Teaching Engineering Students vs. Technology Students: Early Observations

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Abstract

As a former engineering faculty member at several colleges and universities, the author recently accepted a teaching position in an industrial technology program. Baccalaureate educational programs in technology and engineering share some characteristics, but differ in other important areas. Initial anecdotal observations in the classroom and laboratory have hinted at differences in educational preparation, expectations, and attitudes between engineering students and technology students. This paper provides some general background on the history and educational objectives of these disciplines, some early observations regarding industrial technology students, as well as some suggestions for future study.

Introduction

Many colleges and universities offer baccalaureate instructional programs in engineering, engineering technology (ET), and/or industrial technology (IT). Similarities and differences among these programs and their related fields of professional practice are often confusing. As a result, the terminology shall be discussed and defined.

According to the National Center for Education Statistics1,2, engineering programs are those “that prepare individuals to apply mathematical and scientific principles to the solution of practical problems.” Engineering technology programs “prepare individuals to apply basic engineering principles and technical skills in support of engineering and related projects.” An industrial technology program is one “that prepares individuals to apply basic engineering principles and technical skills in support of industrial engineers and managers.”

The recognized agency responsible for accreditation of U.S. engineering programs and many technology programs is ABET, formerly the Accreditation Board for Engineering and Technology, formerly the Engineering Council for Professional Development (ECPD). According to ABET3, “Engineering programs often focus on theory and conceptual design, while engineering technology programs usually focus on application and implementation.”

The Association of Technology, Management, and Applied Engineering (ATMAE) also accredits various technology programs. That agency defines industrial/engineering technology as “a field of study designed to prepare technical and/or technical management-oriented professionals for employment in business, industry, education, and government.”4
All of these definitions are very broad, overlapping, and somewhat vague, perhaps intentionally so as to be highly inclusive. A better understanding of these disciplines can be garnered by examining the historical evolution of the programs included in each.

**Brief history of engineering, ET, and IT programs**

**Engineering**
In the United States, engineering education took a very applied, hands-on approach well into the 20th century. Until late into the 19th century, engineers served apprenticeships with construction and manufacturing organizations as part of their formal training. Early in the 20th century, some influential European immigrant engineers became teaching faculty in U.S. institutions, and introduced engineering science and applied mathematics into engineering curricula. Conceptually, the paradigm shift was to emphasize why things occurred more than how they happened. Acceptance of this philosophical evolution accelerated in the years following the end of World War II, and gathered even more momentum after the publication of the Grinter Report in 1955 and the launching of Sputnik by the Soviet Union in 1957. The Grinter Report suggested a large-scale division of engineering education into engineering science and applied engineering, with the former division having a deeper focus into scientific and mathematical analysis, and the latter embracing much of the more traditional, hands-on experience. Most engineering faculty supported the move into engineering science, although few programs changed their names to reflect the new focus.

**Engineering Technology**
Although two-year programs in engineering technology had been in existence for several years, the Grinter Report’s suggestion for applied engineering programs resulted in the development of bachelor degree programs in engineering technology. Those programs were to retain more of the hands-on coursework that had been present in traditional engineering. In 1967, ECPD accredited the first four-year engineering technology program. It was decided that graduates of these programs should be called technologists, rather than technicians (who were graduates of two-year programs) or engineers. Companies employing those graduates, however, rarely use that title. According to the National Society of Professional Engineers, the difference between engineering education and engineering technology education can be summed up as:

> “Engineering programs are geared toward development of conceptual skills, and consist of a sequence of engineering fundamentals and design courses, built on a foundation of complex mathematics and science courses. Engineering technology programs are oriented toward application, and provide their students introductory mathematics and science courses, and only a qualitative introduction to engineering fundamentals.”

**Industrial Technology**
Industrial Technology (or often, manufacturing technology, construction technology, etc.) evolved in a very different fashion. These programs trace their roots to the learning of what has been variously known as the manual arts or the mechanical arts, and discussion of teaching and learning those methods include references as far back in history as the Code of Hammurabi, circa 2250 B.C. In more modern times, these methods were referred to as the industrial arts, and
often included specialties such as graphic arts, woodworking, and metalworking. In the 20th century, those subjects were commonly taught in high schools, and preparing individuals to be teachers of the industrial arts was an important function in higher education. Graduates of those programs often found that their skills had also prepared them for industrial work in such areas as tool engineering, production supervision, quality control, and similar positions. As a result, many industrial arts teacher education programs expanded their curricula into the field of industrial technology. NAIT, the National Association of Industrial Technology (now known as ATMAE) was founded in 1967 to monitor and set the direction of the new field of industrial technology.

How do these programs differ from one another?

There are at least three important areas of diversity among the programs—quantitative and scientific coursework, laboratory components, and managerial content.

Quantitative and scientific coursework
With their emphasis upon analytical methods, engineering programs typically require the greatest amount of study in this category. Many programs demand two full years of calculus and higher mathematics, as well as one year each of chemistry and calculus-based physics. Engineering technology programs also require calculus, although it is often just a single semester course. Chemistry and physics coursework may also be reduced to single courses each. Industrial technology students often need not study mathematics past the level of pre-calculus, and might take one chemistry course and a trigonometry-based physics course.

Laboratory components
Although laboratories continue to be important components of engineering courses, engineering technology programs typically have laboratories associated with approximately half of their technical courses. This number is often twice as many as the number of laboratory courses taken in engineering programs. Industrial technology programs often require even more laboratory courses; many of these programs state that they provide laboratory components in nearly all required technical courses.

Managerial content
Typically, engineering programs do not require business or managerial coursework. Some exceptions exist, such as industrial engineering programs. However, both engineering technology and industrial technology commonly include business components; some programs even include a required minor in business.

