
AC 2012-3514: PRODUCT AND SYSTEM DEVELOPMENT: CREATING A NEW FOCUS FOR AN ELECTRONICS ENGINEERING TECHNOLOGY PROGRAM

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Introduction

Fifteen years ago, the Electronics and Telecommunications Engineering Technology programs at Texas A&M University were two very distinct options, each designed to address specific industry needs. The Electronics program produced graduates that hired into general electronic systems integrators positions in field service, technical sales, and electronics testing. Telecommunications graduates performed similar functions, but specifically for traditional telephone service providers. Since then, there has been an evolving shift in the career paths of Electronics and Telecommunications graduates. Today, even though the graduates take positions working for small to large companies that span a broad range of market sectors including automotive, medical, oil and gas, quality of life, telecommunications, and semiconductor manufacturing; one can see a common thread in their duties and responsibilities. Most students are hired to support one or more aspects of electronic product and system development.

To a large degree, this can be attributed to the dramatic change in the faculty. Today, all faculty members have degrees in engineering fields and the majority of the faculty has five plus years of industry experience supporting products and systems. However, this can also be attributed to a paradigm shift in how industry now views engineering technology. Fifteen years ago, a majority of the graduates took positions as field service and electronic systems integrators. This has now changed dramatically, with most companies hiring technology graduates for their background and hands-on experience in applied engineering problem-solving. Virtually all graduates have careers that support either specific products or large systems through their life cycle, performing functions such as product design, test engineering, product engineering, applications engineering, sustaining engineering, and systems integration. All of this indicates a need to revisit the current curriculum and program structure.

In addition, other factors have been driving the need for a major curriculum revision. For instance, the state legislature is now recommending that all four-year degree programs reduce their total required credit hours to 120. While this is not realistic for an engineering technology program, the total number of credit hours required for graduation is now a consideration for incoming students. To be more competitive within the University and the College of Engineering, the faculty targeted a reduction from 132 to 128 hours. Recruiting of quality students has also become an important concern. The United States has seen declining enrollments in engineering and technology disciplines over the past five years¹ and this has been no different for the Electronics and Telecommunications programs at Texas A&M University. To address this, the faculty has identified a need for a unique “selling proposition” as one possible solution. The concept of careers in electronic product and system development has resonated well with new students. While this is not a new concept especially in mechanical and manufacturing programs^{2,3}, it is unusual and unique in electronics programs. In addition, an emphasis in product development lends itself well to the programs’ existing interest in entrepreneurship education as evidenced by efforts at other institutions.^{4,5}

With the faculty recognizing this shift, a process has been implemented to merge the two programs into a single Electronics Engineering Technology (EET) program that emphasizes product and system development. First, a product development summit was held to solicit feedback and collect industry best practices. This summit set in motion a number of incremental changes to the curriculum. Then, over the past year, multiple faculty retreats have been held to methodically create a new, restructured curriculum. This has been accomplished through three primary mechanisms. First, the most relevant courses pertaining to modern electronic product and systems were identified and retained. These include basic analog and digital circuits/electronics, embedded hardware/software design, wired and wireless communications, instrumentation, and control systems. Second, the content and objectives of these courses were modified to reflect a strong system design and integration perspective. As part of this, most courses have become project-based, requiring teams of students to work on open-ended, industry designed projects. Finally, courses have been added to the curriculum in areas that support product development such as testing, quality assurance, engineering statistics, and product/system development processes.

Once the new curriculum was designed, it was vetted with an industrial advisory board. The final step is to seek official University approval and to roll out the new curriculum. It is anticipated that this will happen in the Fall of 2012. This paper will discuss all aspects of the development and rollout of the new program including the unique aspects of adopting a product development emphasis in an electronics program. Results from the product development summit will be presented and the restructuring process used by the faculty will be detailed. Finally, feedback and perspectives from both industry and our students will be given.

Curriculum Restructuring Process

Impetus

Currently, the Electronics Engineering Technology (EET) program and the Telecommunications Engineering Technology (TET) program are two distinct options, separately accredited within the Department of Engineering Technology and Industrial Distribution. Fifteen years ago, this was necessary as the two programs served distinctly separate industry customers. EET was focused on educating students to take positions as general electronic systems integrators while TET was focused on providing a workforce for the telecommunications sector, primarily traditional phone service providers. Today, as traditional phone systems have become more and more obsolete, the market for our students has converged. Most students who graduate from EET and TET take positions as electronic product and/or system developers across a diverse set of industries from medical to automotive to telecommunications. Thus, the industry need has now changed from needing two separate programs/options into needing a single program that emphasizes the various aspects of product and system development including design, integration, testing and life cycle management.

