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Technical Project Management Course for Engineering Technology Students

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Abstract

Industrial Engineering Technology curriculum generally provides wide spread knowledge in problem solving, management of resources, and process planning. Project Management is a key skill required by Engineering Technologists, who work in project-driven manufacturing companies. Thus, it is imperative to prepare graduates of engineering technology programs to include a course on project management. An Industry Advisory Council for a university in Louisiana expressed the need for project management trained graduates, and worked with the department faculty to develop a course on technical project management. The developed course is offered as part of a new post-baccalaureate certificate program at the university.

This paper discusses the development of a project management course tailored to Engineering Technology. It starts by identifying the need for project management knowledge and skills. After that it discusses the key components for project management body of knowledge as identified by the Project Management Institute. These components led to identifying relevant course topics to include: Introduction to Project Management, Engineering Economic Analysis, Project Selection, Project Organization, Project Scheduling, Resource Management, and Project Control. It confers efforts related to identifying a suitable textbook, and challenges faced in incorporating hands-on activities in course content. The developed course combines traditional lectures with case studies and places equal emphasis on theory and applications for project management. Furthermore, the developed course is used for instructing project management face-to-face and online, hence the paper discusses adaptations of content to facilitate delivery in these different environments. The paper concludes by providing directions for future development of the course.

Introduction and Background

The National Academy of Engineering forecasts that engineers and technologists will continue to operate in a rapidly changing innovation environment[1].This is compounded by globalization of economies, diversity of social and business groups, multidisciplinary research trends, and cultural and political forces. Engineering systems are of increasing complexity in energy, environment, food, product development, and communications[1]. Hence, it is imperative to introduce engineering and technology practices in undergraduate education, where students can experience the iterative process of designing, analyzing, building and testing. There is a growing importance for engineering practice, but the engineering profession seems to be held in low regard compared to other professions and industry tends to view engineers and technologists as disposable commodities[2].

Industrial Engineering Technology prepares "graduates with the technical and managerial skills necessary to develop, implement, and improve integrated systems that include people, materials, information, equipment, and energy[3]". To do so, a typical Industrial Engineering Technology curriculum provides widespread knowledge in problem solving, management of resources, and process planning. The specific ABET ETAC student outcomes for Engineering Technology are[4]:

a. An ability to select and apply the knowledge, techniques, skills, and modern tools of the discipline to broadly-defined engineering technology activities
b. An ability to select and apply a knowledge of mathematics, science, engineering, and technology to engineering technology problems that require the application of principles and applied procedures or methodologies
c. An ability to conduct standard tests and measurements; to conduct, analyze, and interpret experiments; and to apply experimental results to improve processes
d. An ability to design systems, components, or processes for broadly-defined engineering technology problems appropriate to program educational objectives
e. An ability to function effectively as a member or leader on a technical team
f. An ability to identify, analyze, and solve broadly-defined engineering technology problems
g. An ability to apply written, oral, and graphical communication in both technical and non-technical environments; and an ability to identify and use appropriate technical literature
h. An understanding of the need for and an ability to engage in self-directed continuing professional development
i. An understanding of and a commitment to address professional and ethical responsibilities including a respect for diversity
j. A knowledge of the impact of engineering technology solutions in a societal and global context
k. A commitment to quality, timeliness, and continuous improvement

The emergence of non-traditional education providers (such as online and hybrid) poses challenges for US higher education institutions. To remain competitive, US universities should re-adapt the way education is delivered, and develop curricula that meets the core competencies required in the market place[5]. At a time when local, state, and national resources for education are becoming increasingly scarce, expectations for institutional accountability and student performance are becoming more demanding. There is a need for more educational innovations that have a significant impact on student learning and performance[6].

At least 6 members of an engineering technology department's industry advisory council at a University in Louisiana approached the department with a need to develop a new course on project management. The university administration showed support to develop a new course, and it was offered for the first time in less than one year (Fall 2015). According to long term projections for industrial production managers, the need for managers in industrial situations is 2170/year until 2022. In the Louisiana Workforce Commission's Five-Star Jobs listing, there are approximately 300 advertisements for supervisors, inspectors, controller, and industrial technician advertisements[7] (accessed on 7/14/2015). With this new course, it is expected that graduates with an Industrial Engineering Technology degree will be able to fill a number of project management related positions.

This research takes a pragmatic approach to develop a course on technical project management to be used as an elective for an Industrial Engineering Technology Program at a University in Louisiana. The paper proceeds by discussing the method used to carry out the research. After that it provides a summary of the results. The paper concludes by a discussion of the key findings and provide directions for future development of the course.

