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Project Management as an Active Component of the Aeronautical Engineering Technology Program

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Abstract

The days of the specialized engineer, toiling away in his cubicle or laboratory and focusing exclusively on solving prevailing technical challenges, are fast dwindling. Modern economic realities require a whole new model and mindset for the modern engineer. In the era of "right-sized" corporations, the engineer must assume more responsibilities and wear more occupational hats than ever before. Of all of them, perhaps the one role he or she is least equipped to fulfill is that of project manager. Irrespective of the individual engineer's

Introduction

Many non-engineering industries do not need to concern themselves intimately with the distribution of various project tasks in accordance with individual employee backgrounds, because the tasks are more homogeneous as a result of the non-technical nature of the projects; there are not necessarily both "hard" engineering technical tasks and more ubiquitous project deliverables such as budgets, timelines, resource and responsibility matrices, risk assessments, etc. While both

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preparedness for this additional responsibility, there is no escaping that this is the role today's engineering field has in store for him or her. One of the prevailing causes behind the typical engineer's relative inability to perform as a de facto project manager is the widely-held belief that, while engineering requires a rigid roster of "hard" skills and formal education, project management is more of a "soft" science that requires no additional structured training. This conception is firmly ensconced both in the corporate environs and in the modern academic institution. The latter point is easily demonstrated by a quick perusal of the typical engineering or engineering technology curricula: A brief review will reveal that the number of courses with titles or subject matters such as budgeting, time management, work planning, negotiation, etc., is extremely limited. Yet such preparatory training is essential if the engineer is to be ultimately responsible for all aspects of the final project delivery, and not simply the technical efficacy of the project. By its nature, engineering has an intrinsic framework imposed by the laws of physics, structural and material limitations, etc. By contrast, project management can be much more nebulous and is often permitted to remain so during the course of many modern corporate and industrial engineering efforts. This ambiguous state of the project management effort often results in a "sink or swim" approach, wherein the engineer attempts to deliver all budgetary, administrative, and personnel requirements associated with a project while simultaneously trying to concentrate on the essential technical details of engineering development. The need for integration of project management training and non-technical "real world" scenarios into undergraduate engineering and engineering technology education becomes still more apparent when one considers the ever more prevalent consultant or contract engineering business model, which lives or dies by the accuracy and accountability of its project management methods. The authors of this paper undertook to introduce certain key project management fundamentals and tools into portions of Purdue University's Aeronautical Engineering Technology program.

Keywords: Engineering Technology program, capstone design course, project management

technical and non-technical projects encompass fundamental skills such as writing, reading, and complex decision-making and problem-solving (Cassidy, 2006), it is well understood that additional "hard" aspects of a given project such as design details, materials, drawings, and prototypes are within the typical purview of the modern engineer. This expectation constitutes a major influence on customary engineering and engineering technology course content.

This influence causes project engineering "soft deliverables" to be considered generally less important and consequently less well understood in both academic and industrial surroundings. Given that in her research Cotton found that most employers prefer those "soft" skills (also called "employability skills") to specific technical skills (Cotton, 2001), it is essential that this gap in the average engineering student's training be addressed by the formal introduction of key project management concepts into engineering and engineering technology undergraduate curricula.

The tacit neglect of "soft" project management skills continues unabated from the classroom to the boardroom, laboratory, and industrial plant floor; it does not require undue consideration to conclude that a project must be delivered on time and within budget. As a result, technical project stakeholders and team members may tend to relegate these concerns to the background, while concentrating their efforts on solving engineering problems and making complex design decisions. While this is a natural outcome of engineering training and technical project demands, it can have potentially disastrous consequences if a project is allowed to proceed into the execution stage of the project life cycle without periodic examination of budget, timeline, resource allocation, and other fundamental project management components. The situation is exacerbated as modern streamlined workforces dictate that fewer and fewer non-technical essential personnel are assigned to any project.

This situation has created a gap in contemporary engineering education methodology. In addition to current economic conditions, engineering educational deficiency in this specific area is further complicated by certain pervasive assumptions about the nature of project management (Project Management Institute, 2008) that contrast sharply with widely accepted suppositions about the engineering process. Industry in general and the engineering community in particular hold the belief that the archetypal engineer is already fully equipped via his technical background to handle such diverse problems as insufficient training, unrealistic deadlines, insufficient resources, personality conflicts, uncontrolled project scope expansion, miscommunication, lack of project stakeholder buy-in, etc. Engineers, often as a result of an excessively varied workload and conflicting priorities, tend to be engaged in a "sink or swim" approach to project management, through which they hope to resolve all such outstanding issues as an incidental result of the engineering design process.

