AC 2008-863: MEETING THE NEEDS OF STUDENTS AND EMPLOYERS: DEVELOPMENT OF AN INNOVATIVE GRADUATE PROGRAM IN MANUFACTURING SYSTEMS TECHNOLOGY

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Abstract

Recently, manufacturing has seen tremendous change. Low skill, labor-intensive industries have experienced cutbacks, while new, high-tech manufacturing industries are growing and searching for qualified employees. The skills needed by workers in manufacturing have changed as have the skills needed by its leadership. Indeed, graduate-level education must provide a pool of technical professionals with effective management skills and leadership abilities. Recognizing this, one university NAIT-accredited technology department developed an innovative graduate program designed to provide students with a broad base of knowledge and skills needed to effectively manage and control production in manufacturing environments. The resulting degree is a Master of Science program with a major in Manufacturing Systems Technology. This program's purpose is to produce industrial leaders who 1) make decisions to integrate appropriate technologies, 2) apply advanced principles and practices, 3) creatively use technology in solving practical problems, and 4) manage technology systems in manufacturing. This graduate program is the result of a two-year participatory development process. Key manufacturing partners and the department's industrial advisory council played critical roles in identifying appropriate student outcomes and the resulting curriculum. There are several distinctive aspects of this program including the accommodation of working students through part-time scheduling and online delivery. The program provides students with a blend of both technical and management courses and culminates with an industry-based project. This paper will provide an example for developing a graduate program including problems and opportunities.

Keywords: Graduate Program, Manufacturing, On-line Program, and Curriculum Development

Introduction

Economic development in the southeastern region of the U.S. continues to be heavily influenced by manufacturing. Manufacturing in the region, however, has seen tremendous change over the past decade [1]. Low skill, labor-intensive industries have experienced cutbacks and closures while new, high-tech, automated manufacturing industries are growing and searching for highly skilled workers. Increased productivity demands require more effective, leaner manufacturing operations. The skills needed by workers in manufacturing have changed as have the skills needed by its leadership [2]. Indeed, graduate-level education has become increasingly necessary in order to provide a pool of technical professionals with management skills and leadership abilities in these high-tech manufacturing industries.

Recognizing the importance of developing manufacturing leaders, one university's engineering and technology department has offered degree programs supporting the needs of regional industry. In particular, the development of the area's automotive-based industries continues to

increase. As a result, the department worked to develop an innovative graduate program designed to provide students with a broad base of knowledge and skills needed to effectively manage and control production in highly automated manufacturing environments. The result is a Master of Science degree program with a major in Manufacturing Systems Technology. This program's purpose is to produce industrial leaders who:

- Are prepared to integrate the most advanced and appropriate technologies into manufacturing operations
- Apply advanced strategies and practices used in world-class manufacturing systems
- Creatively implement technology to solve practical problems in the manufacturing environment
- Are equipped with knowledge of key issues affecting the manufacturing sector, both domestically and globally

This paper focuses on the specifics of the two-year participatory development of the program, including the critical role played by key manufacturing partners and the department's industrial advisory board. The paper will describe the process used to create the student outcomes that ultimately became the graduate program in Manufacturing Systems Technology. The program provides the student with a blend of both technical and management course requirements. The program culminates with a two-semester comprehensive industry-based manufacturing management project. The distinctive aspects of this graduate program will be explained including the targeting of students working full-time who are seeking opportunities for professional advancement. The program is open to students with undergraduate degrees in engineering, technology, and business. The program's flexibility allows students to design the coursework to fit their needs and the needs of their employer. Selected features of the degree program will be showcased to illustrate areas of innovation and flexibility. Initial comments from students currently enrolled in the program will also be included.

Graduate Program Description

The purpose of this Master of Science in Manufacturing Systems Technology program is to produce manufacturing leaders who have both technical expertise and manufacturing management skills. The program is designed for professionals working in a technical area or holding a technical undergraduate degree from an accredited university. Often these individuals need additional educational credentials to increase their opportunities for professional advancement. The program provides students with academic experiences balanced with practical applications in manufacturing systems, thus preparing students to assume leadership roles in the evolving world of manufacturing.

