Creation of an Engineering Technology Program

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Abstract

High-quality engineering and engineering technology education is essential to the continued and increasing success of our current and future technological society. Existing and emerging industries need both engineers and engineering technologists to design and develop future innovations.

One large, mid-Atlantic, R1 institution recently created an engineering technology program within their existing engineering college to capitalize on the synergies provided by the college and the new program.

While the College's seven departments are divided by "engineering field" and represent 13 distinct undergraduate majors, the B.S. Engineering Technology degree was intentionally designed to be general and provide flexibility through multiple interdisciplinary opportunities. The B.S. Engineering Technology degree consists of a manufacturing-focused engineering technology core plus two areas of emphasis, selected from a current list of five areas of emphasis. Students have significant flexibility within this general program to focus their education toward specific career goals.

Because of the diverse opportunities provided by the five areas of emphasis, the program includes courses outside the engineering college. Specifically, courses from natural resources, design, business, and arts and sciences comprise significant portions of the areas of emphasis coursework. The goal of the program is to provide flexibility to match individual student goals while providing industry with well-prepared and equipped graduates who can "hit the ground running" upon hiring.

This paper presents the process and outcomes of research related to the creation of this new engineering technology program. It presents the programmatic and curricular structure, the reasoning behind the unique structure, and the challenges of implementation and their (to-date) resolutions. The goal of this work is to inform and encourage other engineering educational institutions to consider this path and to be prepared for the process.

1.0 Introduction

A new B.S. Engineering Technology degree program was recently approved by the West Virginia University (WVU) Board of Governors with classes beginning in fall 2023. This innovative 4-year undergraduate engineering technology program in the WVU Statler College of Engineering and Mineral Resources focuses on preparing students to enter the workforce with the hands-on skills necessary for careers in the manufacturing, energy, industrial and technical service sectors as well as to become industrial entrepreneurs.

Informal feedback from regional industry partners related to manufacturing and process engineering indicated that there is a need for engineering technology graduates with hands-on manufacturing skills combined with basic engineering knowledge. Engineering technology positions in the region range from $47,920 to $118,790 and earn a median annual salary of

$73,260, which is above the national average of $61, 960 [1]. The state and region also encourage entrepreneurs who will create jobs in the community to support many of the area's high-tech and manufacturing industries.

This new educational program was created to support regional industry needs, to recruit new students from diverse populations, retain existing students, improve undergraduate education and student training, and enhance career opportunities for our students. The B.S. Engineering Technology degree is expected to attract new students from a variety of communities and with varying mathematics preparations who are interested in the design, analysis, build and test areas of engineering and would prefer to engage in a hands-on learning environment that focuses on creating and utilizing technology solutions for specific engineering-related problems. It also is expected to increase college and university retention by providing an engineering-related, hands-on alternative for students who initially choose engineering but ultimately decide that engineering is not the right fit for them for a variety of reasons, including a desire for a more hands-on, technology-based educational experience or difficulty with or lack of interest in the required foundational math or science courses or in the theoretical engineering content. Engineering technology addresses these reasons for leaving by providing multiple opportunities for hands-on, practical lab experience with industry scale equipment, such as mills, lathes, PLCs, robots, and material testing equipment, beginning in the first term and by requiring "applied" math and sciences courses that are more focused on engineering applications. The engineering technology program is expected to improve both undergraduate education and student training by providing unique opportunities for undergraduate students to gain practical experiences with industry scale equipment and to work toward and earn industry certifications in SolidWorks®, NIMS®, and equipment certifications as well as in Microsoft Word® and Excel®. Selected upper-level engineering technology courses also count as technical electives for some of the engineering discipline majors, so future engineers also will be able to gain practical hands-on experience.

Finally, the engineering technology program supports the university's land grant mission by providing access and opportunity for students, preparing a highly qualified workforce which will support economic prosperity and job creation, engage industry partners, and assist in the positive transformation of the manufacturing and industrial landscape of the state.

