

AC 2010-394: FUTURE OF ENGINEERING TECHNOLOGY

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Future of Engineering Technology – A Proposal

Abstract

The question of what is the future of engineering technology has been debated for many years. The discipline has seen a substantial decline in program enrollments over the years and the uncertainty of its place in the university academic setting continues. We believe a fundamental change of direction for engineering technology is needed, a change based on the needs of its core constituents – students/alumni and industry.

Our experience suggests that students and alumni of four-year engineering technology programs expect an *engineering career*. There are few occupational positions above the rank of technician that contain the word “technologist” in the job title. There is, however, strong demand for qualified graduates who can work as engineers to solve technical problems, communicate technical information, and work well in a team environment. Qualified four-year engineering technology graduates satisfy this skill set, that is, they possess the skills that are required for most positions offered to graduates of baccalaureate engineering programs.

The core thesis we make is that *four-year (bachelor) TAC of ABET-accredited engineering technology programs* should constitute a separate but equally valid path to *engineering careers in industry*. Such four-year graduates should be as well-qualified academically as engineering graduates for the majority of engineering careers in industry. Graduates from such programs already pursue career paths that strongly overlap those of engineering program graduates with the exception of research-based careers.

We propose five actions to achieve the aim of engineering technology being recognized as a separate but equally valid educational path to an engineering career:

1. Engineering technology must clearly distinguish the four-year engineering technology academic paths that prepare graduates for an engineering career. It is especially important to distinguish these from two-year programs.
2. The academic curricula of four-year engineering technology programs must have a greater *academic uniformity of rigor* as is recognized through the accreditation process to be necessary in the preparation for an engineering career.
3. Four-year engineering technology programs should continue to support inclusion in the current single federal government job classification of engineering.
4. The engineering technology community must work with those organizations that have common interests and not with those organizations that discriminate based on academic pedigree.
5. The graduates are prepared to function as engineers; thus, the program objectives should make the proper claim: ***The degree is Engineering Technology. The career is engineering.***

The history underlying the identity problem of engineering technology is briefly reviewed. Differences and issues between engineering and engineering technology are examined. The reality of engineering career paths is established as a context for the proposed actions.

Introduction

Engineering technology is an area of technical expertise that has been plagued by a significant lack of identity.¹ For example, institutions that have engineering and engineering technology programs will often provide a description as to the differences between engineering technology and engineering. Typically, this description is found by a URL link on the engineering technology webpage and not on the engineering webpage. Even the traditional, distinctive claim by engineering technology programs of being *hands-on* has eroded with the introduction and recent emphasis of applications and design implementation across engineering curricula, especially the EAC of ABET required capstone project. Much of this has been documented over the years.²⁻¹²

The engineering technology community has differentiated itself from engineering through broad claims of academic learning styles and complimentary career paths. Yet these claims have been largely ignored by those outside the engineering technology community. Repetition of the same ineffective claims is futile. It is the authors' belief that little progress has been made in achieving clarity of the objectives of engineering technology programs, and it is time to make changes.

It may be of use to understand some historical roots. The comments of the following paragraphs are either paraphrased or taken directly from a paper by L.E. Grinter, published in the Journal of Engineering Technology, 1984.¹³

The development of the various fields of technology in the 20th century started with primarily dividing things between science and engineering, with science being the dominant component over the earlier years. Programs that were in essence engineering technology programs were taught under the umbrella heading of "engineering." It was during the post-WWII years that the need for greater clarity in the organization of engineering was recognized. The Grinter Report in 1955 proposed a "dual choice for each student" by splitting engineering into two branches, one with a greater scientific focus and one with a greater pragmatic focus. This was not well supported at the time by engineering faculty. However, a transformational event in the form of Sputnik imposed the recommended bifurcation of the Committee on Evaluation of Engineering Education. Dual "engineering curricula" were quickly developed.

The following words are particularly instructive: "Although names, designations, and titles are subjects for long argumentative discussions, the important results is that any department faculty that has an interest in providing a strong scientific orientation to its engineering curriculum can find room therein to do so. And those faculties that prefer to teach through the means of a hands-on or a more pragmatic approach may also do so. It is of no great consequence that the more scientific orientation is usually entitled 'engineering' and the more pragmatic is entitled 'engineering technology.'

"Industry has made little distinction between its young technical employees with respect to type of curriculum from which each graduated. The employer attitude of

large industry may be expressed simply by the adage ‘sink or swim’ while it provides a trial year of rotational experience equally for each BS and BET employee.”

What these words suggest is that engineering and engineering technology have common roots and common goals via different educational paths. A key observation by Grinter is that while the difference in paths exists in academia, industry’s focus is on performance. Hence, for those seeking positions in industry, the importance of academic differences at the time of graduation is typically small, and diminishes further as the graduate gains experience. In industry, it is performance that counts.

