AC 2008-341: A NEW VISION FOR ENGINEERING TECHNOLOGY PROGRAMS TO STRENGTHEN RECRUITMENT AND RETENTION

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A New Vision for Engineering Technology Programs to Strengthen Recruitment and Retention

Abstract

Most engineering technology programs in the United States are struggling with low enrollments and difficulty in recruiting and retaining students. The declining enrollments are especially felt in two-year associate degree technology programs. Despite the claims from industry that it is increasingly difficult to find well qualified workers with technology backgrounds, recruitment still remains a struggle. Engineering programs on the other hand recruit well, but suffer from lower retention.

This paper presents a plan for a major curricular change that is being implemented across the commonwealth at the Pennsylvania State University that will provide stronger matriculation pathways for both two-year technology and engineering transfer students into baccalaureate engineering technology programs. One of the features of this new curriculum is a common freshman year for the Electrical and Mechanical Engineering Technology programs. Another feature is the sophomore year where students elect to follow an associate degree track that is streamlined towards matriculation into a BSET degree or focus squarely on the two year degree, but concentrated in a specialization area identified by local industry.

Recognizing the Problems

Due to low enrollments and difficulty in recruiting students, many colleges and universities are eliminating their engineering technology programs because of high costs. However, high-tech manufacturing companies in the United States rely on graduates from engineering technology programs. The reluctance of students and the lack of encouragement from their parents to enter such programs, despite the demands of the workplace and career potential, have been well documented[1]. "Tech Prep" and other programs have sought to correct what has been seen by many as a simple problem of career awareness and curricular matching, but enrollments in engineering technology programs have not responded. At the same time, many undergraduates seek careers in engineering for which they are ill-prepared, while others avoid programs based on STEM altogether[2]. Also, many graduates of engineering technology programs need additional training in other fields to be useful to their employers[3].

Statistics show that only 10% of high school graduates in the United States pursue either engineering or engineering technology careers, while 20% of German and Japanese students pursue such careers. A primary reason for this difference in career choice is the incomplete understanding both by students and their parents of career possibilities in technology-related disciplines and how those careers can be attained[4]. In 1995, only 6.7% of all US bachelor's degrees awarded were in engineering. During that same year Japan and Germany had much greater percentages of engineering graduates, 19.3% and 19.7%, respectively[5].

Engineering and engineering technology programs are distinct, highly-structured curricula which make it hard for students to transfer from one curriculum to the other. Engineering and engineering technology are both perceived by the general public as "engineering"[6]. Most incoming students do not understand the differences between them; and most attempts to educate them to the differences in secondary school have failed. Students who have technical interests are typically advised and encouraged to enter engineering programs. Very often engineering technology, especially at the associate degree level, is viewed by guidance counselors as a "dead-end vocational program." There is a major mismatch between the perception of these programs and reality. A significant number of students in the engineering program discover this mismatch between their expectations and reality during their freshman year. Disillusion and a feeling of failure cause many students to transfer into entirely different majors. Approximately 70% of engineering students do not complete their chosen curriculum. On the other hand, retention in engineering technology programs is good, but few students select it as a major upon entering college[4].

Addressing the Problems

Recognizing the causes for the lower enrollments is two-fold: recruitment and retention. A new curriculum must be designed that address both issues. In Fall 2006, a University wide task force was appointed to design a new engineering technology curriculum that accomplished the following initiatives.

- Update and modernize the current ET programs.
- Provide improved pathways from engineering programs to engineering technology.
- Provide a common year for EET and MET students.
- Streamline both programs to provide opportunities for more technical electives.
- Use increased technical electives to provide areas of specialization to either improve matriculation into baccalaureate technology programs or to meet the needs of local industry.

Obviously, modernizing the curriculum to ensure technical currency is an initiative that all programs across the country must do periodically to insure quality. This activity helps improve recruitment by making the graduates of the program desirable for employment in industry. The other points will be detailed in the following sections.