Through an evaluation process discussed below, the faculty has decided to merge the two separate curricula into a single, more streamlined degree program to more accurately reflect the needs of today's and future industry markets. It should be noted that an essential part of this modification was to integrate the most relevant existing electronics and telecommunications courses so that this knowledge is now shared by all students. In addition, other courses were modified, added or removed to ensure that a true focus in product and system development was achieved. Thus, through this process, several goals have been achieved:

- Reducing the confusion among our industry customers about the distinction between Electronics Engineering Technology and Telecommunications Engineering Technology.
- Creating an engineering technology program with a strong emphasis in electronic product and system development.
- Creating a unique “selling proposition” which resonates with our customers: industry and students.
- Better leveraging of the faculty’s interest and expertise thus increasing the quality of the education in Engineering Technology.
- Allowing all required courses to now be offered twice a year.
- Reducing the total number of hours in the EET program to 128 which is more aligned with the goal of the state legislature to reduce the total number of hours required for a degree.
- Reducing the overhead of accrediting two separate degree programs when only one is necessary.

Product Development Summit

The original concept of product and system development as an emphasis for a new program originated in the Summer of 2008. As the faculty surveyed both their history of funded research projects and the career path for current students, a strong pattern of activity in product and system development emerged. The vast majority of funded research projects were either government agency or industry funded and involved the design and development of products and systems to address specific customer needs. Examples of these projects included the design of a new RFID inventory system for a customer who had a large inventory of rental equipment to track, the development of a several prototype products for an after-market automotive manufacturer, and the creation of several border surveillance and tracking reference designs for the Department of Homeland Security. At that same time, most graduates were being hired into positions related to product and/or system design, life-cycle maintenance, testing and applications engineering. To explore this new opportunity in more detail, the faculty hosted a one day workshop to discuss product and system development from an industry perspective. This was done by identifying key industry customers who were currently hiring engineering technology graduates into product and system development positions. Each industry was asked to send a representative to the summit to present their perspectives and needs in this area. Represented companies included Texas Instruments, National Instruments and Paragon Innovations. Through this process the faculty identified several improvements that could be made to the curriculum in order to better prepare students for their careers.

To address the feedback received from industry, a number of curricular improvements for both the Electronics and Telecommunications programs were planned and implemented over the next two years. These included:

- To ensure that the students had a true product development experience, the capstone course sequence was improved. Prior to this, the capstone experience did require that the students develop an electronic device prototype but often not for a true customer. Now, the capstone experience requires that all teams have a sponsoring customer and that they interface with the customer to develop requirements and performance specifications prior

to design. Almost one hundred percent of the teams now have an external, industry sponsor/customer. Having to respond to their needs more closely emulates product development in the real world. In addition, the capstone course sequence has developed a standardized product and system development document that formalizes the process and emulates the documentation associated with real-world product development.

- More project-based experiences were integrated throughout the curriculum. These are experiences outside of the normal one-week laboratory experience. The students, often in teams, are given an open-ended problem statement and have to integrate their knowledge to develop a solution in a timely manner. Many of these experiences leverage the product and system development document that was designed for the capstone sequence (discussed above) so that the students develop a culture of appropriate product and system design attitudes and techniques.
- New electronics design and implementation tools have been integrated throughout the curriculum including circuit simulation software, PCB layout software, multiple microcontroller programming environments, and an FPGA integrated design environment.⁶ Some of these tools were already being introduced in a single course but that was not adequately preparing the students in their use. Care was taken to develop a process of use and reuse over multiple courses. This dramatically improved student proficiency and better prepared them to take on the cumulative capstone experience.
- While a hallmark of the engineering technology programs at Texas A&M has been the level at which faculty involve undergraduate students in research, this has increased even more since 2008. As part of the Product Development Summit, the faculty recognized the need for students to have multiple real-world experiences before graduation. While formal course projects were one way to accomplish this, many more opportunities could be created through funded research. In addition, the students' attitudes and approaches are often different when they are being paid rather than paying to work on a project. Now every student that is interested in going beyond their paid education has the opportunity to work with faculty outside of the classroom. For example, just one example of faculty research, the Cisco Product Test Laboratory, employs between ten and twenty percent of the students at any given time.
- Another component of the feedback received from the Summit was that students needed more exposure to the business aspects of product development. To this end, the department head created a seminar series where each week industry speakers are invited to give guest lectures on a variety of topics that include business skills for small businesses, intellectual property, and communication skills for working with upper management and customers. While this is currently not a required seminar, it is open and encouraged for all interested students.