Differences and Issues

There are inherent differences between engineering and engineering technology that give rise to a sometimes sibling-like rivalry and conflict over status and relevance. Both disciplines wish to claim uniqueness and/or superiority. Clearly engineering has dominated the relationship as measured by program enrollments.¹⁴ Significant differences that are at the root of the problem are:

- Academic Paths versus Career Paths

Engineering refers to both an academic path and a functional career path. However, engineering technology refers primarily to an academic path for those with an accredited bachelor degree. *“Engineering technology” refers to four-year TAC of ABET- accredited programs hereafter in this paper unless stated otherwise.* Unaccredited engineering technology degrees and associate engineering technology degrees, which also generally refer to both an academic and career path, are not the primary subject of this paper. The graduates of the latter programs typically enter industry as technicians.

- Understanding of Engineering Technology and Engineering

Engineering technology is not very well understood. To a substantial extent this is true for those in academia and in industry. Hence, when engineering technology issues are discussed, the exchange of opinions may be dominated by oft- repeated stereotypical images. Such stereotypes, which while true to some extent, are indeed only partially true. For example, the lesser emphasis on theory and mathematical rigor causes engineering technology to be viewed as inferior to engineering, that is, *engineering-light*. This is perhaps the most damaging stereotype.

Even engineering is understood in the context of a range of activities: engineering as applied science and math, engineering as problem-solving, and engineering as producing things.¹⁵ The situation is actually more complicated because a myriad of various descriptors exist: engineering, engineering technology, applied science, engineering science, applied mathematics, technology, industrial technology, and others. The overlap between the descriptors is compounded by the numerous degree variations between programs that provide a spectrum of skills and student educational outcomes that match

the wide range of needs required by industry. Forcing a distinct delineation between engineering and engineering technology is simplistic at best and generally inaccurate.

- Degrees Matter

Engineering offers only bachelor (and graduate) degrees while engineering technology offers both associate (two-year) degrees and bachelor degrees (and a few graduate degrees). A two-year degree generally represents lower qualifications when compared to a four-year degree. However, both degrees have the same name and are often grouped together. This linkage can have an undesired consequence of lowering the perception of the entire engineering technology community. In brand marketing this undesired consequence is called the *reverse-halo-effect*.

In addition, there is an element of conflict in having both bachelor and associate degrees within engineering technology because the preparation for an associate degree path should not be assumed to provide the best or desired preparation for the first two years of a four-year degree. Hence, even within what we call engineering technology, there are multiple academic paths.

- Student Body

The academic path for engineering and engineering technology is intended to appeal to and allow success for different subsets of the population seeking a college education. These subsets are not distinct but rather part of a continuum with arbitrary demarcations. For example, some students clearly are the theoretical type and would be out-of-place in engineering technology; and likewise, the experiential learners may be out-of-place in a highly-theoretical program. However, most students are simply not that well delineated with respect to these extremes. Rather they are a mix of each. Hence, the tendency of both engineering and engineering technology to speak of issues in a context that does not recognize the spectrum of the student body is to miss a key reality.

- What's in a Name?

In the USA the use of the title of "Professional Engineer" is restricted to those who are state-licensed as Professional Engineers. But the word "engineer" can be, and is, used in a wide range of settings and is not legally controlled in the USA. More importantly, US industries liberally use this title as a description of job function, and this function may or may not be associated with a specific engineering or other technical degree requirement.

Definitions and Descriptions

Unlike some professions, like medicine and law, where the practice of those professions and the required preparation is generally well understood, such is not the case for engineering. Consider common definitions of engineering from a dictionary: ¹⁶

- The application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.
- The profession of or the work performed by an engineer.
- Engineering - the practical application of science to commerce or industry

The entry for engineering technology is:

- Engineering Technology (ET) is a field of study which focuses on the applications of engineering and modern technology, rather than the theoretical.

What does ABET (Accreditation Board for Engineering and Technology) say? ABET describes the difference between engineering and engineering technology as: "Engineering and technology are separate but intimately related professions. They differ on the basis of:

- "Engineering undergraduate programs include more mathematics work and higher level mathematics than technology programs.
- Engineering undergraduate programs often focus on theory, while technology programs usually focus on application.
- Once they enter the workforce, engineering graduates typically spend their time planning, while engineering technology graduates spend their time making plans work"¹⁷

One university's definition of the differences is: The engineering graduate typically requires a period of 'internship' since engineering programs stress fundamentals. The engineering technology graduate, however, is prepared to immediately begin technical assignments since technology programs stress current industrial practices and design procedures.¹⁸

The NSPE (National Society of Professional Engineers) describes the difference between engineering and engineering technology as:

*"The distinction between engineering and engineering technology emanates primarily from differences in their educational programs. 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. Thus, engineering programs provide their graduates a breadth and depth of knowledge that allows them to function as designers. Engineering technology programs prepare their graduates to apply others' designs."*¹⁹