Method

This paper uses a case-study approach. The curriculum of an Industrial Engineering Technology program from a university in Louisiana is selected. A faculty team of the Engineering Technology department reviewed the university documentation and catalog information (including course descriptions and dependencies, course syllabi, course competencies, and course assignments) to develop a curriculum map in flowchart format. The faculty team studied the body of knowledge provided by the project management institute and researched similar courses on project management available nationwide. The analysis revealed the topics to include in a new course on "Technical Project Management". Finally, the department faculty worked with the industry advisory group and the institution curriculum review committee to establish the new course.

Results and Discussion

The selected Industrial Engineering Technology program has both major and support courses to prepare graduates for technical and supervisory careers in a variety of industries. The program combines technical knowledge with communications skills and teamwork to provide the flexibility needed in today's rapidly changing marketplace. Figure 1 depicts an as-is curriculum map of the selected Industrial Engineering Technology program. The selected program educational objectives are:

- Demonstrate technical proficiency in the field
- Apply quantitative reasoning and critical thinking in solving technical problems
- Effectively communicate technical knowledge, ideas, and proposals to others, including upper management
- Lead project teams in successful completion of projects
- Have strong organizational and management skills

A brief description of some of the courses is as follows (as an example):

- Electrical Principles I: Principles governing current, voltage, resistance and power in DC circuits. Series-parallel and series-parallel circuits. Network theorems.
- Electronic Fabrication Lab: Fabrication techniques for analog and digital circuits. Device symbols and markings, soldering, antistatic techniques, measurement, testing and troubleshooting.
- Electrical Principles II: Alternating current. Capacitors, inductors, and impedance. AC circuit analysis theorems and techniques.
- Engineering Tools and Dimensional Analysis: Principles and practices of measurement technology; use of tools; dimensional analysis; and the use of all the above in applications of technology.
- Technical Drafting I and II: Introduction to drafting, with computer-aided drafting (CAD) applications. Orthographic projection, geometric construction, sectioning, dimensioning, auxiliary views, and text.

