Development of A New Electrical Engineering Technology Program

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Abstract

Troy University is trying to expand its educational programs in engineering and engineering technology to address the needs of industry. Electronics Engineering Technology (EET) is one of the first such programs that are being evaluated to become a new program at Troy University.

Starting a new BS program is always a challenge. This is especially true when there are no similar existing programs at Troy University that can be used as a reference point. There are not enough faculty members with experience in engineering technology program development at Troy University. In order to meet these challenges, Troy University teamed up with a faculty member from a similar engineering technology program at another university.

The team first worked on job market analysis for EET graduates. Information such as salary, number of job openings and requirements at the national level and local area was gathered and analyzed. Requirements for ABET accreditation for the EET program and professional engineering license for EET graduates were gathered and analyzed. How could the team explain the difference between engineering and engineering technology to students, parents, and potential employers? These are typical challenges faced by engineering technology programs. Analyzing these issues can greatly reduce risks for the new program. The program curriculum went through several rounds of revision.

In the end, a balanced program with an emphasis on hands-on learning through laboratory sessions of each course was developed. The team also evaluated resources needed for the new program, including faculty members, laboratory space, and equipment. The paperwork for new program application was submitted in January 2017. This paper presents the details of the new EET program development. The success and lessons learned can provide valuable information for other higher educational institutions that are considering expansion into the area of engineering technology.

Introduction

Troy University is a public high educational institution in the state of Alabama. The University provides a variety of educational programs at the undergraduate and graduate levels within five colleges: Arts and Sciences, Communication and Fine Arts, Education, Health and Human Service, and Business. The Department of Computer Science is the only engineering major, residing in the College of Arts and Sciences. The University is making an effort to expand its educational programs in engineering and engineering technology to address the needs of industry. Electronics Engineering Technology (EET) is one of the first such programs that is being evaluated to become a new program at Troy University.

Starting a new BS program is always a challenge[20]. There are many publications that address creation of new engineering and engineering technology programs. Jaeger *et al.* discussed their experience in creating a new BS program in wireless engineering[10]. This new program was created by combining courses from the Department of Electrical and Computer Engineering and the Department of Computer science and Software Engineering. The establishment of a new Manufacturing Engineering Technology program at Indiana Purdue Fort Wayne drew from past experience of offering manufacturing specific courses in the Mechanical Engineering Technology program[16]. Linn *et al*. presented their efforts in creating a new 4 year degree in process and system engineering technology (PSET)[15]. The creation of the new PSET program was based on an existing Industrial Engineering Technology program with a different focus. Mullett[17] presented a curriculum enhancement effort where the focus of the engineering technology program was shifted from component-based to system-oriented. A similar change of focus and program name was made at Texas A&M University, where the Electronic Engineering Technology and Telecommunication Engineering Technology programs were combined into a new Electronic System Engineering Technology program with a system and product development focus[19]. All these successful new program development efforts are helpful; however, the challenges for the Troy University team are unique. Computer Science is the only existing engineering program at Troy University. Electronics Engineering Technology is quite different from Computer Science Engineering. There are simply no similar existing programs at Troy University that can be used as a reference point. The new program has to be built from scratch. Another challenge is that there are not enough faculty members with experience in engineering technology at Troy University. Faced with these challenges, faculty members at Troy University consulted and worked as a team with a faculty member at Texas A&M University to draw his experience in new engineering technology program development.

In this paper, the process for the new program development and the resulting curriculum are presented.

Engineering vs engineering technology

The first question was what name should the new program adopt? It may seem trivial, but the name of a program can play a critical role for future students and their parents when they choose majors and when students look for jobs[5]. This is important to the success of the new program since many engineering technology programs are struggling with enrollment and recruiting problems[4].