Regardless of the engineering student's particular area of specialization, the need for integration of project management training and non-technical "real world" scenarios into each engineering or engineering technology discipline is critical; the financial stability of contractors, Original Equipment Manufacturers (OEM), contract engineering firms, and system integrators depends on the application of project management tools and methodologies throughout the project life cycle. Proposals and contracts must be based on carefully formulated cost estimates and risk assessments. Work Breakdown Structures and Resource Allocation Matrices are superb tools for ensuring that a project has sufficient resources and achievable objectives. Following project launch, the engineer must apply reactive and predictive control point management to keep the project on track. Such assessments must be married with engineering subject matter expertise throughout the project to have any validity. It is essential that the engineer have sufficient background and education to be both accustomed to and comfortable with the synergy of these concepts in practical application.

Proposed changes and additions to the aeronautical engineering technology program

Since the 1960s, American universities have systematically reduced application-based laboratory course content, and have instead focused more exclusively on research and upon the decrease of the total number of credit hours in their curricula. More recently, this effort has manifested itself in the reduction or complete elimination of course content devoted to the management and timely conclusion of hard engineering deliverables. In their research, McMasters and Matsch (1996) demonstrated the resultant negative impact on engineering graduates. Specifically, they noted that

> Too few of our engineering graduates have an adequate understanding of how to manufacture anything. Fewer still seem to understand the process of large-scale, complex system integration which characterizes so much of what we do in our industry, and it has become increasingly clear to us in industry that the curricula in most of the major universities in the United States overemphasize engineering science at the expense of engineering practice [(p. 3).]

In 2008, to address this issue and fulfill the requirements of ABET, three new design and manufacturing capstone courses were added to the existing curriculum of the Aeronautical Engineering Technology program in Purdue University's Department of Aviation Technology: AT408, Advanced Manufacturing Processes; AT496, Applied Research Proposal; and AT497, Applied Research Project (Dubikovsky & Kestin, 2011). The intent was to create a program that would enable graduates to work in a team environment, efficiently manage all components and phases of the project management life cycle, have the skills and expertise to make critical decisions, and effectively communicate with "pure" engineers (Vlasman, Dubikovsky, Schwartzkopf, & Vallade, 2009). Students are intended to gain extensive hands-on experience, a basic theoretical knowledge in engineering, and a practical project management skill set. The objective is to provide graduates of the program with opportunities to fill entry-level positions at aerospace companies as design, project, and liaison engineers and as technical support personnel. In addition, the program's courses were designed to equip students for future growth into management positions. Inherent in this objective was a timeframe of promotion to management within two to five years following matriculation. Further evidence for the effectiveness of such an approach is shown in the research of Volkwein, Lattuca, Harper, and Domingo (2006).

The AT408 course introduces the students to the design process and requires them to create working instructions, process sheets, and drawings, which eventually provide the guidelines they need to manufacture, assemble, and test components. In AT408, the students are required to use the Six Sigma (Define, Measure, Explore, Develop and Implement [DMEDI]) methodology to create a new product, starting with a defined need and ending with a physical assembly. The Define Phase of the DMEDI process contained in this course permits the undergraduate students to better understand the research needs of the whole department, and to lay the groundwork for real-life projects with outside industrial and academic partners. The student teams then complete the other four DMEDI phases with guidance and mentoring from the instructor. The course's major milestones are composed of three oral reviews: the conceptual design review (CDR), the detailed design review (DDR), and the final presentation. These are presentations in which each student team reports its findings and provides project status updates. During the most recent two semesters, the course was even further refined; AT408 students worked in collaboration with students taking AAE454, Design of Aerospace Structures, at the School of Aeronautics and Astronautics (AAE) at Purdue University (Dubikovsky, Grandt, Goodrich, & Sterkenburg, 2010). AAE students provided "consulting" support to the AT students, with preparation of such documents as Requests for Consulting Services, Statement of Work, etc. Faculty members from the School of Aeronautics and Astronautics were extensively involved with these efforts.

In AT496, students are required to use the Six Sigma (Define, Measure, Analyze, Improve, Control [DMAIC]) methodology to improve an existing process, product, or service, starting with a defined need. During the course of one semester, the students finish the Define phase of their projects and start to investigate the Measure phase. The final deliverables of this course are a proposal and a poster, which could eventually be used for students' presentations in research forums.

In AT497, students are introduced to the DMAIC methodology to improve an existing process, product, or service, starting with a defined need to improve a product. The students continue at the Measure phase of the projects they started in AT496, and then complete the other three DMAIC phases under the course instructor's tutelage. This re-emphasizes and continues the undergraduate students' introduction to the real-life research needs of the whole department that began in AT496.