Faculty Retreats

As one can see, in response to the Product Development Summit, the programs began to make a slow move towards creating a more formal focus in product development. In the Fall of 2010, these changes were assessed and discussed in several faculty meetings. It was at this time that a more drastic shift was considered. As previously discussed, the need for two separate programs had steadily declined, and the programs were looking for a new selling proposition as well. It was decided that as a faculty group, a single program would be designed that leveraged the existing Electronics and Telecommunications courses and that strengthened the product and

system development focus through formal course work. To do this, the faculty scheduled two eight-hour retreats and a three-hour meeting over a two month period. The retreats were held away from the department. It should be also noted that the faculty agreed, up-front, to be open to changes regardless of the impact on an individual's area of expertise.

The first retreat was held in May of 2011 and was primarily a brainstorming session (Figure 1) to create a straw man curriculum. The constraints that were agree upon up front included:

- Creating a product and system development focus that included curriculum on product development from an industry perspective and curriculum on the business aspects of product development.
- More focus on a systems approach to design integrated throughout the curriculum.
- A four credit hour decrease in the number of hours required for the degree.
- An integration of relevant electronics and telecommunications courses.
- Flexibility in the senior year through optional technical electives.
- Retaining the two semester capstone course sequence already developed.



Figure 1. Faculty curriculum restructuring retreat.

The faculty then chose to divide the curriculum into four major tracks necessary for the new focus and then to implement these tracks with courses. These included tracks on Analog Design, Digital and Embedded Design, Communications, and Systems. While there was tension in the first retreat, there was enough time allocated that the faculty was able to overcome this and unite on a first draft of a new curriculum. At the end of the day, the faculty was divided into subgroups, each tasked with providing curricular details for a specific track.

Each subgroup met multiple times prior to the second retreat. The first task of each subgroup was to identify critical topics that needed be covered. Through a mix of course reuse, course modification and new course development, each track was detailed through not only courses, but relevant topics in courses. For an example, Table 1 documents the details of the

Communications Track. All subgroups completed their assignments prior to the second retreat. During the second retreat, the goal was to finalize a new curriculum through use of the four tracks, to finalize and approve the basic content for each course in the new curriculum, and to brainstorm technical electives. Through a vetting process, these tasks were accomplished and the faculty also decided on the initial offerings for the technical electives.

Table 1. Example of the Communications Track Details

RF	Wireless	Networking	Data Comm	Comm Electronics
Parasitics	LAN, WAN	Switching	Security	Amplifiers
Material Properties	WWAN, WLAN, WPAN	Layers	Error Checking	Filters
Propagation	BT, 802.11	Security	MPLS	Mixers
Transmission Lines	Chan Capacity	LAN/WAN	Fragmentation	Oscillators & PLL
Smith Chart	Protocol Development	Signal Encoding	UDP/TCP	Modulators
Impedance Matching	VOIP	Collision Detect/Avoid	QoS	Demodulators
Waveguides	Freq Reuse	VLANS	IP Security	I&Q Systems
Antennas	Traffic Capacity	IP Addr/Routing	Network Manage	Analog - AM, FM, PM
Friis Trans Eq – Free Space	Probability Models	UDP/TCP	Cloud/Storage	Digital – OOK, ASK, FSK, PSK,
Intro to Noise and SNR	Link Budget	Wireshark	XDMA Processes	Analog vs Digital Implementations
Free Space Loss	Sat Links	VOIP	Noise Impact	Receiver Specs
Delays	Cellular Networks	Routers	Spread Spectrum	Transmitter Specs
Satellite Links	TDMA/FDMA/CDMA	Virtual Circuits	DLC	Fiber Optics
	1G/4G	Channel Cap	Frag/Reassembly	Bandwidth Utiliz
	S/I	Transmission	Compression	
		VLSM	Encryption	
		Spanning		

Other Topics that are needed from other courses: Fourier Transform, Frequency Domain vs Time Domain, Spectral Representation of Signals, Phasors, Complex Math, Filtering in the Time and Frequency Domain, Bode Plots, Bandwidth, Lowpass vs Bandpass Systems, Noise in the Frequency Domain, Op Amps, Discrete Transistors/Amps, Signal Conditioning Circuits

Finally, the second retreat was used to discuss concept integration and course projects. Specifically, details on how to more fully integrate the skills and knowledge required for product development throughout the curriculum were discussed.