Even the ASEE once described the difference between engineering and engineering technology on their website as:

"Graduates of Engineering programs apply scientific concepts to develop solutions to real world problems. Their job is more theoretical, involving the design of new products such as a robot that will be used in an auto manufacturing plant. Engineers require more theoretical, scientific and mathematical knowledge. At the same time,

some colleges and universities offer two- and four-year Engineering Technology programs that prepare students for practical design and production work. Graduates of four-year Engineering Technology programs may get jobs similar to those obtained by graduates with a bachelor's degree in engineering.”²⁰

Is the ABET description, “engineering graduates typically spend their time planning, while engineering technology graduates spend their time making plans work” an accurate professional workplace description of how industry functions? Don’t engineers implement their designs and plans, with most likely the help of others such as technicians? And, don’t engineering technology graduates also plan, perhaps not in a research setting, but certainly in an industrial setting?

Where do these multiple interpretations leave us? They leave us with a question, “Are these descriptions accurate?” The authors conclude that the descriptors are often misleading, especially with respect to career functionality. Hence, the distinction between engineering and engineering technology is often a matter of academic program/degree and not career function, as examined in the next section.

The Reality of Career Paths

Web searches for “engineering technology” or “technology” jobs lead to the following:

- Academic positions in engineering technology
- Engineering and Technology Sites (different meaning than engineering technology)
- Information technology sites
- Engineering Technician sites

Thus, engineering technology essentially vanishes as a career path post graduation at the bachelor TAC of ABET-accredited level. This aspect is quite different from engineering where the web hits very much align to the dictionary definition of engineering previously stated.

This aspect reaches the heart of matters in a number of ways. Engineering is the work performed by engineers – a circular definition but instructive because it represents the reality found in industry. In the US you are given the title of engineer if you do work deemed to be engineering. The separation of technical activities into planning by engineers and implementation by engineering technologists, a long-standing statement to distinguish engineering and engineering technology by the academic community, is a misstatement and not supported by any evidence that we have found.

This reality is longstanding. Quoting from the Grinter Report:

“C. Viewpoint of Employers

..... After receiving this expression of attitudes from the engineering institutions the Committee determined to learn something of the viewpoint of employers. At a meeting in Atlanta, Georgia in February, 1954, seven of the largest employers of engineers were invited to advise the Committee. These organizations employ all types of engineers in all functions from research to sales and construction. In fact, most of the organizations represented employ

only a small fraction of their engineers in research, development, and design. On the average less than twenty-five per cent of their engineers work in these fields. One company has most of its engineers employed in operation and another in manufacturing. A third has one of the largest construction organizations in the country. Several employ nearly one half of their engineers in sales. Nevertheless, the industrial representatives who were present concluded that they would prefer nearly all of their engineers to be trained in scientifically oriented curricula.”²¹

Real differences exist between engineering and engineering technology during the academic years. But the academic education received by TAC of ABET bachelor engineering technology graduates is generally consistent with the skills needed for positions that industry labels as engineering positions. Both engineering and engineering technology graduates work and perform in mostly similar career settings upon entering the industrial workplace. Hence, except for research and development careers, the idea of functional distinctive differences in career paths post-graduation is simply incorrect.

The reality is exemplified by one university that lists the jobs its engineering technology graduates actually were engaged in:²²

- Applications engineer
- Automotive design engineer
- Controls engineer
- Design engineer
- Electrical engineer
- Engineer
- Microprocessor design engineer
- Network integration engineer
- Power R&D engineer
- Quality engineer
- Systems engineer
- Test engineer

A second university has the intent of preparing engineering technology graduates:

- “who can bridge the gap between scientific advancement and practical electrical devices and systems”
- who are “educated to convert scientific information into practical devices and systems”
- those who “wish to continue their professional development can take the Fundamentals of Engineering examination”²³

It is of considerable interest to note that the United States Department of Labor substantiated this claim that engineering and engineering technology graduates do not engage in distinct, separate career functions when they rejected a request to create a new minor sub group with the title of Engineering Technologist. Specifically, the department stated that “The title is more appropriately used to identify educational background rather than occupational duties, and the duties performed by Engineering Technologists vary widely.”²⁴ Hence, the claimed career separation that is stated again and again in academic settings, including our own institution, is not borne out by the facts.

Proposed Solutions

The significance of the differences between engineering and engineering technology should be addressed from a different viewpoint. Engineering has two primary constituents:

- Students/graduates
- Industry

We propose five actions to achieve the aim of engineering technology being recognized as a separate but equally valid path to an engineering career:

1. Engineering technology must make clear distinctions of identifying those four-year academic paths that indeed prepare graduates for an engineering career. The programs must be TAC of ABET-accredited. This stance would probably exclude any consideration of programs that primarily focus on producing two-year associate degree graduates without a clear objective of also preparing those students to enter a four-year program, four-year programs that in the latter half focus more on providing additional information and familiarity of that already learned as opposed to providing a greater and deeper understanding with the capability to solve more complex problems. Programs that prepare their graduates for the position of senior technicians, sometimes referred to as “super-techs,” would also be excluded. Clearly, no consideration should be given to two-year programs as the sole preparation for an engineering career.

