

Multidisciplinary Engineering Technology: Rapidly Responding to Educational Opportunities

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In the Fall of 2016, the Department of Engineering Technology and Industrial Distribution (ETID) at Texas A&M University opened a new degree program entitled Multidisciplinary Engineering Technology (MXET). This new program is structured to give students a strong underpinning in both the electronics and mechanical engineering technology disciplines. The curriculum then culminates in a twenty-nine hour focus area that customizes the degree plan for a particular area of the job market. Currently, the degree has a single focus area in Mechatronics, preparing students for careers in the design, development, implementation and support of electromechanical systems that are controlled through embedded hardware and software.

The MXET degree is now being expanded to include new additional focus areas. The first one of these areas is STEM (Science, Technology, Engineering and Mathematics) Teacher Preparation. In collaboration with the College of Education, a MXET focus area is being customized to produce graduates who can sit for their Mathematics/Science/Engineering certification and who can teach at the junior high and high school levels. This new focus will be available starting in the Fall of 2017. The second new focus area is in Entrepreneurial Product Development. This specialization is for the unique student who is interested in starting a technology/product based company, and the goal is to allow the student to incubate their new company while attending courses and finishing their degree. This paper will discuss these two new focus areas in detail and will also discuss the more general process of identifying new focus areas for MXET and using the program to respond more rapidly to the needs of industry, the State and the Nation.

Background and Introduction

In today's high-tech industries, there is a growing need to recruit, hire and promote engineering/engineering technology undergraduates who have the ability to work in a wide range of disciplines. Graduates need to be able to work and communicate across multiple disciplines and understand more than just a single area of engineering. Most new products and systems being developed today include elements of mechanics, electronics, embedded systems, control, and communications. In addition, jobs are available to individuals who possess these skills across a wide range of areas from product design and development to installation, test, operation and maintenance.

To meet this growing need, the Engineering Technology and Industrial Distribution Department (ETID) at Texas A&M University has established a new undergraduate experiential learning-based program that has the ability to rapidly respond to new and fast growing technological areas and needs. The new program, Multidisciplinary Engineering Technology (MXET), provides an underpinning of the important mechanical, electronic and computer systems fundamentals and then builds focus areas on this foundation. The first focus area was in Mechatronics which is currently up and running, the second is in STEM (Science, Technology, Engineering and Mathematics) Teacher Preparation which is in progress of being stood up, and the third which is just being considered is Entrepreneurial Product Development.

By selecting 31 credit hours of Electronic Systems courses, 27 credit hours of Manufacturing/Mechanical courses, and allowing MXET students to participate in either the Electronics Systems or Manufacturing/Mechanical capstone experience, the MXET program was able to be rapidly created and offered to current and future Texas A&M students. Using these courses allowed the MXET program to fulfill the sophomore and junior-level courses using course work that already existed. In addition, based on these sister programs having significant interactions with a wide range of industries, the MXET curriculum was and will continue to be tailored to real-world needs and entry-level job opportunities. Finally, the costs associated with the new program in terms of equipment and faculty positions were reasonable and manageable.

The MXET program was initially limited to accepting 25 students in each of the first two semester of operation; a goal that was easily achieved. Based on the enrollment growth needs of the College of Engineering's 25x25 initiative, this quota was raised for the second year to 50 students per semester which also appears to be achievable based on acceptable applications that have been received prior to the start of the Fall 2017 semester.

It is expected that the first MXET students will graduate from the program in Fall 2018/Spring 2019. MXET will be submitting a request for an ABET visit that will be conducted during the Fall 2018 semester as these first students graduate and would be in concert with the two other sister programs. Because 44 of the 48 credit hours of the MXET technical core as well as 23 of the 29 focus credit hours for the Mechatronics focus area come from these two ABET accredited sister programs, it should be a straightforward process to achieve ABET accreditation during this first visit. In fact, the plan will be to use just the MXET-required technical core to satisfy accreditation requirements which then allows other focus areas to be bundled under the one MXET accreditation.

As of the Fall 2017 semester, the MXET program has approximately 70 students enrolled and the plan would be to increase that to approximately 150 by Fall 2018. Leveraging the coursework, laboratories, faculty and staff in the ESET and MMET programs has allowed the ETID Department to accelerate the startup and implementation of this new area of engineering technology education. This rapid response to industries' needs has created a new level of partnership and interaction for all three programs.

