Engineering Technology Attributes Inherent to Applied Engineering Programs

Edward W. Chandler, Robert A. Strangeway, Owe G. Petersen

Milwaukee School of Engineering

Abstract

For several years there has been discussion about the appropriate name for Bachelor of Science degree programs currently referred to and accredited by ABET as engineering technology programs. Very few graduates of such programs become employed in positions having *technologist* or *engineering technologist* within the title. In fact, several engineering technology programs have as a program objective the ability to function effectively in an applied engineering position, and prepare students for positions in industry that often have *engineer* within the titles. This paper identifies and examines those attributes of engineering technology programs that result in the program preparing its graduates to function effectively in applied engineering positions. The benefits to engineering programs, and to the engineering profession as a whole, of reintegrating qualified engineering technology programs into the engineering programs spectrum are described. The authors conclude that the incorporation of engineering technology programs that have the attributes to prepare students for applied engineering positions in industry, into the engineering programs spectrum would be of direct benefit to both engineering programs and the engineering profession as a whole.

Introduction

For several years there has been discussion about the appropriate name for Bachelor of Science degree programs currently referred to and accredited by ABET as engineering technology programs. Very few graduates of such programs become employed in positions having *technologist* or *engineering technologist* within the title[1,2,3]. In fact, several engineering technology programs have as a program objective the ability to function effectively in an applied engineering position, and these programs prepare students for positions in industry that often have *engineer* within the titles[1,2,4,5,6,7]. Numerous authors have suggested that engineering programs be offered with the choice of engineering science or applied engineering paths[2,6,8,9]. This paper identifies and examines those attributes of engineering technology programs that result in the program preparing its graduates to function effectively in applied engineering positions. Only four-year programs are addressed in this paper.

Among Bachelor of Science degree programs in engineering technology (ET), there are many variations with regard to factors such as mathematical level, depth of mathematics and the sciences used in the discipline (such as electrical, mechanical, or computer ET disciplines), balance between theoretical concepts and application of the concepts, and the types of positions

for which the programs aim to prepare the students. An ET program having factors such as mathematical level, depth of mathematics used in the discipline, and balance between theoretical concepts and application of the concepts that are more aligned with (but not identical to) those typically found in an ABET accredited engineering program is herein referred to as having a high degree of engineering preparation, placing it on the *applied engineering* end of the spectrum of both engineering and ET programs. On the other hand, an ET program with these factors being more aligned with those that might be expected of a person employed as an advanced technician is herein referred to as having a relatively low degree of engineering preparation, placing it on the *advanced technician* end of the spectrum of ET programs. In fact, ET programs on the *advanced technician* end of the spectrum are functionally *technology* or *vocational* programs. Naming such programs as engineering technology programs (a) creates ambiguity in the distinction between programs that prepare graduates to function in applied engineering positions and programs that prepare graduates for advanced technician positions, and (b) results in the perception that engineering technology programs with an applied engineering orientation do not meet the expected rigor of applied engineering programs[7].

The benefits to engineering programs, and to the engineering profession as a whole, of reintegrating engineering technology programs under the engineering umbrella are described following the attributes discussion. These benefits establish a motivation for the reintegration to occur. The processes for the reintegration of qualified engineering technology programs into the engineering programs spectrum, in particular such as program transitions and ABET alterations, are not addressed in this paper.

Description of the Attributes of Applied Engineering Programs

Wolf enumerated most of the significant attributes and issues associated with engineering technology programs in his Anniversary Comments in 1994[1]. Weese and Wolf have a similar enumeration[3]. This section examines these attributes and describes how they pertain to applied engineering programs.

Learning in a Hands-On Environment with Significant Laboratory Content: It is generally accepted that laboratory experiences are prominent in engineering technology programs[1,3]. They are essential to the learning style of most engineering technology students, especially early in their academic programs. Laboratory experiences have been given more emphasis in engineering programs since EC2000. Hence, in general, the importance of laboratory experiences in engineering and engineering technology programs have become more aligned and is not the distinguishing factor that it was pre-EC2000.

Using Mathematics to Learn About Technology: This attribute has wide variation among current engineering technology programs. Many ET programs integrate mathematics education for the explicit use in applied engineering practices, especially design and analysis, whereas other ET programs effectively utilize mathematics in name only. Calculus courses are present in all four-year TAC-ABET accredited ET curricula, but the integration of calculus into the actual technical coursework varies widely. This attribute must be included in a significant way for those ET programs that are to be integrated into engineering.

An Emphasis on Applications-Based Sciences: The essence of this attribute is whether physics courses are calculus-based or not. Often, physics courses in ET programs are not calculus-based because they occur early in the ET curricula, before calculus courses. The primary question ought to be whether the calculus-based physics topics needed within a program, not necessarily covered in the physics courses, are important to the preparation of engineers. Clearly, numerous fundamental topics, such as acceleration along a curve, Gauss' law in electromagnetics, and the modeling of distributed wave phenomena, require calculus. We state as an operational premise that physics topics must be covered on a calculus basis, and that the breadth of topics must be representative of typical engineering programs.

