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Project-based Approach to Engineering Technology Education

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Abstract

The paper contains an overview of the history of engineering education in the United States. It also explains the differences between engineering and engineering technology from an historical perspective. The similarities and differences between those two programs are also being addressed. The article also explains the concept of the project-driven approach in teaching engineering technology courses. The procedure to secure and administer funding for the projects is also addressed. The paper also includes some practical guidelines for implementing a project-based approach.

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1. Introduction

Engineering is an application-focused discipline. It used to be very practical. Before the Engineering programs at the university-level were created, engineers were trained in a trade-apprenticeship program. Designing, analyzing and building an invention was done by the same person or team under the supervision of the master. The first engineering school in the United States (USA) was the West Point Military Academy. (Thaddeus Kosciuszko was one of the founders of that school. The engineering curriculum focused on military applications. It blended military theory and practice. In the early 19th century, engineering was important in civilian applications. There was a need for roads and bridges as well as city infrastructures. C*ivil Engineering* (civilian engineering concept) was created. Many engineering schools were created, for example, Cornell (1830's), Union College (1845), Yale (1852) and Massachusetts Institute of Technology, MIT, (1865) (Grebski and Grebski, 2016). The invention of the steam engine and the Industrial Revolution generated the need for mechanical engineers to design and build farming equipment, water pumps for the mining industry, etc. The chemical industry as well as the use of electric power started the more modern era of the engineering profession. During World War II, many new technologies were developed in the late 1940's and early 1950's. The automobile industry was booming and there was a need for more modern roads and an interstate highway system. At the same time, commercial aviation was developing. Engineering, however, was still a very practical profession, but it was being criticized for being too practical and not scientific enough. In the mid-1960's, President John Kennedy revealed his plan for landing on the moon. Engineering programs were criticized for being too practical and not theoretical enough. By the 1970's, engineering programs in the USA were coming very scientific and theoretical. While the engineering programs were becoming very theoretical, there was a need in industry for practically trained professionals. To satisfy this need, many educational institutions started Engineering Technology programs for the purpose of training hands-on engineers. Many educational institutions in the USA offer simultaneously Engineering and Engineering Technology programs targeting two different job markets. There is a significant overlap between the Engineering and Engineering Technology curricula.

2. Distinction between Engineering and Engineering Technology Programs

Both programs in the United States, Engineering and Engineering Technology, are accredited by the Accreditation Board of Engineering Technology (ABET). However, ABET has two different commissions. They are the

1) Engineering Accreditation Commission (EAC) and

2) Technology Accreditation Commission (TAC)

The accreditation criteria for both programs are different. The difference in the accreditation criteria reflects the nature of the differences between those two programs. Engineering programs focus on theory and design. Engineering Technology programs specialize in application and implementation.

Table 1 demonstrates the spectrum of the technical job functions.

There is some overlap between engineering and engineering technology. It mainly in product design, product testing and evaluation. Engineering programs are more mathematical and include more advanced Math and Science courses. Table 2 demonstrates the differences between the Math and basic Science requirements for the Engineering and Engineering Technology programs.

Table 1. Spectrum of technical job function

Engineering									
				Engineering Technology					
Research	Complex Analysis	Complex Design	Development	Testing and Evaluation	Product Design	Manufacturing	Production	Operation, Service and Maintenance	Distribution and Sales
More theoretical									More application

Table 2. Curricula requirements in foundation courses

Engineering Requirements (United States)		Engineering Technology Requirements (United States)	
Mathematics		Mathematics	
MATH 140	Calculus I	MATH 22	Geometry and Trigonometry
MATH 141	Calculus II	MATH 26	Pre-calculus
MATH 251	Differential Equations	MATH 140	Calculus I
MATH 231	Calculus of Several Variables	MATH 141	Calculus II
MATH 220	Matrices		
Physics		Physics	
PHYS 211	Mechanics	PHYS 150	Mechanics
PHYS 212	Electricity and Magnetism	PHYS 151	Electricity and Magnetism
PHYS 214	Quantum Mechanics		
Chemistry		Chemistry	
CHEM 110	General Chemistry	CHEM 110	General Chemistry
CHEM 111	Chemistry Lab		
CHEM 112	Organic Chemistry		

According to the ABET accreditation criteria, there is also a difference in faculty basic credential requirements for the Engineering and Engineering Technology programs. Faculty teaching in Engineering Technology programs need to have extensive industrial practical experience. Faculty teaching in Engineering programs do not need to have practical industrial experience, but they need to have significant research and scholarly accomplishments. Faculty teaching in both programs need to meet the minimum criteria requirements for both programs.