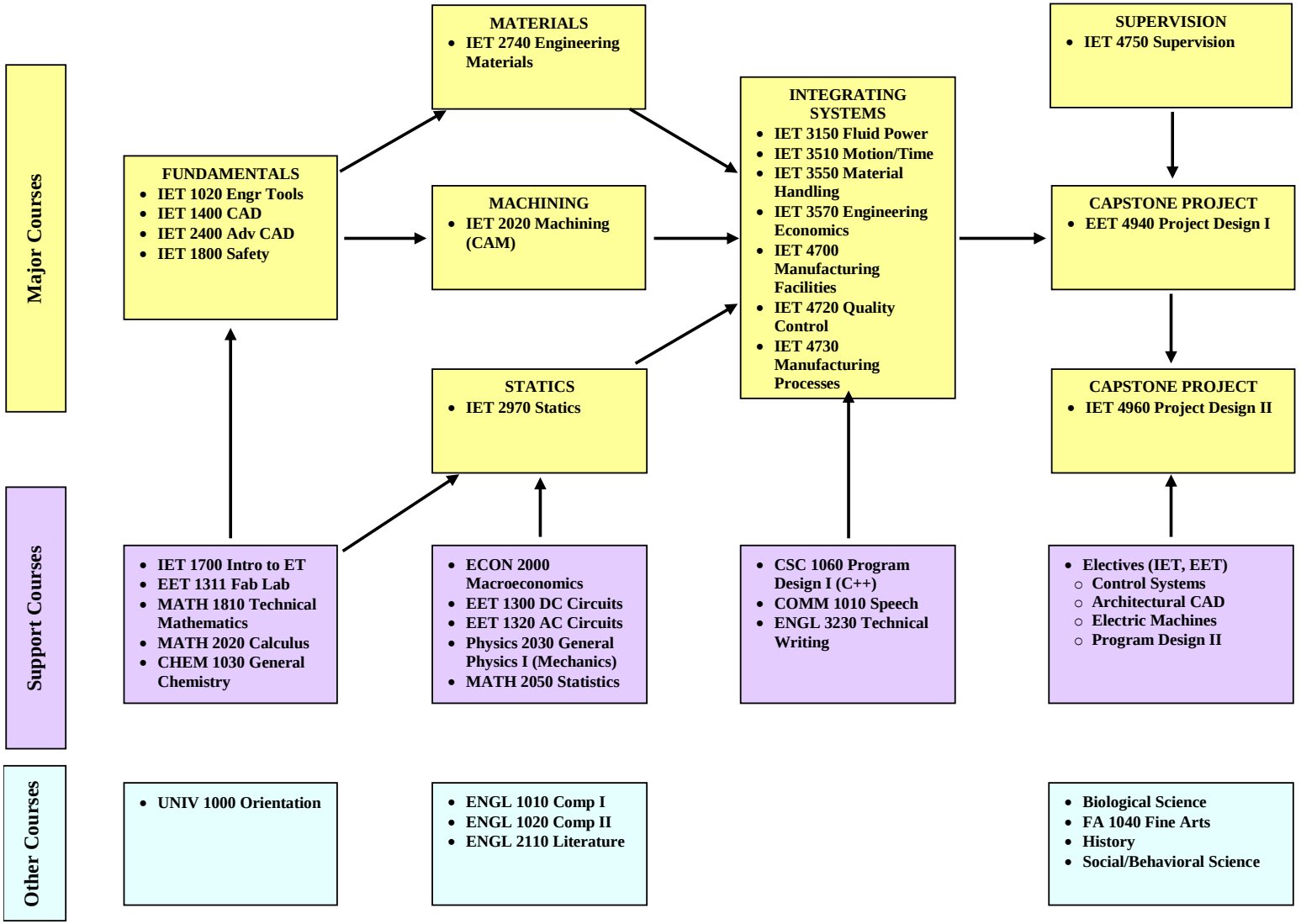

Figure 1. As-Is Curriculum Map of Selected Industrial Engineering Technology Program

- Introduction to Engineering Technology: Specific information for engineering technology students about degree requirements, scholastic resources, careers in engineering technology, job opportunities, academic skills for success in engineering technology, scholarship, and preparing for the future.
- Occupational Safety and Health: Principles and practices of accident prevention and safety program operation in industrial facilities and school laboratories; effective safety organization, management and supervision; teacher, administrator and management liabilities; Occupational Safety and Health Act (OSHA).
- Metals Machining I: Machine tool technology; operator control and computer numerical control (CNC) machining, computer-aided manufacturing (CAM), and production centers. Survey of nontraditional machining processes.
- Engineering Materials: Methods of making basic engineering materials; phase diagrams; crystalline lattice structures; material properties; methods for changing material properties.
- Statics: Principles of statics, vector algebra and vector quantities. Resultants in coplanar force systems, equilibrium in coplanar force systems, analysis of structures, trusses, beams, chains and cables, friction, centroids and centers of gravity, moments of inertia.\
- Fluid Power: Compressible and incompressible fluid statics and dynamics of industrial hydraulic and pneumatic circuits and controls. Software and functional components used to design, construct, and analyze piping circuits.
- Motion and Time Study: Analysis of motions necessary to perform industrial operations; motion economy; development of ratings, allowances, standard data, formula construction, work sampling, wage payment and performance training.
- Material Handling: Material handling as related to manufacturing, warehousing and distribution centers. Topics include methods of movement, storage, inventory control, and retrieval.
- Engineering Economics: Principles and applications of economic analysis presented through engineering-oriented examples. Introduction and definitions of economic factors, analysis methods for evaluating alternative choices, and decision making tools for real-world situations.
- Manufacturing Facilities: Study of the planning processes for facilities location and design, material handling equipment, and manpower requirements. Analysis of production line requirements, assembly line balancing, and automation.
- Quality Control: Methods and procedures employed in industrial quality control, theories of measurement, error, prediction, sampling, tests of significance and models.
- Manufacturing Processes: Design, economics, and control of manufacturing processes. Methods engineering, job shop and automation practices; machining and fabrication processes.
- Elements of Occupational Supervision: Preparation, training, and problems of the supervisor.
- Project Design I: Principles of project management and engineering economics. Development of proposals for senior design project.
- Project Design II: This is a capstone course for engineering technology majors. Students will work with a professor to design a project that reflects several aspects of the student's

curriculum. Group work. Students will prepare a written project report and give an oral presentation.

The project management institute defines project management as "the application of knowledge, skills, tools, and techniques to project activities to meet project requirements[8]". To do so, project managers need to be proficient in managing the various project stages[9]:

1) Initiating
2) Planning
3) Executing
4) Monitoring/Controlling
5) Close-out

Several universities nationwide have courses on project engineering and project management, such as Texas A&M, Harvard, Carnegie Mellon, and University of North Carolina. Table 1 provides a summary of some surveyed courses on project management (as an example).