One suggestion for creating a clear distinction between two- and four-year engineering technology programs is, whenever referring to a program without its complete formal name, to always include the word *associate* when referring to a two-year program, and *bachelor* when referring to a four-year program. For example, a two-year mechanical engineering technology (MET) program would be referred to as an associate MET program.

2. The academic curriculum of the qualifying programs must strive for high and consistent standards, especially in the areas of math and science. The curriculum must culminate in a set of educational outcomes necessary for a career in engineering.

A recent survey of calculus requirements for engineering technology programs revealed significant variance among four-year programs on the amount of calculus required.²⁵ A modification to TAC of ABET criteria could be used to establish minimum math and science requirements that constituents deem necessary in the practice of engineering careers. This should include integral and differential calculus with the application in the technical content courses, but not necessarily require all science courses to be calculus-based.

It is also interesting to note that there is convergence between TAC and EAC program outcomes. Specifically, there is near one-to-one mapping between the TAC and EAC program outcomes with the following equivalencies:

Table 1. Proposed Mapping of ABET Program Outcomes

<u>TAC</u>		<u>EAC</u>
(a)	→	(k)
(b)	→	(a)
(c)	→	(b)
(d)	→	(c)
(e)	→	(d)
(f)	→	(e)
(g)	→	(g)
(h)	→	(i)
(j)	→	(h)

As an example, the outcome TAC (f) “An ability to identify, analyze and solve technical problems” is closely related to the outcome EAC (e), “An ability to identify, formulate, and solve engineering problems.”

3. The administrators of qualifying programs should work with the US Office of Personnel Management (OPM) to continue being included in the present single federal government job classification of engineering,²⁶ work towards having the graduate of a specifically mentioned program name considered as an engineer in that job classification, and **not** create a job classification called *Technologist*. Then various industries with government contracts will start to hire more graduates from TAC of ABET-accredited four-year programs for engineering positions. This status would result in far-reaching positive ramifications for engineering technology programs and their graduates, and would have a positive impact on the technical workforce in the US.
4. The four-year TAC of ABET engineering technology community must work with those organizations that have common interests. Consider one item this community has been striving for: recognized professional status. The community must work with those groups who promote professional status based on demonstrated ability and qualifications, and **not** with those organizations that discriminate based on academic pedigree.

One organization of interest is the National Institute for Certification in Engineering Technologies (NICET). We believe this organization is of great benefit for two-year associate engineering technology programs, but promotes a direction opposite to the direction we are proposing for graduates of four-year bachelor programs. The certification provided by NICET specifically states that graduates of four-year engineering technology programs have no claim to being recognized as performing the function of an engineer in industry, being specifically relegated to a support role. This intent appears to be tied to the catch-22 of you can't be an engineer unless you are licensed as a PE. And, if engineering technologists are also prevented from sitting for the FE and PE exams, then the process of permanently relegating engineering technology graduates to a position of inferiority is complete. The following statement from the NICET website makes matters quite clear:

“NICET certification does not entitle the certificant to practice engineering. The practice of engineering is defined and regulated by state engineering licensing boards; unlawful practice of engineering is a violation of state laws. When not exempted by state law, the performance of work by the engineering technician/technologist which constitutes the practice of engineering must be under the direct supervision and control of a licensed professional engineer.”²⁷

5. Make the proper claim:

***The degree is Engineering Technology
The career is engineering***

Stop skirting reality. Graduates of four-year, bachelor TAC of ABET-accredited programs are qualified for careers in engineering.

Conclusions

Graduates from Engineering Technology programs will continue to pursue and be employed in engineering careers. The educational path provided by four-year TAC of ABET-accredited engineering technology programs differs from that of engineering programs, but the program outcomes and preparation for industry for these two types of programs significantly converge by the time of graduation. The engineering technology community must embrace and promote this reality in its outlook by

- Clearly distinguishing four-year engineering technology programs that prepare graduates for engineering careers from other technology programs,
- Embracing high and consistent academic standards through TAC of ABET criteria,
- Supporting continued inclusion of engineering technology graduates under the single federal government job classification of engineering,
- Working with organizations having common interests and not with organizations who discriminate by academic pedigree, and
- Making the claim: The degree is Engineering Technology. The career is engineering.

The authors sincerely hope that these potentially controversial proposed actions will initiate a serious national discussion within the engineering technology community that will resolve identity issues for engineering technology.

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