The program curriculum has a flexible design focusing on five core areas that are essential for leading a global manufacturing operation. The five core areas include: Manufacturing Operational Systems, Manufacturing Computer/Informational Systems, Manufacturing Simulation, Manufacturing Value Analysis, and Automated Manufacturing Technology. Likewise, the mode of delivery is flexible allowing students to complete the program in a

traditional classroom environment, through distance education online, or through a combination of both online and classroom studies.

The Master of Science in Manufacturing Systems Technology is a 30 semester hour program that includes a two-semester comprehensive project. The program consists of six core courses (18 hours), a sequence of two courses (6 hours) for a comprehensive project at the end of the program, and 2 technical electives (6 hours) that must be approved by the graduate faculty committee. Table 1 provides a brief description for each required course.

Course Descriptions

MFG 505 & MFG 507 – Manufacturing Operational Systems I and II

- Learn about world class manufacturing systems, their integration with production systems, and the implementation of such systems to create low-cost, superior quality products.

MFG 511 – Manufacturing Computer/Information Systems

- Learn how to effectively integrate hardware and software with manufacturing systems.

MFG 515 – Manufacturing Systems Simulation

- The power of computer simulation is used to model the factory floor or a distribution system, allowing the student to estimate how changes in the system may improve productivity and cut costs.

MFG 521 – Manufacturing Value Analysis

- Learn how to make effective economic decisions.

MFG 531 – Automated Manufacturing Technology

- Learn about material processing and machining methods, including robotics, flexible manufacturing systems, and computer numerical control systems.

MFG 595 & 596 –

- Complete an independent, comprehensive project integrating the functional areas of manufacturing systems.

Table 1. Course Descriptions Manufacturing Systems Technology Program Elements

The core courses are designed to provide students with knowledge and abilities needed to effectively lead tomorrow's highly technical manufacturing facilities. Although some of the core consists of courses that include extensive technical content, these courses are focused on

preparing the graduate to manage such systems. Content is therefore presented in recognition that other manufacturing professionals with in-depth training in these technical areas will be responsible for implementation of the technology. This shift in focus allows students with various undergraduate backgrounds to achieve the learning outcomes identified for the courses provided they have adequate manufacturing experiences. Students holding undergraduate degrees in fields other than engineering or engineering technology without appropriate manufacturing experience are required to complete selected undergraduate courses before entering the graduate program.

In addition to the required coursework, students are required to successfully complete a comprehensive examination in conjunction with the defense of the comprehensive project. These program elements are provided in the University's Graduate Bulletin [3].

Graduate Program Development

The program was developed over a two year period combining input from various sources including the department's industrial advisory council, benchmarking similar programs, and key manufacturing partners. After surveys of undergraduate students and regional manufacturing industries revealed a legitimate need for graduate education in manufacturing, the Industrial Advisory Board played a critical role in providing the foundation for what would become the present graduate program in Manufacturing Systems Technology. Over several sessions, members of this group progressed from brainstorming discussions to identifying and verifying specific student outcomes for a program designed to meet the needs of manufacturing in our service region. The Advisory Board membership consists of current manufacturing professionals, retired manufacturing professionals, faculty from an engineering program at another state university, and program alumni representing educational backgrounds from bachelor's to doctoral degrees. The diversity of the group proved to be a tremendous asset in achieving an appropriate balance of technical- and managerial-based outcomes.

One of the more interesting byproducts of this interaction was an intense discussion of the naming of the program. As a whole, the Advisory Board strongly encouraged adoption of a program title containing the word Manufacturing. Since existing, related degrees are typically referred to as Industrial Technology, Industrial Management, Engineering Management, or Technology Management programs; there was hesitation by departmental faculty to deviate from one of these more recognizable names. In the end, the Advisory Council's arguments were strong and the program in Manufacturing Systems Technology was born.

The departmental faculty then began the process of benchmarking graduate programs from several institutions that offered programs that were thought to have related competencies. Programs in Industrial Technology, Industrial Management, Technology Management, Engineering and Technology Management, and Technology were reviewed. From this review a draft set of courses was developed for further review.