Many potential students, their parents, and even some employers are confused about engineering technology programs. They do not understand the difference between engineering and engineering technology. Moreover, there are two year and four-year engineering technology programs. The two-year programs offer AAS degrees and the four-year programs offer BS degrees. Some students and parents mistakenly think that all engineering technology graduates would work as technicians instead of engineers. In academia, the difference these two has been discussed ever since engineering technology programs were created[6, 7, 9]. Engineering and engineering technology have more commonalities than differences. Some argue that engineering technology is perceived by the general public as engineering[9]. For historical reasons engineering moved towards a more theoretical path, while engineering technology stayed as more applied and practical majors[13]. American Society for Engineering Education (ASEE) uses the slogan "The degree is Engineering Technology, the Career is engineering" to emphasize that the career path for engineering technology is similar to that of engineering. However, if one is not careful when designing the curriculum, graduates from engineering technology may need additional training before they can make significant contributions for their employers[18].

Typically, engineering technology programs focus more on industrial applications and practical skills needed in industry. Engineering technology curricula contain more laboratory components than engineering programs. Engineering curricula, on the other hand, contain more theoretical components. Some believe engineering technology is more appropriate for people who would like to have a BS degree and work in industry. Engineering is more appropriate for people who would like to have advanced degrees, e.g., MS, PhD, and work in academia or national research labs.

Cheshier[3] made a persuasive argument that engineering technology has been misnamed. He suggested that a more appropriate title should be "applied engineering". This would differentiate it from the standard engineering curriculum taught today, which should be more appropriately be called "engineering science." There is a motion under consideration by the board of ABET to allow engineering technology programs to have the option of using applied engineering in their name.

Today, there is compelling evidence from an industry perspective that B.S. programs in engineering technology are, in fact, the manifestation of the "applied" pathway to engineering[13]. In 2010, the Engineering Technology Council (ETC) of ASEE surveyed 200 companies in USA to investigate the difference, if any, between engineering and engineering technology graduates. The results showed that 7 out 10 employers make no distinction between the two groups in assigning functions and responsibilities[13]. The employers also see little difference in on-the-job capabilities or job advancement between the two groups. The majority of these companies assign the title of "engineer" to either graduate. The use of applied engineering may receive push-back from engineering programs; they argue engineering is applied by its nature so adding the word "applied" is not a good way to distinguish engineering and engineering technology.

After reviewing all the information related to the name of the program, the faculty involved sought the opinions of potential students, their parents, industrial partners, and the university administrators and finalized the name of the program as Electronics Engineering Technology (EET).

Job market analysis

The objective of the new EET program is to create the workforce resources needed by industry. To justify the establishment of the new program, it is necessary to analyze the need of industry. The team first looked at the outlook for Electronics Engineering Technology graduates in the website of the Bureau of Labor Statistics in the US Department of Labor[2].

Electronics Engineering Technology is not listed as a separate occupation by the Bureau of Labor Statistics. The closest category is Electrical and Electronics Engineers with BS degrees. For reference, the information on Electrical and Electronics Engineering Technicians with Associate's degrees was also looked up. The compensation level and employment opportunities for ET graduates should be between these two categories and very similar to those of Electrical and Electronics Engineers.

According to Bureau of Labor Statistics in the US Department of Labor[2],

- The median pay for Electrical and Electronics Engineers was $95,230 in May 2015.
- The number of jobs available is 315,900.
- From 2014 to 2024, the job opportunities are projected to show little or no change.

"Change in employment is expected to be tempered by slow growth or decline in most manufacturing sectors in which electrical and electronics engineers are employed. Job growth for electrical and electronics engineers will occur largely in engineering services firms, because more companies are expected to cut costs by contracting their engineering services rather than directly employing engineers. These engineers also will be in demand to develop sophisticated consumer electronics. The rapid pace of technological innovation and development will likely drive demand for electrical and electronics engineers in research and development, an area in which engineering expertise will be needed to develop distribution systems related to new technologies. These engineers will play key roles in new developments having to do with solar arrays, semiconductors, and communications technologies."

The job information for Electrical and Electronics Engineering Technicians with Associate's degrees is listed here for reference:

- The median pay for Electrical and Electronics Engineering Technicians is $61,130.
- Number of jobs available is 139,400.
- From 2014 to 2024, the job opportunities are projected to decrease by a small amount of 2,800.