MXET Curriculum

As shown in Figure 1, the Multidisciplinary Engineering Technology program is composed of 127 SCHs which encompasses a University Core, a Math and Science Core, a MXET Technical Core (including Freshman Engineering, two Directed Technical Electives, and a two-semester Capstone Design Project) and a Focus Area of study.

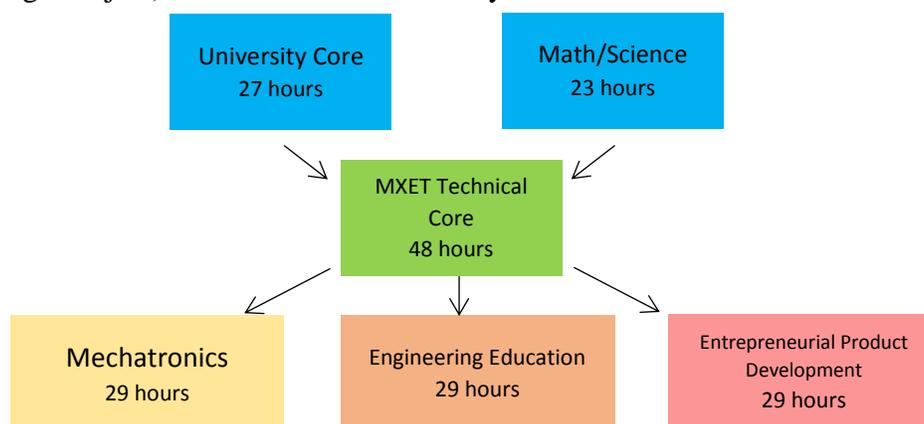


Figure 1. MXET Program Block Diagram (127 SCHs)

The intent of the degree program is to provide undergraduate students more opportunities for a customized experiential learning based education than is typically provided in programs that are more discipline specific, i.e. stove-piped. A number of Focus Areas are possible and others could be developed in the future based on documented industry need and student interest. The first, Mechatronics - also known as electromechanical engineering technology, is an engineering technology discipline that prepares individuals to apply mathematical and scientific principles to the design, development and operational evaluation and maintenance of complex computer controlled electro-mechanical systems and products with embedded electronics, sensors, and actuators [1, 2]. Examples of other Focus Areas that represent the breadth and cross disciplinary aspects of the MXET program include Entrepreneurial New Product Development, Energy Management, and Instrumentation [3]. This Entrepreneurial Product Development Focus Area, which is geared towards the inclusion of business-related concepts and aspects of starting a new venture in a high tech industry segment, will be used to demonstrate how new areas of interest can be achieved when demand and support are available.



Table 1 is a summary of the proposed degree requirements for the MXET program with a mechatronics focus area. These requirements are subdivided into major categories. The General Education Core includes the University Core curriculum (27 SCH) and required Math and Science courses (23 SCH). Required MXET Technical Core Courses (44 SCH) include 40 SCH of coursework from the ESET and MMET programs and the two Freshman Engineering courses (ENGR 111/112). The Mechatronics Focus (29 SCH) includes two new mechatronics courses and other selected ESET and MMET courses. Four hours (4 SCH) of directed technical electives is also included in the multidisciplinary/mechatronics engineering technology program. Similarly, the MXET program with other focus areas such as STEM Teacher Preparation and Entrepreneurial Product Development will also have 127 SCH defined.

Table 1. Required Courses for the BS MXET degree.

| University Core | SCH |
|-------------------------------|------------|
| Composition | 3 |
| History | 3 |
| History | 3 |
| Government | 3 |
| Government | 3 |
| Communications | 3 |
| Creative Arts | 3 |
| Social and Behavioral Science | 3 |
| Engineering Ethics | 3 |
| Math and Science | |
| Engineering Calculus I | 4 |

| | |
|-------------------------|---|
| Engineering Calculus II | 4 |
| Math Elective | 3 |
| Engineering Chemistry | 4 |
| Mechanics | 4 |
| Electricity and Optics | 4 |

MXET Technical Core

| | |
|----------------------------------|---|
| Freshman Engineering I | 2 |
| Freshman Engineering II | 2 |
| Circuit Analysis | 4 |
| Digital Electronics | 4 |
| Embedded Programming in C | 3 |
| Electronics | 4 |
| Instrumentation Systems | 4 |
| Metallic Materials | 3 |
| Mechanics for Technologists | 4 |
| Dynamics | 3 |
| Applications I | 3 |
| Thermodynamics for Technologists | 3 |
| Capstone I | 3 |
| Capstone II | 2 |
| Technical Elective | 4 |