The final meeting was held at the end of the summer 2011 to settle more administrative details including a discussion on the new curriculum's impact on faculty loading, the creation of catalog revisions, and the assignment of responsibility for the new curriculum's formal approval request and phase-in.

The Restructured Curriculum

Overview

Prior to the restructuring, the Electronics and Telecommunications Engineering Technology programs were two separately accredited ABET programs. Through the process described previously, the "best" parts of the two programs were identified and integrated into the new program to ensure that it continued to meet the expectations of current industry customers. Second, courses that were not adequately preparing the students in terms of prerequisites were either changed or eliminated, or if they were not within the control of Engineering Technology, replaced with new program courses that could be designed and taught in-house. Finally, missing subjects or subjects that needed improvement were identified and threaded into the new curriculum. These included system thinking, product development, business acumen, and general electronics testing. The result is the curriculum as seen in Table 2.

The university core curriculum remains virtually the same with one exception. Originally, the students were required to take both technical writing as well as a speech communications course. However, several issues indicated these hours could be used more effectively. First, the new University writing/communications intensive requirement has students take two technical courses where each has a substantial writing and/or oral communications component. These courses are more effective at teaching students engineering technical communications than the courses offered through the English and Communications departments. Second, the sophomore technical writing course offered through the English department is currently being phased out. Third, the Engineering Technology program already does an extremely effective job of both written and oral communications. Through processes that involve internal, as well as external evaluation, the students receive multiple opportunities to have their written and oral communication skills evaluated and critiqued. Thus, the original two courses were merged into a single three-hour communications elective (required by the University). The other three hours have been dropped in order to reduce the credit hours required for the degree as mandated by the state legislature.

The math and science core was also kept intact with the exception that the original statistics course taken from Statistics Department was deemed no longer necessary as discussed below. In order to ensure that the students still took the same level of math as before, the course was made into a math elective. The students now have multiple choices for a third advanced math course based on their interest including vector calculus, linear algebra, and differential equations.

Previously, the students were required to take two College of Engineering courses, engineering ethics and engineering economics. The ethics course has been retained to ensure that the students still receive this exposure. Upon evaluation, the economics course was removed in order to more effectively use these hours. While, the original course did an effective job of teaching students about basic concepts such as interest and amortization, it lacked more everyday business concepts as identified by industry such as how engineering product

development fits into the business decision process. This course has now been replaced with a course on product and system development that covers these topics more effectively and will be taught by an EET faculty member with product development industry experience. Development of this course is being supported by a major electronics device manufacturer.

Table 2. Restructured Electronics Engineering Technology Program Option

Freshman Year					
First Semester			Second Semester		
CHEM 107/117	Gen Chemistry	4 (3-3)	MATH 152	Eng Mathematics II	4 (3-2)
HIST 105	History	3 (3-0)	POLS 206	Government	3 (3-0)
ENTC 151	Engineering Leadership	3 (2-3)	HIST 106	History	3 (3-0)
MATH 151	Eng Mathematics I	4 (3-2)	KINE 198	Health and Fitness	1 (0-2)
ENGL 104	Composition	3 (3-0)	ENTC 219	Digital Electronics	4 (3-3)
		17			15
Sophomore Year					
Third Semester			Fourth Semester		
KINE 199	Req Physical Activity	1 (0-2)	ENTC 315	LAN/MAN	4 (3-3)
MATH XXX	Math Elective*	3(3-0)	ENTC 211	Circuit Analysis II	4 (3-3)
ENTC 210	Circuit Analysis	4 (3-3)	ENTC 349	Microcontroller Architect	4 (3-3)
ENTC 269	Embedded C Prog	3 (2-3)	PHYS 208	Electricity and Optics	4 (3-3)
PHYS 218	Mechanics	4 (3-3)			
		15			16
Junior Year					
Fifth Semester			Sixth Semester		
ENTC 329	Applied Stat and DoE	3 (2-3)	ENTC 352	Electronics Test I	4 (3-3)
ENTC 355	Electro and High Freq	4 (3-3)	ENTC 366	Advanced Networking	3 (2-3)
ENTC 333	Product/System Dev	2 (1-3)	ENTC 455	Wireless Comm	4 (3-3)
ENTC 369	Embedded Soft Sys	4 (3-3)	ENTC 359	Instrumentation	4 (3-3)
ENTC 350	Analog Electronics	4 (3-3)	COMM/ENGL	Comm Elective**	3 (3-0)
		17			18
Senior Year					
Seventh Semester			Eighth Semester		
ENTC XXX	Tech Elective	3 (3-0)	VPA	Visual/ Performing Arts	3 (3-0)
ENGR 482	Ethics and Engineering	3 (2-2)	SBS	Social Science	3 (3-0)
ENTC 452	Electronics Test II	3 (3-3)	ENTC XXX	Tech Elective	3 (3-0)
ENTC 419	Eng Tech Capstone I	3 (3-0)	ENTC 420	Eng Tech Capstone II	2 (0-6)
ENTC 462	Control Systems	4 (3-3)	POLS 207	Government	3 (3-0)
		16			14