3. Project-driven Curriculum in an Engineering Technology Program

Engineering technology programs are focusing on knowledge application and implementation. Project-based learning is the most appropriate method of instruction in this type of curriculum (Ulewicz, 2014; Ulewicz, 2017). Project based learning is an active learning method (Tuia et al., 2009; Kvam, 2000; Alabanese, 2000) which can make students self-motivated and active learners through the process, result, and analysis of the problem. Students can be naturally exposed to the teamwork environment and fully exercise their classroom knowledge into the real field application (Alabanese and Mitchell, 2000; Kvam, 2000; Ayutthaya and Koomsap, 2017)

The authors of this paper have introduced two projects to first and second-year engineering technology students. The projects were linked to the curriculum in Mechanical Engineering Technology at Penn State Hazleton. The design and development of an experimental airplane and a solar powered car have proven to be very challenging and highly motivating for the freshmen and sophomore students. To design and build the experimental airplane, students used the specifications developed by the instructors. They analyzed the feasibility of a full-scale experimental airplane and designed the airplane based on their analysis. In the case of a solar powered car, students were involved in designing a chasse, suspension, power transmission and steering system from a conceptual design to the implementation of hardware. As an example, they decided the specifications of each component. In the case of the motor, students estimated how much horsepower was required to operate the solar powered car, and how many solar panels were needed to charge the battery in order to achieve a real-time continuous operation.

The projects continued through the next academic year with a different group of students. Those students reviewed the previous design and worked to improve or modify it according to their analysis. Students used their knowledge from the classroom such as statics, dynamics, strength of materials, machine design, and so on. By applying the continuous design improvement process semester by semester, the instructors accumulated a history of the students' designs.

4. Design Projects as an Element in Joining Individual Courses

Very often in the engineering technology students are taking individual courses without the ability to cross reference the knowledge from one course to the other (Nitkiewicz and Ayen, 2018). The students are viewing these individual courses as disjointed pieces of a puzzle. Most students do not see the "bigger picture" of the body of knowledge until they gain some industrial experience and get the opportunity to apply the knowledge that they had learned in their academic courses. The "project driven curriculum" allowed the students to see this "bigger picture" rather than the individual pieces of the puzzle (Sheppard and Gallois, 2002). As part of the Penn State Hazleton Mechanical Engineering Technology program, projects were introduced during the fall semester of the freshman year (Cai and Grebski, 2011,). These projects were being introduced in the Engineering Design and Graphics course. The project topics were selected to provide a comprehensive approach to engineering design and required knowledge of statics, dynamics, strength of materials, machine design, tool design, manufacturing processes, etc. The last two projects which were introduced were designing and building a solar powered car and designing and building an experimental aircraft. These projects were very successful in capturing the students' interest as well as increasing the students' motivation. In addition, the scope of the projects allowed them to be linked to all courses in the Mechanical Engineering Technology curriculum. Fig. 1 shows how the projects link to the individual courses in the Mechanical Engineering Technology program. In the Engineering Design and Graphics course (where the project was introduced) the objectives and specifications of the designs were developed. Then students worked on developing a list of tasks which needed to be completed during the designing process as well as during the process of building a prototype. The engineering faculty who were working with the students helped them to link the individual tasks to all the technical courses in the Mechanical Engineering Technology curriculum (Undergraduate Degree Programs Bulletin of Pennsylvania State University) (Fig. 1).

Project funding was secured through fund raising initiatives with local industry. A number of companies provided either financial or in-kind contributions by donating materials or labor. The building of the prototypes was done in co-operation with the local vocational-technical schools. The local vocational-technical schools were better equipped in terms of the tools needed to build the prototypes. The administration of funds and purchasing of materials was handled by the engineering faculty who are teaching in the Penn State Hazleton Mechanical Engineering Technology program.

