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Using ABET Assessment Requirements as a Catalyst for Change: Enhancing and Streamlining the Engineering Management Undergraduate Program at Missouri S&T

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AC 2009-936: USING ABET ASSESSMENT REQUIREMENTS AS A CATALYST FOR CHANGE: ENHANCING AND STREAMLINING THE ENGINEERING MANAGEMENT UNDERGRADUATE PROGRAM AT MISSOURI S&T

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Using ABET Assessment Requirements As a Catalyst for Change: Enhancing and Streamlining the Engineering Management Undergraduate Program at Missouri S&T

Abstract

The Engineering Management (EM) undergraduate degree program at Missouri University of Science & Technology (formerly University of Missouri-Rolla) was the first program of its kind. The program started over 40 years ago and it is one of only five ABET accredited undergraduate EM programs [1]. The initial degree program included a senior year of management courses in conjunction with three years of courses in common engineering disciplines such as mechanical, electrical, and civil engineering. In the 1990s the program underwent a major restructure and students combined core engineering management classes with an emphasis area inside the department. Industrial, manufacturing, packaging, and quality engineering emphasis were added as well as management of technology, while maintaining the ability to pursue traditional engineering emphasis areas.

Recently major changes were made to extend the set of core courses and to streamline the technical emphasis areas. The need for these changes was clear, but attempts to make changes in the past have proven difficult. The new, more stringent ABET accreditation criteria [2], specifically those which relate to Educational Objectives, Program Outcomes, Continuous Improvement, and Curriculum provided the needed impetus and assistance to make significant changes to the undergraduate curriculum. This paper describes the processes which were used to make the changes, and how the ABET criteria influenced these processes. In addition, we also discuss the hurdles and challenges faced as the process moved forward, ultimately leading to the revised curriculum. The paper concludes with specific recommendations for revising undergraduate curriculum in light of the current ABET guidelines.

Introduction and Program History

The engineering management undergraduate degree program at the Missouri University of Science & Technology (formerly University of Missouri-Rolla) was the first program of its kind. The program was started in the mid 1960s and had its first graduating class of eight in 1968 [3]. Professor Bernard Sarchet was the founder of the department and saw the need to blend engineering, science, and technology management into a degree program that would meet engineering accreditation standards and prepare engineers to move into supervisory and management positions. The department was initially administered outside of the School of Engineering, but later became part of that school. The B.S. in Engineering Management degree program first received ABET accreditation in 1979 after the initial accreditation visit in 1978. The department received the full six-year accreditation, and has subsequently been accredited for the full six years after the visits in 1984, 1990, 1996, and 2002. The programs most recent accreditation visit occurred in Fall 2008. Currently, the program is one of five undergraduate Engineering Management programs that are accredited by ABET.

The initial structure of the undergraduate program was one that may be most accurately described as the 3 + 1 approach. In essence, during the first two years, the students were required to take essentially the same courses that any other engineering student would take. Then, the third and fourth years would include approximately one year of courses in a traditional engineering discipline, and one year of core courses that focused more on the business and technology management. Such courses included marketing, management, and accounting. These courses were taught by faculty with at least one engineering degree. This approach was used to ensure EM students appreciated the link between engineering and business. Students were also required to take six hours of upper-level Engineering Management electives. Graduates of the program received a B. S. in Engineering Management with a preference in a traditional engineering field, (for example B.S. in Engineering Management with a Mechanical Engineering Preference). This model was used exclusively until the late 1980s.

In the late 1980s, an internal department preference area was developed that focused on manufacturing and packaging engineering. This emphasis contained a small number of required courses and allowed a variety of electives to complete the emphasis. Comments from the 1990 accreditation provided the impetus to develop five specific internal emphasis areas (changed from preference area). These included the following: Management of Technology, Quality Engineering, Packaging Engineering, Manufacturing Engineering, and Industrial Engineering. The sixth emphasis area was recast as the General Engineering Emphasis, which continued the initial 3 + 1 approach allowing students to blend management and traditional engineering. This model was essentially the same during the 2002 accreditation cycle, although the Quality, Manufacturing, and Packaging Engineering emphasis areas were not heavily emphasized in the department due to faculty expertise and low student interest in those areas.

Since the ABET accreditation visit in 2002, the campus initiated a common total program credit requirement of 128 hours for all engineering BS degrees. This resulted in a reduction from 134 credit hours in the EM degree. The credit hour reduction was driven by a campus initiative, and it occurred without much internal department resistance. The curriculum that was in place beginning in Fall 2005 remained relatively unchanged. However, as ABET provided more direction and focus with regard to the new accreditation criteria, and as the looming ABET visit of 2008 drew near, it became apparent that the curriculum that was in place would not likely pass ABET requirements. Some faculty in the department knew the curriculum needed major overhauls, and that change must occur quickly. Some of these same faculty also knew a major curriculum change would likely face significant resistance for a variety of reasons. The remainder of this paper will discuss how the more well-defined and stringent ABET criteria provided the needed impetus and assistance to make significant changes to the undergraduate curriculum.