2.0 Planning Process

Beginning with the end in mind, the program was structured using the ABET accreditation criteria [2] as a guideline. Additionally, a Google search of "Best Engineering Technology" programs and "B.S. Engineering Technology" programs was conducted followed by a more detailed search of the websites of many engineering technology programs. Focusing on common elements and identifying unique features of B.S. Engineering Technology programs in both peer and aspirational institutions, a basic list of requirements, suggestions, and ideas for the program was created. Discussions within and outside the college helped to hone the list of requirements and desires for the program, which included: no barriers to entry (unlike engineering in which many courses, even introductory courses have math or science pre-requisites), a degree of curricular flexibility (to make it easier for students transferring into this program in their second year to complete a degree within their original 4-year timeframe), a focus on manufacturing,

industry-recognized credentials and certifications, and significant opportunities for hands-on learning.

Another guideline was to capitalize on the synergies of both existing programs and services and the new program. Student support services, including advising, tutoring, and career exploration and preparation opportunities are provided to all students within the college. A manufacturing service center and a student-focused maker space comprise the recently renovated and re-branded "Innovation Hub" which serves as the primary laboratory for the new engineering technology program; and two additional laboratory spaces are being renovated to support materials testing and industrial automation and PLC operations. These facilities and services are available to students in the engineering technology program. Additionally, engineering technology students are expected to participate actively in the many engineering-related student organization and competition teams and provide their unique expertise to contribute to the success of those teams.

3.0 B.S. Engineering Technology Degree Program

The new B.S. Engineering Technology degree program features a core curriculum of manufacturing, CAD, computer aided analysis, electronic circuits, industrial automation, material science, engineering economics, project management, and technical communication. Students also select two areas of emphasis from: (1) Industrial Engineering Technology, (2) Mechanical Engineering Technology, (3) Engineering Management and Entrepreneurship, (4) Energy Technology, and (5) Multidisciplinary Engineering Technology. Graduates will be trained in modern technologies and equipped with the practical skills and hands-on experience necessary to thrive in advanced technology industries. While WVU engineering degree programs emphasize theoretical concepts to design solutions for complex open-ended problems, the engineering technology degree program focuses on teaching students through practical class projects and laboratory experiences how to use the right materials, sensors, electric parts, and processes to solve broadly defined engineering problems. Both approaches to studying engineering fields are necessary to innovating effectively and efficiently to benefit West Virginians and Americans.

3.1 Program Educational Objectives

Drawing from the mission of the university and college, the needs of our constituents, and the ABET Engineering Technology criteria [2], the following educational objectives were developed. Within a few years of graduation, a B.S. Engineering Technology graduate:

- Creates value by applying the appropriate knowledge, techniques, and skills of modern tools of mathematics, science, engineering and technology to organizations through critical and creative thinking, structured problem solving, analysis, evaluation, and improvement of systems and processes.
- Communicates effectively across disciplines and cultures to influence decisions and lead activities in support of organizational goals and objectives.
- Works collaboratively as both a member and leader of cross-functional and inclusive teams comprised of members with varying experience levels, organizational backgrounds, positions, and geographic locations.

- Demonstrates ethical standards in designing and implementing innovative systems or processes taking into account social responsibility, global responsibility, and overall benefit to organizational constituents.
- On a continual basis, pursues professional development and inquiry via graduate study, continuing education and/or training and development through employer-based or industry/sector groups.

3.2 Curriculum

While the engineering technology "core" is designed to provide students with the basic skills needed for many occupations within the engineering technology field, the five areas of emphasis provide the student with the flexibility to tailor their degree to personal goals. The flexibility also permits transfer students to maximize the application of previous credit earned toward this degree to be able to complete it as efficiently as possible. Specifically, students may use previously completed engineering coursework to apply toward a related area of emphasis or toward the multi-disciplinary engineering technology area of emphasis.