Observations

The author taught engineering students for 13 years before accepting a position in an industrial technology department. It must be noted that the comments that follow are based upon only one semester’s observations of the students in his industrial technology classes, as well as many conversations with other faculty members.
Early academic preparation
Most colleges and universities utilize a combination of standardized test scores, such as SAT or ACT, along with high school GPA to make admission decisions. Aggregate data of that type is usually available to faculty members for research purposes. The author’s current institution contains a college of engineering as well as a Technological Studies department, which is located external to the college of engineering. Tables 1 and 2 give the mean ACT composite scores and the mean high school GPA, respectively, for incoming freshman over each of the last five years (data from the university’s Institutional Research Department). Separate data are shown for students in the college of engineering, the Technological Studies department, and the university overall. Note that the number of data points (n) varies from Table 1 to Table 2, as it refers to the number of incoming freshmen who supplied ACT scores and high school GPAs, respectively.

It can be observed from the Table 1 data that incoming engineering freshmen students’ ACT scores slightly exceed those of the total incoming university freshmen each of the five years. On the other hand, the technology freshmen’s scores trail those of the engineering freshmen by about 21%.

Table 1. Composite ACT scores for entering freshmen

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
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<tbody>
<tr>
<td>mean</td>
<td>26.1</td>
<td>26.4</td>
<td>26.5</td>
<td>27.2</td>
<td>26.7</td>
</tr>
<tr>
<td>n</td>
<td>114</td>
<td>106</td>
<td>108</td>
<td>93</td>
<td>114</td>
</tr>
<tr>
<td>mean</td>
<td>25.9</td>
<td>25.4</td>
<td>26.0</td>
<td>26.6</td>
<td>26.5</td>
</tr>
<tr>
<td>n</td>
<td>661</td>
<td>693</td>
<td>598</td>
<td>563</td>
<td>639</td>
</tr>
</tbody>
</table>

Table 2. High school GPA for entering freshmen (4.0 scale)

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
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<tbody>
<tr>
<td>mean</td>
<td>3.68</td>
<td>3.62</td>
<td>3.62</td>
<td>3.76</td>
<td>3.71</td>
</tr>
<tr>
<td>n</td>
<td>122</td>
<td>109</td>
<td>117</td>
<td>96</td>
<td>119</td>
</tr>
<tr>
<td>mean</td>
<td>2.76</td>
<td>2.96</td>
<td>2.96</td>
<td>3.02</td>
<td>3.30</td>
</tr>
<tr>
<td>n</td>
<td>9</td>
<td>15</td>
<td>12</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>mean</td>
<td>3.64</td>
<td>3.64</td>
<td>3.64</td>
<td>3.73</td>
<td>3.70</td>
</tr>
<tr>
<td>n</td>
<td>705</td>
<td>695</td>
<td>631</td>
<td>598</td>
<td>677</td>
</tr>
</tbody>
</table>

Table 2 displays similar results as to high school GPA. Overall, engineering freshmen have slightly higher GPAs than do total university freshmen. The high school GPA of the technology freshmen is approximately 19% lower than that of the engineering freshmen. Based upon the data in Tables 1 and 2, it may be the case that the technology students are less well-prepared for the rigors of university study than the engineering students.

These tables do not tell the entire story, however. A notable number of students who begin as freshman engineering majors change their major to technology after some period of study in engineering. If the ACT scores and high school GPAs of those individual students were known, the result might show a narrowing of the range of data scores later in their programs.
Furthermore, only composite ACT scores were reported in Table 1; individual test scores (English, mathematics, reading, science) might tell a different story.

**Classroom attitudes and performance**

Within a population of college students, attitudes, abilities, and achievement vary considerably among members of any subgroup. However, generalizations can sometimes be valuable tools. Comparing anecdotal observations of former engineering students with current technology students, the author offers the following remarks:

- Technology students appear to be less willing to visit faculty to seek help outside of class than engineering students; however, when they do visit, the students seem to exhibit a more comfortable demeanor.
- Technology students appear to be more involved in extra-curricular activities than engineering students; those activities often seem to take precedence over academics.
- Technology students appear to be less willing to seek out additional information when needed than engineering students; e.g., performing independent research to seek answers as to why things happen.
- Technology students appear to be more comfortable than engineering students when working in groups with other students, such as when performing laboratory assignments or senior projects.
- Technology students appear to expect more detailed explanations during classroom lectures by faculty members than do engineering students.

Obviously, the subjective and anecdotal nature of those bulleted statements brings them into question at multiple levels. It would be inappropriate to attempt to extrapolate valid conclusions from such preliminary data. However, it is valid to use such conjecture to formulate goals and/or hypotheses for continued study.

**Summary and Future Work**

Each of the three fields of study—engineering, engineering technology, and industrial technology—is designed to educate students for careers as technical professionals. Major differences do exist within the programs of study, although there may be a considerable degree of overlap in professional duties practiced by graduates of the three disciplines.

Data show that there may be a significant difference in the high school preparation level of students entering engineering vs. industrial technology programs. Additionally, early observations of the classroom performance of industrial technology students vs. engineering students suggest that there may be very different requirements for successfully teaching those groups. Further study is warranted; some of the relevant topics of study may include these:

- Compare the performance of the three groups on the mathematics and science subject areas within the ACT. Since all of the disciplines deal with technology, which by definition is the application of science, those scores might be more relevant than the composite ACT.
• Similarly, compare the high school grades received in mathematics and science courses, rather than overall GPA.
• Survey technology students and engineering students regarding their expectations of faculty, their study habits, and their learning methods. Analyze the data from that survey to draw conclusions which could be used to improve teaching and learning.

References

13. Industrial Technology at Ohio University, retrieved February 2012 from: http://www.ohio.edu/industrialtech