DEIB in Engineering Teaching programs in the US

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Diversity, Equity, Inclusion, and Belonging (DEIB) in ET programs in the US

Abstract

Institutions in the US that provide Engineering Technology (ET) degrees prepare both 2-year and 4-year graduates for careers in government, industry, and/or business. Graduates from ET institutions are one of the most diverse of the science, technology, engineering, and mathematics (STEM) fields. The 2-year ET graduates employed in technician roles align well with the 15.XX Classification of Instructional Programs (CIP) code designations, the corresponding US Bureau of Labor Statistics occupational classification, and employers have a good understanding of their role.

Diversity is a strength of 4-year ET grads, but there is confusion in collecting/reporting data, and in general how to classify them. The value of an ET degree is often described as having more application of engineering fundamentals leading to a practical problem-solving approach. Unfortunately, the ET 4-year degree is not currently treated equitably in some areas such as in the CIP codes used, government hiring policies, and for professional licensure rules in states that do not allow 4-year ET grads to be registered as professional engineers (Note: 2-year ET grads are technicians and would not qualify for professional engineering licensure. The licensure equity issue only applies to 4-year ET grads).

The 15.XX CIP code Engineering/Engineering-Related Technologies/Technicians designation has categories for Electrical ET (15.03) and Mechanical ET (15.08) that each contain similar wording that describes the role of a technician, but not necessarily an ET 4-year graduate. Specifically, the phrase, "… apply basic engineering principles and technical skills **in support of** electrical, electronics and communication engineers", and "… apply basic engineering principles and technical skills **in support of engineers** engaged in the design and development …" respectively. There are other alternatives to ET 4-year programs using the 15.XX descriptions, but there are none that make a clear separation between ET 2-year technicians and 4-year ET graduates. This can result in diminished opportunities for ET graduates and faculty.

The government has policies for hiring into engineering positions. The general standard for hiring professional engineers is called GS-0800, which states that graduates from a related curriculum such as ET, must have "had at least one year of professional engineering experience acquired under professional engineering supervision and guidance". In other words, an ET grad needs to have prior work experience for an entry level engineering position in the government. To avoid this obstacle, it is common for an ET grad to be hired into another designation for one year and then seek a transfer to an engineering position. This hardship will most likely deter ET grads from seeking government positions.

Professional licensure of 4-year ET grads and 4-year engineering grads are treated exactly the same in only 12 states, and each state has different policies. Currently, there

are two states that are the most restrictive (Illinois and Kansas) that totally block 4-year ET grads, even if the individual has a PhD in Engineering from an institution that has ABET EAC accredited engineering programs. This prohibits 4-year ET grads from; 1) pursuing higher salary positions available that require professional licensure, and 2) owning their own engineering company.

ET grads are forced to take the FE exam only in states that permit licensure of 4-year ET grads. In the two "hell-no" states ET grads are not valued for their ability to protect the public health, safety, and welfare even though they are truly qualified. Actions to address all three of these issues are discussed and progress towards the goal of inclusiveness for a diverse population of ET grads are presented.

Background Information - Diversity of Engineering and ET

According to the National Center for Education Statistics 2019/20 data [1] the diversity among the nation's 2-yr institutions is higher than in 4-yr institutions. For example, 54.7% of the STEM associate degree graduates were White as compared to the 59.8% of bachelor degree graduates. Associate degrees in ET prepare graduates for careers where they are commonly referred to as technicians. Students also attend 2-yr institutions sometimes earning pre-engineering degrees intended to matriculate into 4-yr programs. A 2019 study [2] shows findings that enrollment in community colleges increased over time among women, where male enrollment did not change significantly in the same time period. Also, the study shows that members of underrepresented minority (URM) groups were more likely than Whites to have attended community colleges and earned Associate degrees.