In very rare cases, ET graduates with a four-year BS degree would find jobs with a title of technician. In these cases, the pay will be much higher than the average because they are over-qualified. They may be quickly promoted to managerial positions.

In the state of Alabama, the Department of Labor published the following employment and wage information in November 2016:

Table 1. Employment information in the State of Alabama[1]

Job title	Estimated employment	Mean	Entry
Electrical Engineers	5030	$98,083	$64,266
Electronic Engineers, except computer	2110	$107,362	$69,079
Electrical & Electronics Engineering Technicians	2060	$61,142	$39,819

Information from other independent sources such salary.com[8] is consistent with the official information provided by the Department of Labors. For instance, the distribution of salary for people with a job title of Electrical Engineer I is illustrated in the following graph[8] (accessed in December 24, 2016).

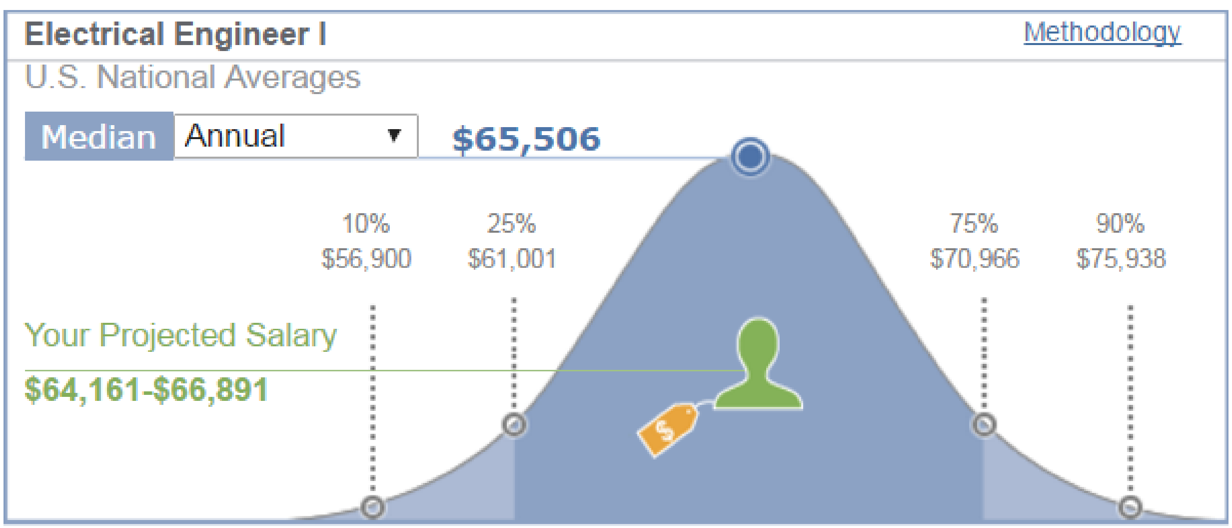

Figure 1. Salary for electrical engineer I estimated by Salary.com

The median annual Electrical Engineer I salary is $65,506 as of April 26, 2016, with a range usually between $60,745-$71,532, not including bonus and benefit information and other factors that impact base pay. The median annual Electronic Engineer I salary is $65,713 as of April 26, 2016, with a range usually between $60,949-$71,715, not including bonus and benefit information and other factors that impact base pay.

A unique feature of salary.com is that you can search for specific areas. Below are the results of areas in the vicinity of Troy[8].

