missions, have committed themselves to the long-term maintenance of a single *general* Engineering program (either of a general nature or with discipline-specific concentrations). Second, *general* Engineering programs serve younger, less well established engineering programs as transitional structures, facilitating the eventual progression to separate discipline-specific programs. Or, similarly, *general* Engineering programs serve as incubators for established, multi-program institutions to expand into new and emerging disciplines. These uses probably account for the majority of all *general* Engineering programs. Finally, some *general* Engineering programs, typically at multi-program institutions, are designed to allow a small subset of students with unique career interests to pursue interdisciplinary study, either across engineering disciplines or between engineering and some non-engineering discipline. Baylor University represents an institution that has, over time, used its *general* Engineering major for each of these purposes.

## References

1. ABET Accredited Programs, [http://www.abet.org/accredited\\_prgs.html](http://www.abet.org/accredited_prgs.html)
2. ASEE Directory of Engineering Colleges – Profiles, <http://www.asee.org/publications/colleges/default.cfm>
3. usnews.com Best Undergraduate Engineering Programs, <http://www.usnews.com/usnews/edu/college/rankings/rankengineering.htm>
4. ASEE Profiles of Engineering and Engineering Technology Colleges , 2000 Edition, <http://www.asee.org/colleges/part1.PDF>

## Biographical Information

### JIM FARISON

Jim Farison joined Baylor University in August 1998 as Prof. and chair of Engineering, after serving in Electrical Engineering (64-96) and Bioengineering (96-98) at the U. of Toledo, including a period as Dean of Engineering (70-80). He holds BSEE, U. Toledo, MSEE and PhD, Stanford U., P.E. (Ohio, Texas), sr. member IEEE, ASEE campus representative and Multidisciplinary Engineering vice chair, and has served as an IEEE ABET/EAC evaluator.

### BYRON NEWBERRY

Byron Newberry is Assoc. Prof. of Engineering at Baylor University, and chairs the faculty committee that oversees Baylor's Engineering major. He joined Baylor in 1994, after serving as Asst. Prof. of AE&EM at the Univ. of Cincinnati (1989-1994) and Research Associate at the Center for Nondestructive Evaluation, Iowa State Univ. (1985-1988). His degrees are BSAE from the Univ. of Alabama, and MSAE and PhDEM from Iowa State Univ.