Bachelor degrees in traditional engineering and ET prepare graduates for careers where they are commonly referred to as engineers. The total enrolled URM graduates from engineering 4-yr programs are typically higher by a factor of ten as compared to 4-yr engineering technology (ET) programs. An ASEE study [3] indicates that in 2021 there were 24,634 engineering 4-yr degrees awarded to URM students compared to 2,144 4-yr degrees awarded to ET majors. Even though the total numbers are higher in engineering programs, the percentage of URM students earning degrees are higher in ET than in engineering programs. The percentage of bachelor's degrees awarded in 2010 to URM engineering students were 16.5 % of the total, compared to 19.8 % in ET.

Data from an ASEE study [3] can be used to compare the total number of students enrolled in engineering and ET programs, such as the 586,589 total engineering students in 2021 compared to the 30,038 total ET students enrolled. The percentage of Black or African American ET students enrolled were nearly twice as high in 2021, 9.1% in ET programs compared to 5.4% in engineering programs. Asian Americans in ET programs also outpaced engineering programs 16.1% compared to 7.5%.

With respect to women enrolled, the numbers are lower in ET than in traditional engineering. The ASEE 2021 numbers [3] indicate that 23.6% of the students' awarded degrees in engineering were female, compared to the ET programs having only 15.5%

female. There has been a positive gain in the percentage of women for both engineering and ET programs since 2010. There are also noticeable differences in STEM undergraduate programs with respect to attracting males and females. In a study of women in engineering [4], males dominated enrollment in 4-yr engineering and ET, computer science, and architecture, building and planning. In comparison, females dominated undergraduate programs in medicine, veterinary science, and agriculture and related subjects. The nature of ET programs having more application-based lab courses than traditional engineering may be an influencing factor in these differences.

Research [5], [6] seeks to gain an understanding of why there is a higher percentage of URM students in ET programs than in traditional engineering. These studies look at previous research and search for insight into the needs of students that are often in the minority. Data indicate that incoming ET URM students are more likely coming from under-privileged or underserved urban or rural high schools. It is recommended that additional attention should be given to underserved schools that may have less exposure to rigorous college preparatory coursework, and that effective practices and programming can be developed to improve retention of this cohort.

With respect to diversity of students, ET programs are showing somewhat higher levels than traditional engineering. Presented in this paper are issues related to diversity, equity, inclusion, and sense of belonging of ET students and programs as compared to traditional engineering. This is a collection of topics that are common conversation among the community of ET academic, government, and industry representatives. The three main topics are related to CIP Code designation, government policies, and professional licensure which are common themes of the ASEE Engineering Technology Division (ETD) and ASEE Engineering Technology Council (ETC) meetings, workshops, and conferences.

DEIB Issues in CIP Code Designations for ET

The Classification of Instructional Programs (CIP) is the accepted federal government statistical standard on instructional program classifications and is used in a variety of education information surveys and databases. CIP was originally developed by the U.S. Department of Education's National Center for Education Statistics (NCES) in 1980 [7], with the latest revision in 2020 (Changes to the CIP are evaluated upon request in ten-year increments). All academic institutions report each program using this taxonomic coding scheme of instructional programs. Its purpose is to facilitate the organization, collection, and reporting of fields of study and program completions.

Parents of prospective students and persons looking for colleges to attend sometimes examine the CIP code designation to better understand the degree opportunities. This makes it difficult for ET program administrators to use accurate data for marketing and recruitment. The Bureau of Labor Statistics (BLS) in the US Department of Labor uses a Standard Occupational Classification (SOC) code to report occupational employment and wage statistics. NCES with the BLS created the CIP-SOC Crosswalk to connect the CIP and SOC codes which further misconstrues the statistics for 4-yr ET degrees.

CIP codes generally apply to all levels of certificates and degrees. So, this is an issue for the CIP code used to describe some ET programs like Mechanical ET and Electrical ET. The two-digit designation used for ET programs is 15.XX, defined in the CIP as "Engineering/Engineering-Related Technologies/Technicians". So, this classification groups the 2-yr Associate and the 4-yr Bachelor degree together. The classification also may include the programs that have less engineering and more management courses in their curriculum. The corresponding SOC Crosswalk code is (17-3020) "Engineering Technologists and Technicians, Except Drafters".