- The median annual Electronics Engineer I salary in Georgiana, AL is $60,965 as of April 26, 2016, with a range usually between$54,126-$67,416, not including bonus and benefit information and other factors that impact base pay.
- The median annual Electronics Engineer I salary in Montgomery, AL is $60,965 as of April 26, 2016, with a range usually between $54,126-$67,416, not including bonus and benefit information and other factors that impact base pay.
- The median annual Electronics Engineer I salary in Dothan, AL is $55,598 as of April 26, 2016, with a range usually between $49,361-$61,481, not including bonus and benefit information and other factors that impact base pay.
- The median annual Electronics Engineer I salary in Troy, AL is $58,048 as of April 26, 2016, with a range usually between $51,539-$64,195, not including bonus and benefit information and other factors that impact base pay.
- The median annual Electronics Engineer I salary in Atlanta, GA is $64,332 as of January 14, 2017, with a range usually between $62,178-$66,060, not including bonus and benefit information and other factors that impact base pay.
- The median annual Electronics Engineer I salary in Birmingham, AL is $66,202 as of January 14, 2017, with a range usually between $63,985-$67,980, not including bonus and benefit information and other factors that impact base pay.

All these employment data look promising for EET graduates and were used during the decision making process for the establishment of the new program.

EET curriculum design

The following factors were considered during the design of the EET curriculum: potential ABET accreditation in future, emphasis hands-on experience with many laboratories associated with technical courses, a required capstone design course, balance of courses load for each semester, and resource constraints.

For most four-year BS programs, a minimum total program credit hour of 120 is required[12]. Many ET programs have total program hours of around 128. The recent trend is to reduce the total program hours. After a few rounds of revisions, the new EET program ended up with 120 total program hours. Each semester, students take 15-16 credit hours of courses.

Most of the common core courses such as mathematics, physics, and chemistry are scheduled for the first year. Starting from the second year, students would take technical courses offered by the EET program. A capstone course, as required by ABET, is included in the last semester to provide students with an opportunity to use the knowledge they learn before the capstone course in a design project.

The curriculum contains fundamental courses such as Circuit Theory, Electronic Devices and Materials, and Digital Circuits and Systems. It also contains more advanced technical courses in specific areas such as Fundamental of Microcontrollers, Automation and Control, Signal Processing, Data Communication and Networking, Measurement and Instrumentation, and Optical Electronics.
The final curriculum is shown as follows

	Fall Semester	**Spring Semester**
Year 1	General Studies Math (3) (area III) English Composition I (3) (area I) Chemistry I + Lab (3+1) (area III) University Orientation (1) (area V) General Studies (3) (area II) Total: 14 hours	Calculus I (4) English Composition II (3) (area I) General Studies science (3+1) (area III) General Studies (3) (area II) General Studies (1) (area V) Total: 15 hours
Year 2	Calculus II (4) Physics with Calculus I +Lab (3+1) GEM 1100 (3) Literature I (3) (area II) Total: 14 hours	Physics with Calculus II + Lab (3+1) General Studies (3) (area II) Electronic Devices and Materials (3) General Studies (3) (area V) General Studies (3) (area V) Total: 16 hours
Year 3	Analog Circuits and Systems + Lab (3+1) Computer Science I (3) (area V) Fine Art Elective (3) (area II) General Studies History (3) (area IV) General Studies (3) (area V) Total: 16 hours	Digital Circuits and Systems + Lab (3+1) General Studies (3) (area IV) Electronic Testing with Lab (4) Measurement and Instrumentation (3) Total: 14 hours
Year 4	Fundamentals of Microcontrollers + Lab (3+1) General Studies (1) (area V) Automation and Control + Lab (3+1) Optical Electronics (3) General Studies (3) (area V) Total: 15 hours	Data Communication and Networking (3) EET Capstone (3) General Studies (3) (area IV) LSI/VLSI + Lab (3+1) General Studies (3) (area IV) Total: 16 hours

Total Program credit hours: 120

As per ABET requirements, total technical courses should be between 1/3 and 2/3 of total program credit hours. Since the total program credit hour is 120, this means the technical courses should be between 40 and 80 hours. The EET program has 56 credit hours from technical courses, meeting the ABET requirement.

Summer internships are not a part of the curriculum; however, students are strongly recommended to apply for internships during their junior or senior year.

Laboratory is a critical component of engineering technology curriculum. EET students need to have more hands-on experience than EE students. The hands-on experience will improve employment opportunities for EET graduates. Therefore, many technical courses in the curriculum have laboratories. As a result, the EET program is trying to secure two large laboratory rooms that can be shared by multiple courses.