Driver for Change

Curriculum changes may come about for a variety of reasons in the normal life cycle of an academic department. Changes in faculty make-up, university missions, and changing industry requirements are all examples that may lead to curriculum changes. Academic departments generally have curriculum committees that are charged with managing and approving curriculum changes. This approach is well suited for the common curriculum adjustments that occur in academia. However, when ABET initially developed the ABET 2000 criteria that radically

changed the approach toward accreditation, normal curriculum change mechanisms presented significant challenges.

Missouri S&T's Engineering Management Department was accredited in 2002 under ABET 2000 criteria with an essentially unchanged curriculum. However, there were indications of potential future problems in the areas of educational objectives, outcomes, and continuous improvement efforts. In addition, significant concerns were raised due to curriculum issues related to engineering and design content. Efforts were made to respond to these concerns, but progress was slow. There was vigorous debate among the faculty over what changes should be made and what those changes should comprise. However, as ABET more rigorously defined their expectations with regard to Criteria 2 (Educational Objectives), 3 (Program Outcomes), and 4 (Continuous Improvement), the department realized that positive results from the impending 2008 ABET visit were in jeopardy. Furthermore, it was known that ABET evaluators were looking more closely at the distribution of engineering and design content in program curriculum. For an engineering management program with a significant amount of traditional business content in its core, this was thought to be a potential weakness. We also knew that our capstone course, which focused on strategic management using case studies (cited as a concern during the previous visit) would not likely be viewed in a positive light this time. Despite these problem indicators, efforts to modify the curriculum through the normal committee process were not successful. A quote from John Kenneth Galbraith [5] summarizes the situation well, "Faced with the choice between changing one's mind and proving that there is no need to do so, almost everyone gets busy on the proof." Yet many in the department feared that if change did not occur the EM program would likely have one or more of the ABET criterion cited as a "deficiency" in the next accreditation visit. This was obviously not an acceptable alternative.

Fortunately, the more rigorous ABET requirements provided a means to revise the EM undergraduate curriculum that could break through resistance to change in the department. Specifically, ABET required the educational objectives were to be developed based on a constituent driven process [2]. In our case, constituents included students, faculty, Academy of Engineering Management members, and representatives from industry/companies that employed EM graduates. In the Spring of 2007, the constituent group met and went through a "clean-slate" brainstorming process to develop the first draft of the educational objectives. Further iterations and refinements of the objectives were made with this core group through email and phone contact. Finally, the statements were presented to the entire department faculty for further refinement. Changes or comments were then shared with the original constituent group, and final faculty approval was received Fall 2007. Once these objectives were approved and compared to the curriculum, it became very clear that major changes were needed relative to the undergraduate core courses. The core courses ensure all graduate will receive required content that was deemed necessary and that would address specific program outcomes, which would then be assessed through multiple performance criteria. The educational objectives derived from this process are shown below in Exhibit 1.

Program Educational Objectives

Graduates of the Engineering Management Program will exhibit proficiency and excellence in the areas of technology, finance, human relations, communications, and professional behavior. Within these areas of proficiency, graduates will exhibit the explicit skills and knowledge as detailed below.

Technical Knowledge and Analytical Problem Solving: Graduates of the Engineering Management Program are able to analyze and solve complex problems utilizing:

- a mastery of Engineering Management tools and techniques including those utilized in operations management, project management, management of technology, and supply chain management
- in-depth knowledge in at least one emphasis area within Engineering Management
- an understanding of the fundamental principles and concepts of engineering
- sound business judgment
- relevant analytical and modeling tools such as statistics.

Finance: Graduates of the Engineering Management Program are responsible and financially aware managers and leaders who utilize basic finance, accounting, engineering economy, and risk analysis methods to manage and identify the financial impact of business opportunities.

Human Relations: Graduates of the Engineering Management Program are competent leaders who develop and utilize the skills and abilities of teams and individuals within the organization as evidenced by proficiency in:

- team building
- conflict resolution
- efficient and effective management of constituents with diverse skills
- empowering teams and individuals through coaching and mentoring
- conducting effective and efficient meetings.

Communication: Graduates of the Engineering Management Program engage others through effective oral, technical, and written communication evidenced by:

- active listening
- clarity and conciseness in presentation
- an ability to adjust content and presentation style to audience
- confidence and discernment in asking appropriate questions to obtain information vital to the project or task at hand.

Professional Behavior: Graduates of the Engineering Management Program will continually grow in their awareness and understanding of the societal, ethical, cultural, legal, and political issues prevalent in an increasingly global society.

Integration: Drawing on proficiencies in the areas described above, graduates of the Engineering Management Program are able to integrate their skills and knowledge to:

- effectively manage people, talent, time, and financial resources
- develop successful marketing strategies
- develop plans for projects and programs
- analyze problems, consider alternatives, and implement solutions.