For example, the CIP for Mechanical Engineering Technology programs that most institutions use for reporting is (15-0805) Mechanical/Mechanical Engineering Technology/Technician, which is defined as,

> "A program that prepares individuals to apply basic engineering principles and technical skills **in support of engineers** engaged in the design and development phases of a wide variety of projects involving mechanical systems. Includes instruction in principles of mechanics, applications to specific engineering systems, design testing procedures, prototype and operational testing and inspection procedures, manufacturing system-testing procedures, test equipment operation and maintenance, and report preparation." [8].

This CIP is related in the CIP-SOC Crosswalk [9] to the SOC (17-3027) Mechanical Engineering Technologists and Technicians. When looking at the definitions of the designations there are terms that do not describe graduates from most 4-yr MET programs as defined,

> "Apply theory and principles of mechanical engineering to modify, develop, test, or adjust machinery and equipment **under direction of engineering staff or physical scientists.**" [10].

It can be argued that entry level engineers in all companies "work in support of" and/or "under the direction of engineering staff", but this phrase generally applies to 2-yr technician level positions and not 4-yr ET graduates. According to Land [11], a survey of over 200 companies indicates that 7 out of 10 companies make no distinctions between traditional engineering and ET graduates when hiring into engineering positions. The survey conducted in this study reveals that there are no differences in assigning functions and responsibilities, or important differences in capabilities of traditional engineers and 4-yr ET graduates while on the job.

New CIP codes added in 2020 are improved descriptions of 2-yr and 4-yr engineering technology management degrees in an effort to provide equitable treatment. These new CIP codes are the 2020 CIP code: 14.0103 Applied Engineering, and the Applied Engineering Technologies/Technicians uses the 2020 CIP code: 15.001. The Applied Engineering CIP uses the terminology,

> "…principles inherent to engineering **to the management** and design of systems …", and "… instruction in basic engineering principles, **project management**, industrial processes, production and **operations management**, …" [12].

This may be an accurate description for Association of Technology, Management, and Applied Engineering (ATMAE) accredited ET programs, but most ETAC of ABET ET

programs do not require a high level of management in the curriculum. According to JWright et.al. [13], a survey of 341 ETD listserv members responded positively to considering rebranding "engineering technology" to "applied engineering" because ET graduates rarely are hired with the title "engineering technologist".

At the 2022 Engineering Technology Leadership Institute (ETLI) sponsored and administrated by the ASEE Engineering Technology Council (ETC), the CIP code issue was one of the high priority objectives voiced from the attendees. It was noted by one participant that in North Carolina, the 15.XX CIP code results in much lower funding per student for ET programs.

A solution might be that NCES combines CIP codes 14.XX and 15.XX, which would reduce some of the barriers. With respect to hiring and retaining ET faculty, it is difficult because of low salaries when the university administration uses College and University Professional Association (CUPA) numbers with a CIP code of 14.XX rather than 15.XX for salary comparisons. According to CUPA [14], the 14.XX CIP code faculty salaries for tenured full professors are $124,842 compared to those of 15.XX CIP code for the same rank are $99,952. The salary differential makes it difficult to attract faculty with a PhD and industrial experience to teach in an ET department at a 4-yr institution.

Equity in GS 0800

The GS 0800 is a governmental general schedule (GS) for classes of positions concerned with engineering or architectural projects, facilities, structures, systems, processes, equipment, devices, material or methods. The schedule lists the position duties of which are to advise on, administer, supervise, or perform professional, scientific, or technical work. GS classification standards, qualifications, pay structure, and related human resources policies are administered by the U.S. Office of Personnel Management (OPM). Civilian employees qualify for these governmental positions by meeting the requirements laid out in the 0800 document.