For computer related laboratories, the EET program just needs computers, software for each computer and network access. For other labs, each station will be equipped with an oscilloscope, a digital multimeter, a signal generator, and a power supply. For circuit courses, a part kit that contains an electronic breadboard, resistors, inductors, capacitors, wires, and other electronic components will be used. This kit can be provided to each student team, or the EET program can ask students to purchase the kits and bring to the lab. There are other specific equipment and components that are needed for special projects. For example, a control course may use both DC- and stepper-motors, as well as robots. For instrumentation and control courses, the EET program will need data acquisition systems such as LabVIEW DAQ. In the measurement and instrumentation courses, students may begin by constructing a simple voltmeter or ammeter from a galvanometer as a means of learning the limitations of accuracy, precision, and dynamic range of measuring instruments.

If lab space becomes a serious issue, the EET program may try to have students to bring their own device (BYOD) and their own laptops, which is something being tried out in many engineering schools. This would allow labs being run in a classroom. An additional advantage of this approach is that it will enable students to work on projects outside of class time. Currently, the EET program is in the process of designing the laboratory rooms and procuring the necessary equipment for each laboratory.

Anticipated enrollment

Troy University has a total estimated enrollment of approximately 8000 students at its main campus where the EET program is to be offered. There are a variety of majors and programs to which EET might be compared. None is exactly like EET, but there are as many as 7 majors and programs which may draw similar students: Physics (PHY), Mathematics (MTH), Geomatics (GEOM), Computer Science (CS), Applied Computer Science (ACS), Medical Laboratory Science Concentration in Biology (BML), and the Bachelor of Applied Sciences in Resources and Technology Management (BAS/RTM). Of these programs, two—ACS and BAS/RTM—are based online or at satellite campuses, and thus have relatively low enrollment at the main campus. Additionally, one of these programs, PHY, is a relatively new program which was first launched in 2013. This program has seen steady growth in enrollment since first being launched, with its first majors graduating in the 2015 academic year.

All of the programs mentioned above have seen growth in or steady maintenance of enrollment and graduation rates at the main campus of Troy University during the course of the last 5 years.

Table 2. Enrollment at the Troy University's main campus at the beginning of the academic year by major and by year.

Major or Program	2012 enrollment	2013 enrollment	2014 enrollment	2015 enrollment	2016 enrollment
BML	NA	NA	10	23	18
CS	122	179	194	252	274
GEOM	39	33	38	38	50
MTH	73	73	58	72	84
PHY	NA	4	13	30	39

These numbers represent the total number of students enrolled in a program (not new enrollees). Therefore, the number of graduates per year would be approximately ¼ of the enrollment number for a program which is maintaining an approximately steady-state enrollment level (e.g. MTH or GEOM). For a program which is currently growing, the graduation rate would be expected to be much smaller, e.g. in physics the program is only 4 years old and there were only 13 students enrolled as of 2014, so most of the 39 students enrolled in 2016 would be first- and second-year students. These assumptions are borne out by the graduation data for these programs:

Table 3. Graduation numbers at Troy University's main campus at the beginning of the academic year by major and by year.

Major or Program	2011 Graduates	2012 Graduates	2013 Graduates	2014 Graduates	2015 Graduates
BML	NA	NA	NA	NA	NA
CS	4	12	18	19	27
GEOM	11	9	3	11	7
MTH	16	18	20	21	21
PHY	0	0	0	1	1

Thus, MTH graduates approximately ¼ of their students each year and replaces these with new enrollments, and GEOM does likewise. The BML program is relatively new in name, but it previously existed under a different name which had an approximate enrollment of 20 (total) and a graduation rate of ~4-5 per year. This exists as a concentration in the Biology department. Programs like CS and PHY which are undergoing rapid growths therefore also graduate far fewer students relative to their enrollment totals. Additionally, as many as 1/3 of the students with declared majors in PHY are in fact "pre-engineering" students who must transfer to another university with an engineering program after 2 years to complete their degrees.