Blue – Current Telecom Courses

Green – Current Electronics Courses

Red – New Technical Courses

* Students can choose a math elective from MATH 251, MATH 304, STAT 211. MATH 308 will also be accepted.

** Students can choose a communications elective from COMM 205 and ENGL 301.

From a technical coursework perspective, multiple course changes have been made. First, the C programming course offered through the Computer Science department has been replaced by a new Electronics course. The need for C program in engineering technology

program is specifically to prepare students for coursework in embedded systems, programming microcontroller targets. Unfortunately, the original course was taught as a traditional programming course using personal computers as the target platform and did not adequately prepare students for the embedded systems course sequence. The new course will be taught within the program and will teach basic programming skills using an embedded processor as the target. This should not only better prepare students but will allow additional topics in embedded systems to be added to the sequence including the use of real-time operating systems.

Second, the original electronics and telecommunication curricula have been merged. Those courses that most applied to the product development focus were kept. From the electronics side, this includes analog and digital circuits, the embedded system sequence, instrumentation and controls. In addition, the courses in device testing have been retained and modified to ensure that they encompass the testing of general electronic products and systems as well as individual devices. From the telecommunications side, it was decided that since most modern electronic products and systems communicate, the courses in wired and wireless data communications should be retained. Thus, the students will receive coursework in IP communications and various other wired and wireless protocols including serial, USB, SPI, I2C, Zigbee, Bluetooth, 802.11 etc.

Third, in order to add some flexibility to the curriculum, two technical electives have been added to the senior year. The goal will be to offer four different electives, each taught once per year. To start, these will be in the areas of data communications protocols, energy systems, mobile device programming, and advanced electronics. However, these electives are designed to be flexible and can change based on new areas of technical need.

Finally, the faculty has identified several areas where integrated instruction is needed. These include product development, systems thinking, embedded systems design, and electronics testing. It was decided that rather than treat these areas through a single course, these concepts would be threaded throughout the curriculum in order to ingrain these traits in our students. The areas are discussed in more detail below.

Product Development

As mentioned previously, a critical step in fostering the product development process in the students is to teach them a specific design process that can be followed repeatedly as they progress through increasingly challenging projects. The system development process document (SDPD) that has been developed through several iterations and that has been vetted through industry embodies this process. This document leads students through a thought process that involves working with the customer to develop a problem statement, a conceptual solution, product functional and performance requirements, a functional block diagram design, an assessment/selection of technical solutions, a work breakdown structure, a list of milestones and deliverables, a timeline, a budget, a task assignment matrix, and a test matrix. In its entirety, the SDPD presents an approach to the technical design process. Thus, the SDPD is used over and over again at all levels of the new curriculum to ensure that the students develop a systematic approach to product and system development.

Once the students are comfortable with the technical process, they will then take a course in the junior year that addresses the less technical side of product development. While there had been previous efforts to teach product development concepts in the curriculum⁷, this course (the tentative syllabus can be seen in Table 3) presents more formally the administrative, customer

and business aspects of product development. By having students take this in their junior year they will be able to integrate this knowledge into their capstone project.

In addition to a formal course in product development, specific courses throughout the curriculum will have regular invited speakers from industry to present case studies of the product development process used by their companies.

Table 3. Tentative schedule for the product development course

Week	Lectures
1	Basics of new product development
2	What are you developing and why?
3	Defining your product strategy.
4	Voice of market
5	Voice of customer, market segmentation
6	Review/Exam #1
7	Development process Business plan/market research
8	Managing projects on track
9	Selecting and assigning the task to your best people
10	New challenges in product development
11	Global aspect of developing products
12	Review/Exam #2
13	IP Process, Funding opportunities and resources
14	Presenting a professional business plan/presentation
15	Final Exam/Reports are due

Finally, through their capstone project the students will experience the real-world product and system development process. Over the course of several years, this experience has been refined to the point where industry now sponsors students regularly in order to solve product and system design problems. The capstone sequence as it is now taught requires every student to:

- Form a small company with a team of three to four students
- Develop a company web presence
- Brainstorm an idea for an actual electronic product or system
- Find a customer/sponsor
- Develop a complete product design
- Develop a complete project management plan
- Implement the product using their management plan
- Conduct weekly management-level status briefings to stakeholders
- Completely document their product design, implementation, and testing process
- Have the product accepted by the customer (requirement for graduation)

Systems Thinking

The original curriculum approaches systems design and thinking through a very traditional approach. Most of the coursework in the freshman through the beginning of the

junior year introduces students to basic concepts (analog circuits, digital logic, power, etc.). It is not until the second semester of the junior year that students are truly introduced to system level concepts, and then this is done from primarily an analysis perspective. Then, in their senior year students are finally given a truly open-ended, complex design problem. Thus, it is no wonder that they often struggle with the process and expend large amounts of effort pursuing dead-end solutions.

To truly develop their product and system design skills, this had to change and the new curriculum now takes a more innovative approach to systems thinking. First, the student will take a freshman/sophomore level course where they are exposed first-hand to the concept of a system. In this course, they are also introduced to a system development process document that they have to apply to a simple example. Second, they will use the same system development process document repeatedly in increasingly more complex course projects moving from an analysis perspective in the sophomore year to a design perspective in the junior year. For example, in their instrumentation course they will design and implement a smart sensor using this process. It is expected that through this continual exposure to systems thinking concepts, each student will adopt an attitude of and aptitude for system design principles.

Embedded Systems Development

Another skill necessary for an engineer who is designing and working with electronic products and systems is a proficiency in embedded systems design. Thus, the new program contains a very strong component in this area. Through a three-course sequence, students will learn to design and program complex embedded systems. The first course will be an introduction to C programming specifically aimed at the ARM architecture. This course will not only teach students basic C programming skills, but will also expose them to microcontroller development environments and the nuances of programming and using the resources available on an embedded device. The second course will then take them through an in-depth look at the typical resources on an embedded device and through the use of assembly language, help them understand the architecture of the embedded system. This course will also introduce the concept of interfacing an embedded device to the outside world for monitoring and control. Finally, the third course will focus on embedded software design, algorithm development, and real time operating systems to give the students more formal skills in software design and implementation techniques.

In addition to this course sequence, students will also have projects in other courses where they have to develop basic embedded system hardware and software. In some of these projects, they will intentionally use microcontrollers from other manufacturers so that they must extrapolate their knowledge of the ARM processor and apply it to new devices. It is expected that this process will increase their fluency and comfort level with embedded system design.

Electronics Testing

A final area of product development of particular importance to the Texas A&M engineering technology programs is product and device testing. This is an area of interest to industry that has evolved over many years. Originally, companies looked to the engineering technology programs to provide test engineers specifically for semiconductor devices. This has now grown to encompass test in a more general sense, with industry hiring graduates to not only test devices but also integrated systems, products, and software systems. To this end, the new curriculum now integrates testing at a higher level. Not only will students take a two-course

sequence in test, but the testing of devices and systems will be emphasized at all levels of the curriculum. As early as the sophomore year, projects and labs will contain a test component where students learn formal test procedures (the concept of the test matrix, test plan and test report) when analyzing the function of a device, product or system. In addition, their capstone project will have a formal test reporting component where the students demonstrate they have met all customer design and performance specifications. In fact, product testing is now integrated into the system development process document discussed previously to ensure that students recognize the importance of test in any product or system design.

Technical Industry Advisory Committee Feedback

In the Fall of 2011, the new curriculum was vetted with industry. For this purpose, a special technical industry advisory committee (TIAC) was created. This was done by selecting representatives from a wide array of companies that spanned the automotive, telecommunications, energy, semiconductor, quality of life, and industrial instrumentation sectors. In addition, care was taken to select representatives from small, medium, and large companies. The one common thread was that all companies selected provide either product or system solutions to their customers.

The format of the meeting was to present the new curriculum and then let industry critique the overall concept. The afternoon was then used to have industry review and critique each of the tracks separately with specific emphasis placed on the systems track. The final session of the day sought input on recruiting (students and new industry customers) and on developing industry involvement in the deployment of the new curriculum. Overall, the response from industry was overwhelmingly positive. Care had been taken to incorporate industry feedback in the initial design and that came through in the vetting process. With that said, many suggestions were made to enhance the new draft curriculum that included:

- Adding a focus on the system engineering process (creativity) and the product engineering process (detail & Management) to the Product Development course.
- Adding business case studies and financial/economic concepts to the curriculum.
- Replacing the new course in communication electronics with a second wired communications/networking course.
- Developing a culture of maintaining a true engineering notebook.
- Ensuring opportunities for students to develop skills for communicating with a non-technical audience
- Incorporating required field trips and/or internships so that students see product development in an industrial setting.
- Moving laboratory assignments from a canned format to open-ended problem statements by the end of the sophomore year.
- Giving students multiple opportunities to communicate laboratory results to each other.
- Integrating project management and leadership concepts vertically and horizontally.
- Giving students opportunities to experience in-box design (product design) and out-of-box design (large system integration) so that they see both as viable career paths.
- Introducing system and product testing early in the curriculum.
- Ensuring that electives are divided between those that focus on the engineering process versus product development process.

- Creating a new elective on teaching other programming languages such as Java, Java Script, Perl, SQL, VB, VBA.
- Recruiting for both quality and diversity.
- Developing quantitative metrics for marketing such as median pay, rate of pay increases, placement rate, number of 1-on-1 hours between students and faculty, percent with "local" jobs, number of industry visits/lectures, facilities, capstone projects.

Processes are now in place to incorporate this feedback into the curriculum. For example, the communications subgroup is currently replacing the communications electronics course with an advanced networking course. By working with industry, relevant topics are currently being explored and a final course syllabus will be finished before the end of Spring 2012. Also, a process for requiring an engineering notebook in all technical courses has been created. Students will be required to purchase a standard engineering notebook in their first technical course. Then, each course will periodically require that the students put basic concept information (not general course notes or example problems) in their notebooks. The result will be a notebook that follows them throughout their degree and will contain essential concepts that have been identified by the faculty from every course they take. As an incentive to ensure that their notebook is kept up to date, many courses will allow the use of the notebook as a reference on exams. Finally, quantitative metrics are currently being gathered so that new marketing material can be created. In short, the faculty is rapidly working through and incorporating the list of suggestions such that the new curriculum will be ready for deployment in the Fall of 2012.

University Approval Process and New Curriculum Deployment

Because of university deadlines, the approval process had to begin before the industry vetting process was completed. Thus, the request to merge two programs, the new draft curriculum and catalog changes were all submitted in the Fall of 2011. In addition, the requests for new and modified courses were also submitted at the same time. By doing this, it is possible that the new curriculum could be approved as early as the Fall of 2012. To date, it has cleared the College of Engineering process and the University Curriculum Committee process. The programs are now waiting for final approval from the Faculty Senate. Obviously, in order to incorporate industry feedback, the faculty will have to submit revisions in the next catalog cycle to update the draft curriculum.

While approval is being sought, new recruiting materials are being developed. As part of the process, the program administrative assistant is compiling metrics on job placement, job titles, mean starting salary and potential for upward mobility. This data will be incorporated into new brochures for both industry and students. However, the faculty has immediately created new posters (Figure 2) for use at high schools, two year schools and around campus. As new logos are developed for the program, these materials will be updated again. Already visits to general studies on campus and to regional high schools are using the new selling proposition and initial response has been excellent. The concept of actual product and system design as a career focus meshes well with student expectations for their career paths.

In anticipation of a Fall 2012 deployment, the faculty have already developed substitution plans for current students in both the electronics and telecommunications engineering technology programs. In addition, all new students are being informed of a potential catalog change when then new curriculum is approved. Finally, the faculty has started the development of the new

courses that will be required in the fall. The next step will be to start looking at how these changes will impact the next ABET visit in the Fall of 2013.

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Figure 2. Ad featuring product and system development.

Future Plans

Once the curriculum is in place and all of the students have been advised with appropriate degree plans that take into account their catalog, the faculty will pursue several avenues of opportunity. These include the creation of new industry collaborations for both academic and research purposes, the identification of areas appropriate for new technical electives, and the establishment of the new Product Innovation Cellar.

Industry Collaborations

As mentioned previously, a hallmark of the engineering technology programs at Texas A&M University are the close industrial collaborations that provide invaluable real-world experiences for the undergraduate students. For example, Drs. Goulart and Song work closely with Cisco and have well established collaborative, applied research programs. Between these two faculty members, approximately thirty students are employed at any given time and over ten student internships are created each summer. A second example is Dr. Zoghi's research program in RFID applications for the oil and gas industry. This program employs five to ten students each year to develop RFID solutions for industrial customers. Other faculty research programs exist that target the power industries and the semiconductor test industry.

With the new product development emphasis in place, the goal is for all tenured and tenure-track faculty to replicate these successes and involve new market sectors including the automotive and health care industries. Within two years, it is anticipated that every undergraduate student in the program will have at least one product development research and internship experience before graduation.