Table 1. Existing Courses on Project Management

University	Project Management Course Information
Texas A&M[10]	**TMGT 458- Project Management** Textbook: Kerzner, H. Project Management: A Systems Approach to Planning, Scheduling, and Controlling, 10th ed. Course Objectives: • Recognize issues in a realistic project scenario. • Employ work breakdown structures (WBS) in a project application. • Demonstrate the use of appropriate network scheduling techniques. • Produce a project proposal. • Discuss the implementation of a proposed plan.
Harvard[11]	**MGMT E-5030- Project Management** No textbook, but the course introduces the tasks and challenges fundamental to project management, the vital function of managing complex projects across multiple functions. Course Objectives: • Understand and employ project management strategy design, development, and deployment • Utilize project management tools, techniques, and skills • Align critical resources for effective project implementation • Understand the implications, challenges, and opportunities of organizational dynamics in project management • Identify and utilize key performance metrics for project success

	• Improve cost, quality, and delivery with efficient and effective project management processes • Deploy and lead high performance project management teams in your organization • Impart project management knowledge, tools, and processes to your colleagues • Create Project Management Office (PMO) architecture in your organization • Recognize and mitigate the early seeds of failure in the project life cycle
North Carolina[12]	**67-326: Global Project Management** Textbook: Articles and Cases (links will be provided or cases distributed); Guide to Case Analysis (Discussion of Preparing, Discussing, Presenting Cases - UC, Santa Barbara) Course Objectives: • Understanding of projects, their formation, and follow-through. • Understanding of the different types of project-based organizations • Understanding of project management tools. • Dealing with real-world problems and the people associated with them. • The ability to transfer knowledge gained in this course to a production work environment.

As a result of reviewing the body of knowledge provided by the project management institute and similar courses on project management available nationwide, the selected engineering technology department developed a new course on technical project management that discusses the following topics:

Part 1: Project Development
a. Basic Project Structure
b. Initiating Process
c. Planning Process

Part 2: Project Schedule Analysis
a. Activity Definition
b. Activity Sequencing
c. Resource Estimating
d. Activity Duration Estimating
e. Schedule Development

Part 3: Project Cost Analysis
a. Cost Estimating
b. Budget Development

Part 4: Project Monitoring and Control
a. Schedule and Cost Monitoring
b. Schedule and Cost Control

The department then proceeded to selecting a suitable textbook for a first introduction to project management tailored to Industrial Engineering Technology students, the following criteria were used for textbook selection:

- Alignment to Project Management Institute Body of Knowledge
- Balance between theory and application of project management
- Availability of Case Studies
- Availability of instructor resources

As a result, the following textbook was adopted: Goetsch, D. L. (2015). Project Management for Engineering and Technology. ISBN-10: 013281640-7. ISBN-13: 978013281640-3. Pearson.

After that, the department proceeded with the paperwork to add a new course to the university catalog through the institutions' curriculum review committee. Due to the university administration's support of the new offering and the possibility of including it in new certificate programs, the course was approved upon submission (less than 1-year).

Then, it was offered for the first time face-to-face in fall 2015, where 11 engineering technology students enrolled in the course as an elective. The end of course evaluations for the course were promising (all categories had means of 4.5 and above on Likert scale; with 1 being Never and 5 being always; 4 students provided feedback):

- Learning objectives for this class were clear.
- The material covered in this class agreed with the learning objectives.
- Assignments and tests aligned with the class material taught.
- The amount of work for this class was appropriate.
- The grading policy for this class was cleared stated.
- The learning environment for this class was acceptable.
- This class was intellectually stimulating.
- Consider this course: Overall, I would rate this course as ...

Some students provided narrative comments pertaining to the provided course, such as:

- "Gave many real life relations to the topics, and had many examples. Was always willing to help students one on one".
- "The instructor took the initiative to give extra material that help me better understand the lessons given".
- "Fully met my expectations. The content was intriguing and given very well".
- "My expectations were met because my interest in the course grew".
- "The instructor did a wonderful job teaching this course. It has many concepts that can be put to use in my field".

The department is in the process of building a course shell for offering the developed Technical Project Management course online. The course shell will include:

- Interactive case studies
- Interactive assignments
- Interactive quizzes
- Interactive discussions
- Face-to-face time with the instructor through WebEx or Skype on weekly basis

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