Another goal of the WVU B.S. Engineering Technology program is to provide students with opportunities to earn industry approved certifications such as SolidWorks®, NIMS®, and equipment certifications. Two courses were designed to introduce and then further expand students' knowledge of 3D modeling. These courses are Engineering Graphics and Descriptive Geometry and laboratory (ETEC 210 and ETEC 210L) and Applications of Technology and laboratory (ETEC 220 and ETEC 220L). In ETEC 210 and ETEC 210L students will be introduced to engineering drawings and SolidWorks. In this introductory course, students will take the Certified SolidWorks Associate exam (CSWA). They will have two opportunities to pass the exam. The exam will be a graded portion of the lab (ETEC 210L). In the Applications of Technology (ETEC 220) course, students will continue to develop their modeling skills as well as learn about manufacturing processes that heavily use 3D modeling software such as 3D printers and laser cutters/engravers. In ETEC 220L students will have two opportunities to pass the Certified SolidWorks Professional exam which will also be a graded portion of the lab. Since these courses are first- and second-year courses, it will allow students to be more marketable when they are searching for co-ops and internships because they can add the certifications to their resumes.

3.3 Engineering Technology Student Outcomes

Upon graduation, all Bachelor of Science in Engineering Technology students will have an ability to:

1. Apply knowledge, techniques, and skills of modern tools of mathematics, science, engineering, and technology to solve broadly defined engineering problems appropriate to the discipline
2. Design systems, components, or processes meeting specified needs for broadly defined engineering problems appropriate to the discipline
3. Apply written, oral, and graphical communication in broadly defined technical and non-technical environments; and an ability to identify and use appropriate technical literature
4. Conduct standard tests, measurements, and experiments and to analyze and interpret the results to improve processes; and

5. Function effectively as a member as well as a leader on technical teams.

These outcomes correlate directly to the student outcomes defined by ABET for B.S. degrees in Engineering Technology [1].

4.0 Laboratories

One programmatic goal is to provide opportunities for students to familiarize themselves with common industrial scale manufacturing and related field equipment. This goal is achieved through a variety of laboratory experiences created in several courses. Students first must be adequately trained to operate the equipment safely and then have maximum time to use each machine to become proficient in their operation. To maximize each student's time on each machine and ensure student safety, standard operating procedures (SOPs) will be disseminated prior to each lab, students must pass a quiz on information related to the safe operation of the applicable machine before being permitted access to that machine during the lab experience. Additional instructional videos on safety and machine operation are provided for students to watch before, during, and after lab. For courses offered in the Innovation Hub once students are adequately trained on a piece of equipment, they are able to use it to complete projects during times when the Hub is open and labs are not meeting.

Through the unique "Applied Workshop" and "Technology Certification" courses students are provided additional opportunities to gain hands-on experience with specific pieces of equipment by providing technical support to student competition teams or by pursuing a certificate program, such as NIMS certification and becoming certified on a specific machine. Students are also encouraged to participate in co-ops and internships through the "Professional Field Experience" course. All students must complete at least three credit hours of "practical experience" earned through completion of one of the above-listed courses.

4.1 Manufacturing and Electronics Labs

The main laboratory for four engineering technology courses related to manufacturing processes, applications of technology, and electronic circuits is located in the recently (2020) renovated and rebranded "Innovation Hub" which combines a manufacturing service center and a student-focused maker space.

The maker space includes wood-working tools, a computer lab with a variety of engineering software, plus common manufacturing and prototyping equipment such as: manual mills, MIG welders, laser cutters/engravers, a vacuum former, a small-scale waterjet, a PCB rework system, sheet metal forming equipment, and a fully stocked electronics component wall. Students, faculty, and staff have access to training and use of this manufacturing and prototyping equipment to support research, courses, and private projects through the maker space.
The manufacturing service center houses multiple pieces of industrial scale manual and CNC machining equipment, including mills and lathes, an industrial scale water jet, a 5-axis wire EDM, a 4 ft by 8 ft CNC routing table, a large format laser cutter/engraver, PCB fabrication equipment, an array of 3D printers including FDM, SLA, DMLS, and MIG and TIG welding. This facility serves the external community by providing a manufacturing option to industry using an entrepreneurial model and supports research, courses, clubs, student competition teams, and outreach events by producing student, faculty, or staff designs at cost.