Exhibit 1 – EM Program Educational Objectives

As stated above, it became clear that the current curriculum structure relative to the core and the emphasis areas offered in the department had to change. Relative to the core set of courses, five new courses were added (engineering economy, integrated accounting & finance, project management, quality philosophies and methods, and capstone senior design), and three were eliminated (engineering management practices, accounting, and finance). In terms of credit hours the core increased from 20 to 26 credit hours. This necessitated a reduction in the emphasis area hours from 24 to 18 credit hours. In addition the internal emphasis areas were reduced from five to two. Industrial Engineering and Management of Technology remained. Manufacturing, quality, and packaging engineering were repressed. The general emphasis area remained also requiring 18 credit hours. Clearly, the department had undergone a radical change relative to its undergraduate curriculum.

Processes for Change

The dominate process used to make the radical changes that occurred was the constituent driven process required by ABET. Ultimately this involved gaining approval from the entire faculty. The process provided clear evidence that our students could be better prepared for future success. This enabled serious deliberation to occur through first an ad-hoc committee, followed by the normal curriculum committee, and subsequently approved according to normal department protocol. The process also ensured that all EM graduates would receive more than the minimum hours in engineering and design credit. The revised core eliminated the potential for an ABET evaluator to question the minimum requirements. Courses that were added to the core clearly included engineering content. The senior design capstone course also added engineering content and met the strict requirements required by ABET.

The ad-hoc committee was a small subgroup that had more in depth knowledge of ABET curriculum requirements. This group developed various proposals, working closely with core faculty members. These proposals were floated as “trial balloons” to allow additional feedback and gauge receptiveness. Once the suggestions were taken to the curriculum committee deliberations became more intense. This was not unexpected as entire emphasis areas were eliminated or surviving areas were radically changed. However, the revised structure for the emphasis areas which consisted of nine hours of required courses and nine hours of technical electives, allowed the opportunity for focused clusters. For instance a student could choose to emphasize in industrial engineering, but they could also focus on quality or other focused areas with the available nine hours of technical electives. They might also take additional courses in industrial engineering or management of technology. This allowed faculty members whose expertise were not in the remaining emphasis areas to still contribute in the undergraduate curriculum via electives. A positive byproduct of this change was more efficient scheduling of departmental technical electives. Finally, after the curriculum committee gave its stamp of approval, the faculty quickly approved the changes and the process moved forward through normal campus channels.

Hurdles and Challenges

The major challenge of the entire process can best be described as resistance to change [4]. The old adage of “if it ain’t broke, don’t fix it” was clearly present as the process moved forward.

More specifically, there was a belief in some quarters that since the program received ABET accreditation in 2002 that it certainly would do so again in 2008. Without the constituent driven process providing the major push, it is doubtful that changes would have occurred. That process clearly identified areas of weakness and provided a reasonable mechanism to communicate without emotions, pre-conceived notions, or personal biases, or at least minimize those impediments.

Another potential barrier to change went away on its own accord. As stated, the manufacturing emphasis areas was repressed and not maintained as an emphasis area. With low student interest and a decline in manufacturing engineering faculty the decision to eliminate the emphasis was straightforward.

The third barrier, and perhaps the greatest challenge, was developing a more traditional senior design capstone course. Historically, it was believed that the strategic management/case studies approach was the natural capstone for a degree that blended science, mathematics, technology, and business. Real world case studies provided a variety of information ranging from financial to organizational. Many of the cases were highly technical and provided meaning challenges to the students. This method also served the philosophy on which the program was founded and enjoyed success for over forty years. However, the concern cited in 2002 ABET findings were a clear indicator that change was needed. In retrospect if a more traditional capstone design course were not developed and offered in the new curriculum, a deficiency was likely during the 2008 ABET visit. While the motivation to initiate change may have been fear of ABET it has clearly been beneficial for the EM undergraduate students

Conclusions and Recommendations

As Engineering Management faculty, we teach the importance of continuous improvement and making managerial decisions based on data. Still it is difficult to implement change in an academic department. Those who work in academic departments understand that personality, ego, and tradition are but a few of the factors (yet significant) that can impede change. Moreover, collective rules and regulations, and “shared governance” principles can actually stop change that is needed. But, when change must occur, and is necessitated by an external force (accreditation), some process or processes must be used to break through the barriers of change unique to the academic environment. In our case, the constituent driven process, required by ABET, was the prime driver of change. The process not only provided a useful framework for achieving change, it also allowed for the voice of our stakeholders to be heard. This process did provide data, but it also allowed for reasonable communications and interactions to try and achieve a common goal. Sometimes people just want to be heard. In the cases where more than just being heard was required, we found the ad-hoc subcommittee to be very useful. This process eliminated most of the resistance to change that we encountered. However, where the greatest resistance was encountered, face to face “intense fellowship” monitored by a referee, was required and give and take on both sides was the result. This “intense fellowship” is not a reference to a total battle royal, rather, it is a statement that deeper, and sometimes intense communication must occur to make sure opposing parties understand and appreciate conflicting positions. In the case described in this paper, that appreciation led to a better solution, and ultimately a better core curriculum.

In this time of financial uncertainty, perhaps W. Edwards Deming said it best, “It is not necessary to change. Survival is not mandatory.” [5] We strongly recommend that programs use the ABET constituent driven process as the driver for change in curriculum matters. We also suggest finding alternative approaches to facilitate communication at all levels while dealing with the unique faculty and academic environment.

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