Additionally, there are many logical "feeder" programs in Troy University's home state. Virtually every one of the community colleges in this state has some version of a 2-year program in EET (or an equivalent). There is only one other university in the state which offers an equivalent to EET as a 4-year degree program—this is Jacksonville State University, which offers an Applied Electronics Engineering degree through its school of Business and Industry. The department of Applied Engineering—which includes the Applied Manufacturing Engineering program along with the Applied Electronics Engineering Program—had 25 students graduate with a B.S. degree in the spring of 2016[10].

This leads to a projection of 15 students/year enrolled newly enrolled in (and subsequently graduating from) the EET program at Troy University. The program is expected to be larger than the PHY or BML majors, and comparable to or slightly larger than the successful GEOM program.

Accreditation and PE license

The plan is to have ABET accreditation in five years. In order to prepare for the ABET accreditation, the EET program is establishing an industrial advisory committee (IAC) with representation from organizations served by the program graduates. The IAC will be periodically reviewing the program's curriculum and advising the program on the establishment, review, and revision of its mission and vision statements, program educational objectives, and student outcomes. The committee members will be from industry or government agencies. The IAC will also provide advisement on current and future aspects of the technical fields for which the graduates are being prepared. A continuous improvement process will be established so that assessment of student learning will be conducted periodically and the results will be analyzed for improvement actions. The assessment will involve students, faculty members, and external stakeholders such as the industrial advisory committee.

During the feasibility study of the EET program, special attention was directed to the issue of professional engineering license. It is desirable for EET graduates to be eligible to apply for a PE license. The requirements for professional engineering license vary from state to state. In the state of Alabama, the requirements are as follows:

- Graduation in an approved engineering curriculum plus four years' experience. -- A graduate of **an approved engineering curriculum of four years** or more from a school or college approved by the board who has successfully passed a board approved examination in the fundamental engineering subjects and who has a specific record of an additional four years or more of progressive experience in engineering work of a grade and character satisfactory to the board shall be admitted to a board approved examination in the principles and practice of engineering. Upon passing this examination, the applicant shall be granted a certificate of licensure to practice engineering in this state, provided the applicant is otherwise qualified.

- **Graduation in an unapproved engineering curriculum plus six years' experience. --** A graduate of an unapproved engineering curriculum of four years or more who has successfully passed a board approved examination in the fundamental engineering subjects and who has a specific record of an additional six years or more of progressive experience in engineering work of a grade and character satisfactory to the board shall be admitted to a board approved examination in the principles and practice of engineering. Upon passing this examination, the applicant shall be granted a certificate of licensure to practice engineering in this state, provided the applicant is otherwise qualified.

Therefore, if the program is ABET accredited (or some other equivalent accreditations), then the graduates need 4 years of work experience to sit in the PE exam. If the program is not ABET accredited, 6 years of work experience are needed. The eligibility for EET graduates to sit in a PE exam could be a selling point when recruiting students.

Conclusions

In this paper, the process and result of establishing a new electronics engineering technology program are discussed. Literatures were reviewed before determining the name of the program. Future ABET accreditation was considered when designing the curriculum. Job market for EET graduates was analyzed. Other issues such as PE license eligibility were also considered. The main challenge faced by the faculty members at Troy was lacking of experience in developing engineering technology programs. Troy University worked closely with a faculty member from a similar four-year engineering technology program at Texas A&M University in many aspects of the new program development. Input from local industry also played a critical role in the process of the EET program development. The detailed study of job market for EET graduates, ABET accreditation, and PE license eligibility made the application for establishing the EET program much easier.

After the program is approved, the focus will be on curriculum development and student recruitment. One of the target recruitment sources is students in two-year community colleges. A success story of collaboration between ET programs and community colleges was presented in[14], which provides the EET program with useful information. Another area that requires work is faculty hiring. So far, EET is making great progress in all areas. Additional progress will be reported in future ASEE conferences.

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