MXET Focus Area

| | |
|------------------------------|----|
| Courses depend on focus area | 29 |
|------------------------------|----|

| | |
|--------------------------------------|------------|
| Total SCH for MXET Curriculum | 127 |
|--------------------------------------|------------|

Existing Mechatronics Focus

The first MXET focus area to be implemented was Mechatronics. This particular area of experiential undergraduate education was selected for a number of reasons. These include a growing interest from the private and public sectors in a multidisciplinary engineering technology program that was general in nature, but included five critical engineering components: mechanics, electronics, embedded systems and computers, control, and communications. Next was the leadership and support of Dr. Reza Langari, ETID Department Head, who provided resources and encouragement to move forward on the development of the new program. Significant support from two sister programs, Electronic Systems and Manufacturing/Mechanical was also necessary to accommodate additional students in current courses selected for the new program. This new program also worked well in helping meet the new enrollment goals set by the College of Engineering as part of its 25x25 initiative. Finally, significant interest to pursue this degree program was demonstrated by transfer and freshman engineering students. Since its announcement, the Mechatronics focus area of the MXET program has also gained increased interest among a number of high-tech industry segments including aerospace, automotive, oil & gas, medical and communications.



In addition to the required courses for the MXET degree discussed previously, those students pursuing the Mechatronics focus area must complete eight additional courses totaling twenty-nine semester credit hours. Three of these courses (12 credit hours) are taken from the

Electronic Systems program, three (11 credit hours) from the Manufacturing/Mechanical program and two new courses (6 credit hours) offered by the MXET program.

The Electronic Systems courses will include Computer Architectures, Embedded Systems and Control Systems. The Manufacturing/Mechanical courses will include Fluid Mechanics and Power, Product Design and Solid Modeling, and Strengths of Materials. Mechatronics I will focus on mobile ground-based robotics with both autonomous and wireless control capabilities. Mechatronics II will look at robot-centric work cell applications and technology. In addition, because of its growing importance to industry across the board, Internet of Things offered by the Electronic Systems program will be strongly recommended as one of the two technical electives required of all MXET students.

New STEM Teacher Preparation Focus

While the MXET program was initially designed and approved with a single focus area in Mechatronics, the goal from the outset was to create new focus areas as opportunities were identified. The first of these opportunities was based on ongoing work by various faculty members in the department. For approximately the last seven years, the department has engaged in numerous outreach activities involving K-12 education and STEM. Some of the activities include:

- **Robotics Workshops:** For the past six years, the faculty in ETID have offered summer workshops for junior high and high school students. These workshops focus on the design of the mechanical and embedded control of an autonomous mobile robot.
- **Summer Teacher Programs:** Faculty have led multiple programs focused on junior high and high school teachers designed to support their interest in integrating STEM, and in particular engineering, into their classrooms.
- **Education Research:** Faculty in ETID have funding from multiple sources including an NSF ITEST project for promoting STEM education and careers in the K-12 environment.
- **Other Interactions:** The department supports numerous other activities in the area of STEM including teacher assistance programs with their STEM activities, programs to teach project management in the high school environment, summer research programs for teachers, and support of K-12 STEM competitions in areas such as robotics.

Not only are these activities important from a service aspect, but for faculty in ETID, many of these contribute to the department's mission of pursuing educational research. Through these efforts, the department developed a relationship with Texas A&M's AggieTeach program and began to investigate the creation of a new academic program focused on educating new teachers that had an interest in teaching STEM (especially engineering) courses at the junior high and high school level. These efforts eventually led to a partnership with the College of Education and have now resulted in the formation of a new MXET focus area.

With growing interest in high schools offering engineering courses being driven by programs such as Project Lead the Way and the development of new standards such as the most recent Next Generation Science Standards, the College of Engineering and the College of Education have agreed that a new program targeted at producing teachers with competent engineering and technology backgrounds is needed. After long discussions, it was decided that this program would be housed in engineering technology and would take advantage of the flexibility of the MXET program. The new STEM Teacher Preparation focus area is now being added to the core MXET program to create a new degree program that will prepare those engineering technology students who have an interest and a passion to teach at the junior high and high school level. The degree adds a twenty-nine hours of coursework taught by the College of Education that includes educational pedagogy, methods courses, and a supervised, semester-long, in-situ clinical teaching

course. In addition, the students will take technical electives in engineering leadership and product development.