The basic requirement dictated by the 0800 is that the person must have a degree in engineering from a school of engineering with at least one program accredited by ABET. There are provisions set forth for exceptions to this rule. One of the exceptions includes the case where a person has a degree other than engineering with related curriculum such as ET. The 0800 document states that an ET degree,

> "…**may** be accepted in lieu of a bachelor's degree in engineering, provided the applicant has had at least 1 year of professional engineering experience acquired under professional engineering supervision and guidance." [15].

This offers an ET graduate only one option to be hired into an entry level position with a governmental agency. This option is to work in the private sector for one year to gain the necessary credential to be hired into an "entry level" government position. The likelihood of an ET grad to leave a career in the private sector decreases as the time extends past the one-year time period. Institutions that require a year-long co-op or internship program may qualify as the year of professional engineering experience.

A second option is that an ET graduate seeking a position with a governmental agency can accept a position in another classification such as engineering technical, 0802. This position does not require professional knowledge and abilities represented by completing a professional curriculum leading to a bachelor's degree in engineering. These positions are not as highly compensated as engineering positions, therefore leading to the disadvantage to the ET graduate for at least one year until the experience has been gained.

Equity in Professional Licensure

The National Council of Examiners for Engineering and Surveying (NCEES) is made up of members of the states' boards of engineering and surveying from all US states and territories. NCEES provides professional licensure exams for engineers and surveyors as well as Model Laws regarding licensure of engineers and surveyors. Typically, a person must pass both the Fundamentals of Engineering Exam (FE) and the Professional Engineering Exam (PE exam) to be a registered, professional engineer.

Taking the Fundamentals of Engineering (FE) exam is the first step in the process to become a professional licensed engineer (PE). Governmental agencies and some private companies sometimes require engineers to be licensed. Obstacles exist in the United States for 4-year ET graduates to be licensed, and in some states 4-year ET grads are prohibited from even attempting either the FE exam or PE exams. Engineers are licensed at the state level by professional licensing boards, each having different requirements even though the FE and PE exams are the same in all states.

According to the NSPE [16] and subsequent revisions by M. Gordon, there are currently pathways to licensure for ET graduates in all but two states, which are Illinois and Kansas. There are an additional eleven states that allow licensing of ET graduates only with the requirement of an additional degree. There are five states that are less restrictive that have additional requirements such as curriculum review by the state board. Twenty-one of the least restrictive states require an average of three extra years of field experience beyond the engineering degree requirement of four years. There are twelve states that have no additional requirements for ET graduates compared to engineering grads.

ABET accredits engineering programs under the engineering accreditation commission (EAC) and ET programs under the Engineering Technology Accreditation Commission (ETAC). The accreditation standards for 4-year ET and engineering programs are different, but the goals and objectives of the programs are extremely similar. Both EAC and ETAC accreditation criteria for baccalaureate programs focus on producing highly ethical, independent, critical thinkers who utilize their technical knowledge to protect the health, safety and welfare of the public. For example, EAC Criterion 3.2. states,

> "an ability to apply engineering design to produce solutions that meet specified needs with consideration of **public health, safety, and welfare**, as well as global, cultural, social, environmental, and economic factors." [17],

and ETAC Criterion 5.D. states,

> "Include design considerations appropriate to the discipline and degree level such as: industry and engineering standards and codes; **public safety and health**; and local and global impact of engineering solutions on individuals, organizations and society." [18].

NCEES recently passed a motion by a 45 to 20 margin to update their Position and Policy Statement PS 35, Future Education Requirements for Engineering Licensure, to include 4-yr ET graduates. The pathways to licensure are currently defined as:

> "A bachelor's degree in engineering from a program accredited by EAC/ABET and a master's or earned doctoral degree in engineering in the same technical area from an institution that offers EAC/ABET-accredited programs, or the equivalent." [19].