The previous statement does not imply that all physics courses must be calculus-based. For example, if an algebra-based physics of mechanics course is followed by a calculus-based statics and dynamics course(s), then the topics of concern clearly are covered on a calculus basis. A similar argument can be made for electromagnetics. In fact, the conceptual basis of electromagnetics topics that is typically covered in the context of capacitor and inductor operation in electric circuits courses has been the prerequisite for three calculus-based electromagnetics/transmission lines courses in the Electrical Engineering Technology program at MSOE for several years. The authors contend that the sciences must be eventually covered on a calculus basis, whether in calculus-based physics courses or subsequently in advanced courses, for the adequate preparation of students in applied engineering programs.

Faculty with Relevant Industrial Experience: The recent outcomes-based ABET accreditation criteria have de-emphasized this attribute. The previous ABET "bean-counting" of the number of years of relevant industrial experience has been replaced by the newer ABET expectation that faculty have qualifying experience to support instruction designed to satisfy program objectives and outcomes. This attribute should clearly remain intact for those programs that have an applied engineering mission statement.

Professional Accreditation - Quality Standards for Programs: It is interesting that the same professional societies are involved with ABET accreditation of both engineering and engineering technology programs. The accreditation of applied engineering programs under the engineering umbrella would enhance consistency of quality standards for programs.

Progressively Increasing Depth and Analytic Expectations: This attribute is clearly a hallmark of many engineering technology programs. The two-plus-two program structure that is commonly used by many ET programs generally incorporates this attribute. The two-plus-two structure allows students with associate degrees to progress into applied engineering studies, and for those who do not wish to continue or who are not qualified to continue applied engineering studies at the baccalaureate level, provides a credential useful for employment as a technician in industry. A large variable at the present time is the degree of preparation for baccalaureate studies that is provided by associate degree programs. Some associate degree programs carefully increase conceptual and analytic expectations of students as they progress through the associate-level curriculum, while others are not significantly more than a collection of courses with few prerequisites. This variation in preparation is unacceptable for ET programs that are to become applied engineering programs. Clearly, the former type of associate degree program is crucial to the development of students in applied engineering. A program that does not have increasing

depth as one progresses through it will not provide a sufficient preparation for applied engineering positions.

Employment and Career Prospects Including Design: For most positions in industry other than research and development, employers generally do not distinguish between engineering and four-year engineering technology graduates[1,3,4,7]. This aspect has not changed since the 1960s. Industry is satisfied with both engineering and engineering technology graduates in applied engineering positions, with the notable exception in some states of professional registration issues (addressed later in this paper).

We remark that a hallmark of engineering programs is design. Any engineering program on the applied side of the spectrum must also embody significant design experience. Not all engineering technology programs incorporate design as a primary program outcome. ET programs without design content should not become applied engineering programs, unless they are significantly changed.

Professional Engineering (PE) Registration: This attribute is one of the more contentious issues. Buchanan, McNeill, and Petersen directly addressed this issue in their 1998 paper[4]. Petersen stated that passing or failing the PE (or the FE) exam should be based on merit, not pedigree. The inclusion of ET programs on the applied engineering end of the engineering spectrum, and the removal of ET programs that are functionally technology but not engineering technology programs, should resolve the PE issue. All engineering program graduates, anywhere within the engineering spectrum, should have the educational preparation that is required to take the FE exam.

Sufficient Preparation for Graduate School: The significance of this attribute is directly related to the program outcomes and objectives of an engineering program. The question is usually not whether a student can continue into graduate studies, but rather how much additional preparation might be required, especially for graduate engineering studies. Program flexibility is particularly attractive in this respect, such as a graduate studies elective track within undergraduate engineering programs on the applied end of the engineering spectrum. This attribute, while generally associated with current engineering programs, is not the primary attribute that constitutes an engineering program. It is, of course, one of the significant indicators for assessment of a lifelong learning program objective.

Thus, the fulfillment of the above listed attributes is realizable in an applied engineering context and, for the most part, these attributes currently exist in engineering technology programs on the applied engineering end of the spectrum. This fact alone is not a sufficient condition for a successful reintegration of engineering technology into the applied end of the engineering spectrum. Also needed for successful reintegration are clearly described benefits to existing engineering programs and to the engineering profession as a whole, addressed in the next section.