Current Curriculum

The Pennsylvania State University College of Engineering offers programs in both engineering and engineering technology at various campus locations across the commonwealth. Thirteen engineering majors are available at University Park and two majors are offered at other campus locations. Generally engineering students complete their first two years at one of the smaller campuses then transfer to the University Park campus to finish the degree.

Penn State's engineering technology program is one of the largest engineering technology programs in the country. The program offers five baccalaureate degrees and nine associate degrees at twelve locations in Pennsylvania. Engineering technology students complete their associate degree at one of the campuses and then enter the work force, or continue on for an additional two years to earn a baccalaureate degree in engineering technology.

The focus here is on the electrical engineering technology (EET) and mechanical engineering technology (MET) degrees. Presently, these two programs share 38 credits that are in common to both degrees. The credit break down between non-technical general education and common technical courses is shown below.

General Education: 15 credits total
Writing and Speaking (6 credits) – English 15, CAS 100
Arts, Humanities, and Social Sciences (9 credits) – AHS electives

Common Technical Courses: 23 credits total
Technical Mathematics (10 credits) – Math 81 (3), Math 82 (3), and Math 83 (4)
Technical Physics (6 credits) – Physics 150 (3), Physics 151 (3)
Engineering Design and CAD (3 credits) – EGT 101 (1), EGT 102 (1), ET 2 (1)
Electrical Circuits (4 credits) – EET 101 (3), EET 109 (1)

The general education courses comprise of English composition, public speaking, arts, humanities, and social science. The common technical courses contain technical math through introductory applied calculus, technical physics, both mechanics and electrical science, mechanical and computer drafting and design, and electrical circuits. These common courses made it possible to have a common first semester for both programs which has been implemented during the previous 15 years at Penn State.

<u>EET Degree</u>

For the EET degree, as shown below, students take an additional 28 credits of EET courses in the areas of circuits, computer applications, digital electronics and microprocessors, PLCs, and machines. Note that four of these credits in electrical circuits are already accounted in the common technical course list.

EET Courses (32-34 credits, 28 additional)
Circuits (9 credits): EET 101 (3), EET 109 (1), EET 114 (4), EET 118 (1)
Computer Applications (1 credit): ET 5 (1)
Digital and Processors (7 credits): CMPET 117 (3), CMPET 120 (1), and CMPET 211 (3)
Machines and PLCS (7 credits): EET 213W (5), EET 220 (2)
Electronics (7 credits): EET 210 (2), EET 205 (1), EET 216 (3), EET 221 (1)
Technical Elective (1 - 3 credits)

A minimum of 66 credits is needed for the Associate Degree in Electrical Engineering Technology.

MET Degree

For the MET degree, as shown below, students take an additional 29 credits of the MET courses in the areas of statics, dynamics, strength of materials, machine design, engineering graphics, and industrial engineering technology. Note that three of the credits in engineering graphics are already accounted for in the common technical course list.

MET courses (32 credits, 29 additional)
- Engineering Mechanics (10 credits): MCHT 111 (3), MCHT 213 (3), MCHT 214 (1), MET 206 (3)
- Engineering Graphics (7 credits): EGT 101 (1), EGT 102 (1), ET 2 (1), EGT 114 (2), EGT 201 (2)
- Machine Design (3 credits): MET 210W (3)
- Industrial Engineering Technology (7 credits): IET 101 (3), IET 215 (2), and IET 216 (2)
- Technical Electives (5 credits)

A minimum of 67 credits is needed for the Associate Degree in Mechanical Engineering Technology.

Opportunities Increased Recruitment of Engineering Transfer Students

A majority of students admitted into engineering programs at Penn State do not continue to pursue an engineering major at Penn State after the freshman year. There are many reasons for this; however it appears that those students ill prepared to take the required calculus course, MATH 140, in the freshman year account for most of the attrition rate, which averages about 70%. Approximately 90% of those students change to a non-engineering related major. This statistic presents an opportunity to attract these former engineering students into an engineering technology program by aligning the introductory ET courses with those used in engineering. Engineering students not ready for calculus typically take a college algebra course, Math 22, and a trigonometry course, Math 26, prior to Math 140. These math credits can be used in the engineering technology program in place of the technical math. Additionally, most engineering students have already taken a three credit course in Introductory Engineering Design, EDSGN 100. These credits can also be used in the engineering technology program. Table 1, shown below, lists the new required courses for math and engineering design used for both engineering and engineering technology and the former technology courses they replaced.