This new degree plan will not only prepared students with a strong math, science, engineering and teaching education but will also allow them to sit for their Math, Science, and Engineering education certification. This certification allows graduates to teach math, science and engineering courses at the junior high and high school level making them extremely marketable. The new focus area has been developed and is currently being prepared for submission to the University curriculum review process. In parallel, a request is being prepared for submission to the State of Texas to allow students of this program to sit for the certification exam upon graduation.

New Entrepreneurial Product Development Focus

The third focus area that the ETID Department is considering is one that would emphasize engineering product development and entrepreneurship. In this undergraduate program, the two technical electives and capstone design sequence would be used to prepare small groups of individuals to form and operate startup companies that would create new engineering-based products and systems. An obvious area for these new businesses/companies to pursue would be in the IoT space. With an estimated 26 Billion IoT units in operation by 2020, this technology will have significant opportunities for young men and women to create new startup companies ranging from product design and development to installation and maintenance.

In addition to the technology core of the MXET program, the focus area course work would include the technical aspects of product design and development linked to the business-oriented coursework necessary to start and operate a business, and understand and use financial tools such as Cash Flow, Income Statements and Profit and Loss Statements. Once a small team of students complete this curriculum, one or more of them should be able to launch a new business in the Brazos Valley.

Other initiatives at the College and University levels are emphasizing the importance of including an entrepreneurial mindset into both graduate and undergraduate programs. MXET would take this concept to the next level by transitioning from theory to practice. To meet these type of goals and objectives, support from external organizations and companies will be required. A new business model will also have be created that will allow all stakeholders to benefit from startups in which they participated. Although this will not be a straightforward task, many former students are now retiring and moving back to the Bryan/College Station area. Many of these Aggies can add value to new startups that focus on technical product development. It is reasonable to assume that many retired Aggies would be interested in participating in this new degree program if a business model can be created that allows stakeholders to earn ownership by providing resources such as funding, labor, etc.

Identifying new Focus Areas

As stated previously, the MXET program was designed purposely to be flexible through its twenty-nine credit hour focus area. While this flexibility is positive and allows faculty to rapidly respond to emerging disciplines and industry sectors, it is also important to have an identification and approval process that supports quality and ensures marketability of graduates. Therefore, all new focus areas that are proposed must pass two criteria:

- **Uniqueness:** New focus areas are typically identified through one of two methods. One method is that new programs can come from an explicit demand or a faculty-perceived need in industry. Most typically, the identification of these types of focus areas comes through the strong partnerships that our department has with industry and will typically be mutual

proposal by faculty and industry. The second avenue is through partnerships with other academic programs within or outside of ETID. Both of the programs above fall into one of these two categories. Once a new focus area is proposed, a committee that includes the MXET program coordinator, the ETID department head and associate department head for academics evaluate the value of the proposed area to the department and to future students. First, it must be unique and not duplicative of other academic programs at Texas A&M. Second, it must be substantiated through data indicating the market for the graduates and the ease of placement of these graduates. In addition to focus areas offered at the main campus in College Station, other Texas A&M campuses are looking at offering other specializations for focus areas of the MXET program. One such example is the electro-marine focus that could be offered at the A&M campus in Galveston.

- **Quality:** Once a new focus area is proposed, evaluated for uniqueness and the curriculum is designed, it will be evaluated by the MXET program coordinator and a committee of faculty for quality. While any existing coursework that is used in the new focus area has already been vetted, all new coursework will be evaluated by the committee. In addition, the committee also evaluates the new focus area as a whole to ensure that the proposed curriculum supports the stated goals and will produce graduates with excellent career opportunities. Finally, once the curriculum is approved by the department, it will be sent forward to be approved by the College and the University. Because the MXET program has been approved at the state level, new focus areas will not require this level of review and approval. Through this process, it is anticipated that all new focus areas will be scrutinized so that academic quality is ensured and that duplication of effort is avoided.

Conclusion

The Multidisciplinary Engineering Technology program at Texas A&M University is a new type of engineering technology program designed specifically to be agile with the ability to respond rapidly to emerging educational disciplines and industry needs. The program builds upon a strong core of math, science, electrical and mechanical coursework. A twenty-nine hour focus area is then added that can be customized based on an identified need or opportunity. Currently, the program has a single focus area in Mechatronics which is being offered as well as two additional focus areas, STEM Education and Entrepreneurial Product Development that are being developed and added. It is through a formal committee process that new focus areas are identified, vetted and ensured for quality. Most importantly, new focus areas must guarantee minimal duplication of effort by the faculty and a sustainable market for graduates.

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