The newly proposed wording states the pathway to licensure as, "A bachelor's degree in engineering or engineering technology." The PS 35 does not dictate how individual state licensure boards will vote in the future, but it does open the door for equitable treatment of ET graduates.

Discussion of Issues

Equity is recognizing that individuals do not necessarily have equal starting points and may need differential supports to adjust for imbalances. Fair and impartial treatment of ET graduates is a matter of inclusivity. The ET community seeks to examine and adjust CIP codes, GS-0800, and professional licensure to promote equity and parity for ET graduates. If the CIP code designations for 14.XX and 15.XX were combined, or if the 14.XX wording is changed to separate the degree levels for engineering technicians and bachelor degree ET graduates, this may lead to the other two issues to be resolved.

A 2021 report by the Center for Public Integrity [20] found that black engineers face disproportional barriers in states with 4-year ET grad licensure restrictions. Even worse, some of the laws restricting licensure have their roots in the segregationist South.

The mathematics requirements in engineering and ET degrees are where some of the critical differences in curricula exist. The fundamental question is whether differential equations and linear algebra are necessities to be designated as an engineer. Most ET programs include pre-calculus and calculus along with statistics mathematics courses. Many ET graduates successfully complete the calculations in the FE exam, applying principles of algebra and trigonometry rather than differential equations and linear algebra.

In 2009 ETC/ETD organized the ET National Forum (ETNF) to provide a voice in advancing ET education. In 2020 ETNF conducted a survey of practicing mechanical, electrical, and civil engineers that identifies 13 specific math topics and asks practicing engineers two questions: (1) how frequently they use skills that are reflective of each of the 13 math topics, and (2) how important to the practice of engineering in general they view each skill to be. The majority (251) of the 350 responses came from various offices of Bechtel, Inc., 46 came from various offices of GE-Aerospace, and the remaining 53

came from 41 different sources. The survey results show that respondents recalled that the second highest rated math skills required by their degree to be ordinary and partial differential equations. Conversely, when compared to skills required on the job, these skills were judged to be essentially the least used of the 13 listed math skills. Furthermore, the areas of statistics and numerical analysis were shown as the 6th and 9th most common items to be part of a degree program but were rated 3rd and 4th on the usage scale.

Future Actions

The ASEE ETC sponsors and administers a visit to Capitol Hill each year during the ETLI conference. This is an opportunity for leaders in the ET community to gather to make their voices heard by lawmakers. In 2022 ET leaders met with representatives that have impact on OPM and GS 0800. In the meetings the group emphasized that the federal government is losing out on a population of great engineers with hands on talent. The first follow up step planned was for the Chance to Compete Act administration to reach out to OPM to reconsider why they are excluding ET graduates. For instance, the healthcare industry has equipment needs for the VA, and there is a critical shortage of people to fill these positions. The goal for 2023 is to return to OPM and present a new case with more backing for overseers and executive orders.

Conclusions & Recommendations

The diversity of the students in ET programs is a strength, but equity, inclusivity, and sense of belonging issues exist. The equity issues lead to a sense that 4-year ET is excluded from opportunities that exist for traditional engineering graduates. Some of these are scholarships, awards, licensure in some states and professional engineering careers in the government.

The successes of ET programs across the country speak volumes to illustrate how employers find ET programs are providing well educated skilled engineers. There are institutions that have ET and engineering degree programs side by side in the same units sharing resources. This can be the ideal situation for students to avoid differentiation by degree title, and that ET is an optional pathway to a career in engineering that is less theoretical and more applied.

A vision is necessary for diverse ET graduates to reach a point of fair and impartial career opportunities. The pathway to achieve this vision is to work towards specific goals. Some of these goals are the following:

1. CIP Codes for ET 4-yr graduates that do not use the statement “in support of engineers”, but rather that they perform duties of engineers.
2. A modified GS 0800 to include 4-yr ET degrees.
3. All states provide an equitable pathway to licensure for 4-year ET graduates – ideally one that is exactly the same as for 4-year engineering grads.

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