Old Technology Course		New Engineering Course	
Course	Credits	Course	Credits
Math 81	3	Math 26	3
Math 82	3	Math 22	3
Math 83	4	Math 140	4
EGT 101 EGT 102 ET 2	1 1 1	EDSGN 100	3

Table 1 – New Engineering Courses used in Technology Programs

This change provides 13 credits of common technical courses between engineering and engineering technology that improves pathways for engineering transfer students. Additionally this change has the added benefit to the campuses of optimizing resources and improving enrollments in the introductory courses. The later point is further improved by designing a common first year curriculum for EET and MET.

Common First Year in Engineering Technology: EET and MET

Presently there exists a common semester for EET and MET students in the current program. The rationale behind extending it by another semester in the new program is two-fold. First, and more importantly, is the industry demand for more a multi-disciplinary technologist[7]. This common first year, consisting of 32 credits, provides graduates with the knowledge and skills necessary to apply current methods and technology to the development, design, operation, and management of electro-mechanical systems, particularly in those industries where automated systems are prevalent, such as industrial automation and mechatronics[8].

The second benefit of providing a common year is from an advising perspective. Students will gain exposure to both EET and MET and be in a better position to make a more informed decision in to which path may be better for them. Additionally, students that may desire both associate degrees will be able to count more common credits.

The common first year, as shown below, is implemented by introducing the students to both an electrical and mechanical systems course in the first semester. These new courses provide a broad overview of the discipline from a top down, systems perspective.

Fall (Semester 1)	Cr		**Spring (Semester 2)**	Cr
English Composition	3		Math : Adv. College Algebra	3
Math : Trigonometry	3		Speech Communications	3
Engineering Design & Graphics	3		General Education	3
Electrical Systems	3		Digital Electronics & Lab	4
Mechanical Systems	3		Statics & Lab	4
Total Credits	15		Total Credits	17

Table 2 – Common Freshman Year for EET and MET

The Electrical Systems course provides students with an overview of the field of electrical engineering technology. It covers the fundamentals of circuit analysis such as Kirchoff's laws, parallel and series circuits, and then applies that knowledge to various common place electrical systems such as: appliances, vending machines, and garage door openers. The course also introduces the students to the scope of electrical systems by including components and topics such as resistors, capacitors, inductors, switches, relays, fuses, amplifiers, transformers, and motors.

The Mechanical Systems course provides students with an overview of the field of mechanical engineering technology. It covers the fundamentals of mechanical design, forces in structures and machines, materials and stresses, fluid engineering, thermal and energy systems, motion and power transmission. The course also introduces the students to the fundamentals of the basic manufacturing process, dimensional measurement tools, and statistical process control.

The multidisciplinary approach continues in the second semester of the common year. Both EET and MET students gain four additional credits of exposure to their respective cross discipline. EET take a course on statics, which is the prerequisite for strength of materials and machine design. This course gives EET students with the background needed for mechanical design. MET students take a course in digital electronics which gives them the prerequisites to take a future course in programmable logic controllers, thus integrating process control to the application of electro-mechanical systems.

The Sophomore Year

The second year of the curriculum is program specific. Most of the core technical courses are taken in the third semester. Delaying and streamlining these core courses to the third semester has two immediate benefits. First, students have more time to develop stronger math skills before they must be applied in the technical courses, thus improving retention. Secondly, more credits are available for technical electives which can be used to develop areas of specialization. The EET program has 13 credits of technical electives. The MET program has 8 to 10 credits.

A majority of Penn State Associate Degree ET graduates do not go directly into the work force, but rather continue in baccalaureate degree programs. Therefore, one of the specialization tracks has to be one that leads to a more efficient matriculation into the BS program. Students following this track select electives that satisfy, or in some case exceed, the entry requirements of the follow up institution. On the other hand, students that wish to enter the work force directly after two years select an alternative specialization track. The tracks are shown in Table 3 below.