Classroom activities in the aforementioned courses are intended to introduce students to project integration management methodology and the overall project life cycle, as defined by the Project Management Institute's (PMI's) Project Management Body of Knowledge (PMBOK) Guide. The class context clarifies the natural intersection between Six Sigma techniques and PMI methodologies and teaches students to blend these tools during project development and management. This blended application is considered to be industry best practice, and familiarity with this practice will prove valuable to students over the long term.

Successful completion of the course is measured by the students' ability to deliver the project management elements associated with each phase of the project life cycle, which are defined in PMI's Project Management Processes (Project Management Institute, 2008). These include, but are not restricted to, the following:

1. Project Initiation Process: Statement of Work (SOW), Project Charter, Designation of Project Stakeholders
2. Project Planning Process: Project Management Plan, Project Scope, Requirements, Project Schedule, Communication Management Plan, etc.
3. Project Execution Process: Issues/Technical Resolution Log, Project Tracking/ Rebaselining, etc., Status Reports, Budgetary Updates, etc.
4. Project Control Process: Change Requests, Corrective and Preventative Actions, Progress Reports, Change Management, etc.
5. Project Closure Process: Lessons Learned, Process Improvements, Formalized Final Project Documentation (e.g., prints, drawings, etc.), Completed prototypes, Product Models, etc.

Any instructor who proposes to impart real-world project management skills to students must ensure that the dichotomy between the classroom environment and the industrial work place is eliminated to the greatest extent practical. The instructor must endeavor to simulate the more adverse project management circumstances, such as those conditions typically associated with a formalized functional or weak matrix organization. Such organizations tend to exhibit a hierarchical structure, with rigid compartmentalization of personnel by function or specialty, such as engineering, human resources, skilled trades, finance, etc. There is often no place in this sort of infrastructure for dedicated project management personnel or a central project management office. This kind of organizational structure tends to be particularly challenging for project managers, because authority over funding, resource allocation, and personnel tends to rest with functional management rather than with project management personnel (Project Management Institute, 2008). Without official authority, the engineer in charge often engages in extensive negotiation and risk mitigation efforts to ensure timely project completion.

So as to thoroughly prepare engineering and engineering technology students to operate as de facto project managers, AT408, AT496, and AT497 are structured and conducted according to a functional or weak organizational matrix standard; students enrolled in AT408, AT496, and AT497 have little or no official project management authority. In order to obtain the necessary project resources, Aeronautical Engineering Technology students must successfully communicate, negotiate, and perform collaboratively with faculty members and students from the Purdue School of Astronautics and Aeronautics. The process of presentation, justification, and negotiation is ongoing throughout the project, from inception to final delivery (Dubikovsky et al., 2010). Working in teams in a simulated industrial environment, students must begin their project with a formal project charter, proposed budget, and role/responsibility matrix for approval, and they must negotiate final deliverables and distribution of resources based on scope, risk assessments, project timeline, and other factors. Also, students must negotiate and select means to communicate effectively using available tools such as Skype, email, instant messaging, texting, voicemail, phone, etc.

Introduction of a project management component within a program elevates requirements placed on a course instructor. He or she takes the role of facilitator or guide (Barrows, 1996) and therefore must be knowledgeable about project management. Fortunately, the implementation of project management tools does not require any financial resources. Most of information is freely available on the Internet or in numerous publications. Much of the implementation effort is borne by the instructor. Not all faculty members have previously performed a project engineer/manager's duties and are ready to take on a new challenge. There are many free or cost-effective avenues available to the instructor by which he or she may address these concerns, however, including participation in preliminary project management courses. Although not strictly necessary, an instructor may opt to obtain a PMP licensure or certification from the Project Management Institute. Depending on the degree of certification, the total cost associated with each individual PMP certification is typically well under $1,000 for materials, training, and examination fees.

Conclusions

The authors strongly believe that the experiences mentioned herein provide necessary skills for students to be hired and retain jobs in industry. They also have better chances to progress into management positions in three to five years after graduation. There is enough anecdotal evidence to support this belief based on current and past class responses and alumni feedback. The fact that, even during economic downturns, graduates from Purdue's Aeronautical Engineering Technology program do not have trouble finding jobs supports this claim. Future research will be done with a survey instrument developed by the authors to collect data from students showing the extent to which their skills have increased in areas such as teamwork, communication, analysis, problem definition, time management, etc. There are also plans to survey graduates of the program in the near future to gather evidence on their successes in industry and readiness to tackle real-life engineering challenges.

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