The abbreviation and name of courses (Undergraduate Degree Programs Bulletin of Pennsylvania State University) related to the projects are below:

1) EDSGN 100: Introduction to Engineering Design
2) EGT 114: Spatial Analysis and Computer Aided Drafting
3) EGT 201: Advanced Computer Aided Drafting
4) MCHT 111: Statics
5) MCHT 213: Strength and Properties of Materials
6) MCHT214: Strength and Properties of Materials Laboratory
7) MET 206: Dynamics and Machine Elements
8) MET 210W: Product Design
9) IET 101: Manufacturing Materials, Processes and Laboratory
10) IET215: Production Design

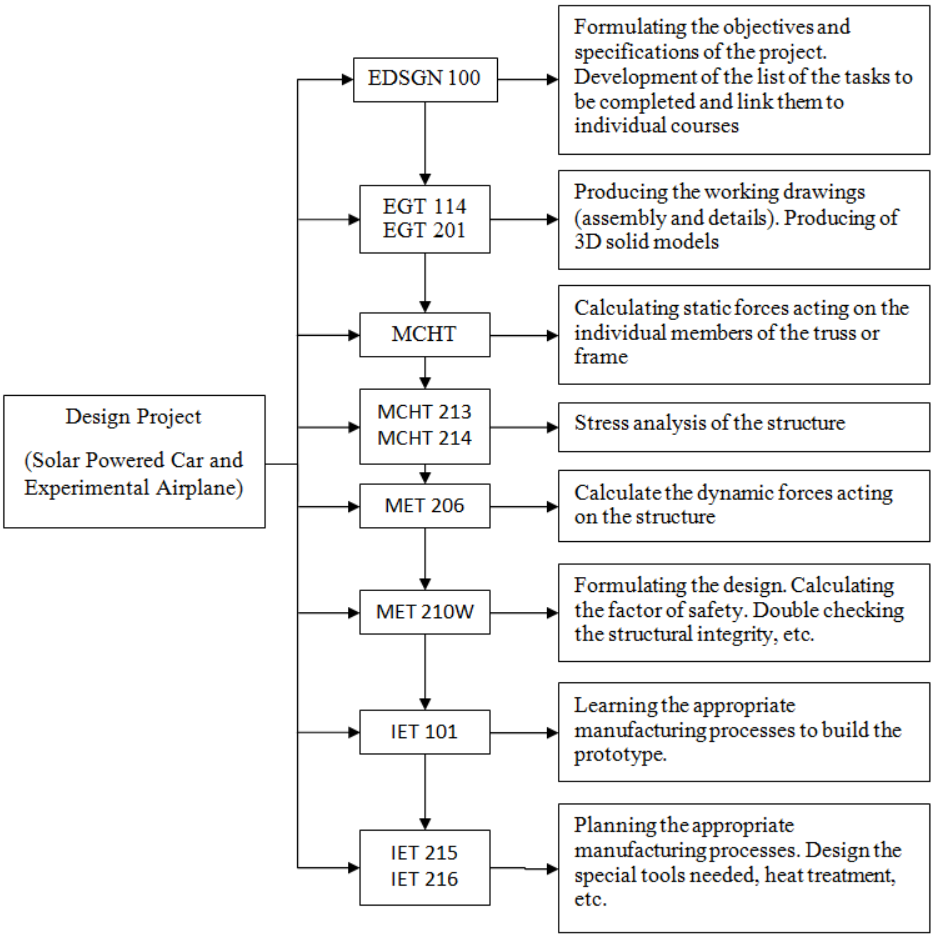

Fig. 1. Project related activities linked to the MET curriculum

The prototypes for both projects are shown in Fig. 2 and Fig. 3.

Fig. 2. Experimental aircraft designed and built by students

Fig. 3. Solar-powered car designed and built by students

5. Conclusion

This project-based approach was found to be a very effective method for teaching engineering technology courses in the Mechanical Engineering Technology program at Penn State Hazleton.

The authors of this presentation have noticed an increase in the students' motivation and performance. The project-based approach also provides opportunities to expose students to a teamwork type of environment as well as addresses the need for lifelong learning.

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基于项目的工程技术教育方法

關鍵詞
PBL
教育
工程

摘要
本文概述了美国工程教育的历史。它还从历史的角度解释了工程技术与工程技术之间的差异。这两个程序之间的异同也正在解决中。本文还解释了工程技术课程的教学中项目驱动方法的概念。还讨论了确保和管理项目资金的程序。
本文还包括一些实施基于项目的方法的实用指南。