Benefits of Reintegrating Engineering Technology Programs into Engineering

Benefits to engineering programs, and to the engineering profession, of reintegrating engineering technology programs into the engineering discipline are examined in this section. Bluntly stated, there is no motivation for this reintegration to occur if the engineering community does not perceive any significant benefit to engineering programs or to the engineering profession as a whole. Historically, Grinter documented the efforts to bifurcate engineering education into engineering science and applied engineering programs, but that the politics at the time were not amenable "to adopt such a radical change" [4]. Instead, a split into engineering and engineering technology programs resulted.

The consequences of the split are significant. Most of the issues addressed in the previous section are evident from the engineering technology perspective. There are significant issues from the engineering perspective as well. Resolving the issues from the engineering perspective would be of direct benefit to engineering programs and to the engineering profession as a whole.

- *Flexibility in engineering programs*: Many of the current engineering programs have an engineering science characteristic due to the strong research-oriented basis of the environment in which they reside. An applied engineering path at institutions offering such programs or even within such programs would significantly improve retention of students with an applied engineering preference. Students that would otherwise be likely to fail in programs with an engineering science flavor could succeed in a program with an applied engineering path, and become graduates who function well in applied engineering positions in industry.

  This suggestion should not be interpreted as lowering the quality of a program to retain more students. Instead, the suggestion is to include applied engineering outcomes and objectives in the program, as an alternative path. The value of and need for such an alternative path should be based on the impacts that graduates taking this path can have on the engineering profession[10]. Accomplishing this alternative applied engineering path would require a component of the faculty who would be capable of instructing the appropriate courses and overseeing the path within the engineering curriculum. This aspect might be especially suitable for dedicated adjunct faculty. Qualified students who would otherwise leave the profession would instead be prepared for meaningful careers within the engineering profession and would be alumni instead of dropouts from engineering programs.

- *Broader student recruiting base*: Many students may reject engineering as a choice of study because they perceive it as preparation primarily for research and development functions. If engineering programs visibly included an applied engineering path, students would perceive an expanded choice of career functions. This might be especially attractive to non-traditional and first-time college student audiences.

- *Elimination of the ambiguity of academic preparation for engineering positions*: Current engineering technology programs span a wide degree of preparation for engineering positions. This spread, in addition to the preparation offered by engineering programs,

creates considerable ambiguity. The incorporation of qualified engineering technology programs into the applied end of the engineering education spectrum and the classification of non-qualified engineering technology programs as *technology* programs would virtually eliminate this ambiguity.

Conclusion

This paper has addressed fundamental issues in the discussion of the reintegration of engineering technology programs into the engineering programs spectrum. Key attributes of applied engineering programs would include:

- effective use of mathematics in program instruction, including the integration of calculus into engineering analyses
- calculus-based instruction of physics topics within the curriculum
- faculty with relevant industrial experience
- courses with progressively increasing depth, such that courses early in the curriculum provide a consistent preparation for applied engineering studies later in the curriculum
- incorporation of design into the curricula, consistent with engineering program objectives and outcomes
- educational preparation that is required to successfully pass the FE exam
- educational preparation that is sufficient for graduate studies, perhaps through the use of a graduate studies elective track within the Bachelor of Science degree program

Key benefits to engineering programs and the engineering profession as a whole include:

- engineering program flexibility that results in retention of students with an applied engineering preference
- a broader student recruiting base
- elimination of the ambiguity of academic preparation for engineer positions

Thus, the incorporation of engineering technology programs that have the attributes appropriate to prepare students for applied engineering positions in industry, into the engineering programs spectrum would avoid the ambiguity and confusion with the name *engineering technology* as it is currently used, and would be of direct benefit to both engineering programs and the engineering profession as a whole.

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Biographical Information

EDWARD W. CHANDLER
Dr. Chandler is Program Director of Electrical Engineering Technology and Professor of Electrical Engineering and Computer Science at the Milwaukee School of Engineering (MSOE). He also currently performs systems engineering consulting for DISA (U.S. DoD) and for L-3 Communications. He received his Ph.D. degree (EE) from Purdue University in 1985, and is a registered PE in Wisconsin. He teaches courses in circuits and communications.

ROBERT A. STRANGEWAY
Dr. Strangeway is Professor in the Electrical Engineering and Computer Science Department at Milwaukee School of Engineering (MSOE). He is also currently performing research on millimeter-wave components and systems at the Medical College of Wisconsin, Milwaukee, WI. He earned his Ph.D. degree (EE) from Marquette University in 1996. He teaches courses in circuits, signals, electromagnetic fields, and RF/microwaves.

OWE G. PETERSEN
Dr. Petersen is Department Chair and Professor of Electrical Engineering and Computer Science at the Milwaukee School of Engineering (MSOE). He is a former Member of Technical Staff at AT&T Bell Laboratories and received his Ph.D. degree from the University of Pennsylvania in 1971. He is a Senior Member of the IEEE and an ABET EAC program evaluator in Electrical Engineering.

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