New Technical Elective Course Development

With the added flexibility of technical electives, each faculty member will be looking for opportunities to develop new electives that add value to the new curriculum. Currently, the number of students in the program limits the maximum number of electives to a total of four, each being offered once per year. As recruiting efforts begin to grow the enrollment, it is envisioned that the program will be able to offer up to six different electives. Even at that number, decisions will have to be made as to which electives to offer. Metrics that will be used for those decisions include appropriateness of the topic with respect to product and system development, the desire to maintain a balance between in-the-box and system integration topics, and the level of financial and in-kind support offered by industry.

Product Innovation Cellar

Currently, all hardware and software projects rely on the limited resources available in the engineering technology laboratories. While these resources have proven to be adequate, a new facility is envisioned where students have 24/7 access to everything they need to develop new product and system prototypes. Over 3000 square feet of space has already been identified for this new facility and approximately \$200k in funding has been earmarked. The new facility, dubbed the Product Innovation Cellar (PIC), can be seen in Figure 3 and will allow students to work in an open, collaborative environment on product and system development projects, sharing ideas, skills and resources. In addition, the facility will be large enough to accommodate select student groups from other engineering and engineering technology programs in the College. This should facilitate new, multidisciplinary activities in the future. Work has already begun on the PIC implementation, and the faculty has coordinated with University development officers to look for donors to help support the new facility.

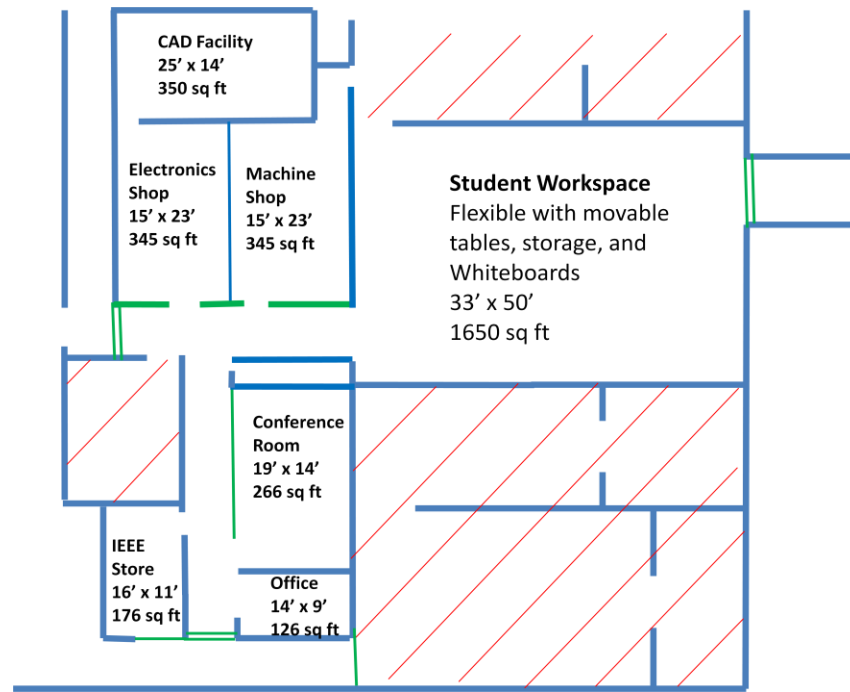


Figure 3. Concept for the Product Innovation Cellar

Summary

Beginning in the Fall of 2008, the Electronics and Telecommunications Engineering Technology faculty have been moving their two independent programs to a single program focused on electronic product and system development in order to respond to changing industry need. Through a process that involved internal evaluation as well as external industry involvement, the new curriculum has now been designed, vetted, and improved. Pending University approval, the new curriculum will be put in place starting in the Fall of 2012.

The new curriculum not only better suits the need of today's industry customers, it also provides a unique and exciting selling proposition for recruiting. Prospective students are responding well to the new emphasis which is not unexpected. It is clear that when many high school students think of electronics technology, they see themselves working with hands-on technology and understanding/designing real electronics products rather than focusing only on low-level mathematics and theory. Thus, the new focus resonates well with what they envision their future career paths to be.

After the initial roll-out of the curriculum, continuous improvement processes will be put into place to ensure that the new curriculum continues to evolve. In addition, the faculty will be working continuously with industry to ensure that the new technical electives remain current and relevant. Finally, as the curriculum is implemented additional publications will be generated to disseminate details of the new courses and feedback from students and industry.

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