Safety is a focus in all lab courses where students will be operating equipment. Students will be expected to pass a safety exam before working in the facility and to use best operating practices within the facility at all times. Lab capacity is capped at 24 students per 3-hour lab due to facilities and faculty availability. Students, in groups of 2, will rotate to two machine-types with each group getting approximately 50 minutes. Since there are at least two machines of each type, 8 students can be in the lab at a time.

4.2 Materials Testing Laboratory

Existing space has been identified and is being renovated to create a materials testing lab to be shared by the Mechanical and Aerospace department and the Engineering Technology program. Some existing materials testing equipment will be moved to this space and a new universal tester plus an impact tester, and a fatigue tester will be added to this space along with a heating furnace. The shared lab will be used for the mechanical engineering material science courses, as well as for the engineering technology materials science with applications course.

4.3 PLC Laboratory

Space has also been identified and is being renovated to create an Industrial Automation PLC Laboratory with an industrial robot and PLC units and software. The engineering technology program plans to purchase Allen Bradley Compact Logix PLCs, associated student tool kits, Power Flex VFDs, graphic terminals, and associated software. In addition to this equipment, the program is exploring licensing Factory I/O which will allow students to gain experience with a variety of scenarios and programs in a simulated setting.

4.4 Hands-On Experiences

Additionally, the Statler College hosts approximately 100 student organizations and student competition teams that will welcome the engineering technology students. The engineering technology students bring specific skills that many engineering students do not have, so the teams are strengthened through the collaboration. For example, in the EcoCar challenge, while working together with engineering students on the car design and implementation, engineering technology students will have the additional skills to create prototype parts needed for the car. Since engineers and engineering technologists work together in a variety of roles within industry, providing collaborative opportunities to developing engineers and engineering technologists will help these students hone their collaboration skills and better prepare them for their future careers.

The “Application Workshop” course (ETEC 370) provides the formal structure for active engagement on student competition teams related to engineering and engineering technology. Through this course, students earn credit by applying their skills to solving large challenges and by practicing teamwork, professionalism, engineering ethics, and technical problem solving in a real-world setting. The setting can be within an engineering competition team or within an industrial setting through an internship or co-op experience. This one credit course can be repeated up to three times to meet the 3-credit “application” requirement of the B.S. Engineering Technology degree. The 3-credit “application” requirement may also be met through the one-credit course, Technology Certification (ETEC 450), in which the student is supervised in pursuing and earning industry approved certification on a skill (like welding), a piece of equipment, or process. These certifications may be tailored to the students’ career goals.

5.0 Challenges & Future Plans

Because of the interdisciplinary nature of the various areas of emphasis, support had to be garnered from four Colleges within the university: Engineering and Mineral Resources; Agriculture, Natural Resources and Design; Arts and Sciences; Business and Economics. Negotiations related to course capacity, offering frequency, and pre-requisites were necessary to ensure students in the B.S. Engineering Technology program had sufficient course offerings in each area of emphasis.

Cost is a perpetual challenge in the university landscape nationwide. While initial investments are being made in faculty hiring and laboratory renovation, additional funding is begin sought from a variety of sources to support additional equipment, materials, and on-going maintenance and operation costs.

As with all new programs, many "unknowns" exist and create challenges for those planning and implementing these programs. For example, since the program was fully approved in February 2023, recruitment for the inaugural class in fall 2023 has a short timeline. Getting the word out to current and prospective students in this short time frame is a challenge. Staffing the program when enrollment in unknown is an additional challenge. With class size limitations created by existing lab space, planning the number of course sections (and associated staffing) is a challenge as well.

The faculty planning this program, fortunately, have the support of the College Dean and the Provost office which is helpful as they continually adapt to a very fluid situation. The excitement of creating a new program, however, encourages them to continue pushing forward to meeting the goal. In future papers, we hope to present the results of this planning – the data related to the first year or more of implementation.

6.0 References

[1] O*NET Online. https://www.onetonline.org. Accessed 04/07/2023.

[2] Criteria for Accrediting Engineering Technology Programs, 2022-2023. ABET https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-technology-programs-2022-2023/. Accessed 02/26/2023.