EET Specialization Tracks	MET Specialization Tracks
Baccalaureate Track	Baccalaureate Track
Computer and Embedded Systems	CAD/IST
Power Systems	Maintenance
Testing and Instrumentation	Manufacturing

Table 3 – Tracks of Specialization for EET and MET

EET Sophomore Year

All EET students take a common core of courses totaling 21 credits in the second year. They take an additional 13 credits depending on the track they select. Table 4, shown below, lists the core EET courses and the additional 13 credits for the BS track.

Core EET Courses	Cr.	BS Track	Cr.	Other Tracks	Cr.
Electrical Circuits & Lab	5	Electrical Machines	3	Science Elective	3
Microcontrollers & DSP	3	Math: Calculus	4	Track Specific	6-7
Electronics	4	Physics: Electrical	3	Technical Electives	3-4
Physics: Mechanics	3	Technical Elective	3		
General Education	6				
Total	21	Total	13	Total	13

Table 4 – Sophomore Year Requirements for EET Program and Tracks of Specialization

The remaining three tracks all require a general science elective, 6 to 7 credits of track specific courses, and 3 to 4 credits of free technical electives. The track specific requirements are show below:

- Computer and Embedded Systems: Computer Science (3), Data Acquisition (3), Tech. Elective (4)
- Power Systems: Electrical Machines and Lab (4), PLC's (3), Tech. Elective (4)
- Testing and Instrumentation: Data Acquisition (3), PLC's (3), Tech. Elective (4)

MET Sophomore Year

All MET students take a common core of courses totaling 24 credits in the second year. They take an additional 8 to 10 credits depending on the track that they select. Table 5 shows the core MET courses and the list of courses which are acceptable to satisfy the technical elective requirements.

Core MET Courses	Cr.	BS Track	Cr.	Other Tracks	Cr.
Manufacturing Processes & Lab	4	Math: Calculus	4	Engineering Graphics	2
Engineering Graphics	2	Tech Electives*	4-6	Track Specific	6-8
Strength of Materials	3			Computer Science	
Physics: Electrical	3				
Dynamics	3				
Machine Design	3				
General Education	6				
Total	24	Total	8-10	Total	8-10

Table 5 – Sophomore Year Requirements for MET Program and Tracks of Specialization

* Students heading for the BS track select 4 to 6 credits of additional credits depending on the intended baccalaureate program they are matriculating to. These credits are selected from the following list: Chemistry (3), Electrical Circuits (4), Statistics (3), Engineering Graphics (2).

The remaining three tracks all require two credits of engineering graphics and additional 6-8 credits of track specific technical electives. These track specific requirements are:

- CAD/IST Track: Engineering Graphics (2), Information Science Technology (3-4), Electronic Data Control (3)
- Preventive Maintenance Track: Engineering Graphics (2), Preventive Maintenance (6)
- Manufacturing Track: Engineering Graphics (2), Manufacturing (6)

Conclusions

The proposed curricular changes in the engineering technology programs will allow the University to better serve industry and students in the Commonwealth of Pennsylvania. The creation of different specialty tracks will assist the programs in meeting the demands of local industry. At the same time the core curriculum remains the same statewide. Each campus would offer the baccalaureate degree track plus at least one specialty track based on the recommendation of the local industrial advisory committee. A *common freshman year* between the EET and MET programs as well as using some baccalaureate engineering courses will increase the efficiency of operating the programs. Students can postpone the decision of selecting either major until the end of their freshman year, that is, after they have take some courses in both fields.

These curricular changes will also make the transition from engineering to engineering technology more student-friendly and therefore has the potential to increase enrollments in the both programs. Marketing the programs as direct paths to baccalaureate degrees has the potential to directly recruit more high school students, thus increasing enrollments

as well. The common first year will also improve retention by allowing students to concentrate on developing strong math skills and appreciate the broad scope of the electrical and mechanical engineering technology fields.

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