The draft set of courses was then shared with a select group of manufacturing partners to garner feedback as an aid in determining the composition of the final curriculum. These partners helped to identify some content that could be combined into a single course and some content that could be part of elective courses available to students. This group suggested that project-based learning was crucial for the success of the program since it was designed primarily for working professionals and it suggested a six semester hour project option for students not completing a thesis.

Finally, the proposed package was presented to the Industrial Advisory Board for final review. The program consisted of eighteen hours of core requirements, six hours of electives, and six hours for project or thesis. As a result of this final review, the thesis option was discarded completely and the first three hours of the project were modified to provide significant project management instruction. Because our program is an application-oriented degree program, the advisory board recommended that the thesis option be eliminated. This decision would allow all students to complete a comprehensive industrial project prior to graduation.

Now that the needed program had been developed, the next step in the process was gaining approval through the state's Commission on Higher Education. Duplication of programs is a major concern within the state and the process for approval includes an initial step that allows all the graduate colleges from other institutions to respond to a proposed new program. Although there was only one graduate program in Industrial Technology within our state, most institutions have graduate programs in business. As our program was developed, considerable care was taken to emphasize differences in the Manufacturing Systems Technology program and these business programs as experience has shown that often times there is a perceived overlap in content. When responses were received by the state, it was the Industrial Engineering programs that suggested that the Manufacturing Systems Technology proposal seemed to have tremendous duplication of their programs! Although we were able to effectively address these concerns, this roadblock appeared unexpectedly and served as a lesson learned. Reflecting on the experience, we conclude that our situation actually validated the need for the program. Business programs provide ample managerial skills to students but very little technical prowess. Engineering programs tend to provide extensive technical instruction but little in the way of managing in the manufacturing environment. Both (at least in this state) sometimes view programs in Technology as a threat, possibly because these programs provide a balance that can better prepare manufacturing professionals to effectively lead their companies.

Distinctive Aspects of Graduate Program

This program has several distinctive characteristics. One of the main distinctive aspects of this program is its design for students who are currently working and need a part-time curriculum. Courses are structured so that students can complete six credit hours each semester. Table 2 provides the recommended sequence of courses. The six hours of electives included in the program are purposely very flexible to allow each individual student to select the elective courses that best suit the needs of his or her projected career path. For example, some students heavily involved in information technology may choose to take graduate computer science courses. Other students may select graduate business courses to meet their needs. We even have some students

Recommended Course Sequences	
Fall Start	**Spring Start**
Year One	**Year One**
Fall: MFG 505, MFG 531	Spring: MFG 505, MFG 511
Spring: MFG 507, MFG 511	Summer: Elective 1
Summer: Elective 1, Elective 2	Fall: MFG 521, MFG 531
Year Two	**Year Two**
Fall: MFG 521, MFG 595	Spring: MFG 507, MFG 515
Spring: MFG 515, MFG 596	Summer: Elective 2
	Fall: MFG 595
	Spring: MFG 596

Table 2. Plan of Study Manufacturing Systems Technology Program

that are teaching at local community colleges that select education courses for their electives. The elective courses may be taken at JSU or transferred from another institution. This flexibility allows

some of our students to utilize professional development courses that sometimes result in graduate credit being awarded by an institution.

Another feature of the program that offers flexibility to the student is the recent transition of the program to an entirely online offering. It became apparent after scheduling the courses on campus for several semesters that the rigors of attending classes coupled with working manufacturing management hours were too difficult for many of our graduate students. It would not be uncommon for a student to miss class because of an emergency on the factory floor, a business trip overseas, or another work-related event. In response to these situations, it was decided that offering the classes in the online environment posed a legitimate solution to scheduling difficulties. Additionally, the online classes in the program do not have specified class meeting times, adding another component of flexibility to the online environment.

Beginning in the fall semester of 2007, two core classes per semester were transitioned to online courses. It is estimated that all classes in the graduate program will be in online format by the spring semester of 2009. The gradual changeover from on-campus course offerings to online course distribution gives students in the on-campus program an opportunity to complete their degrees in the on-campus format.

Of course, the transition to online classes opens up a national, and probably global, pool of candidates for the program. This larger pool of degree candidates will provide a more diverse student population and is expected to enrich class discussions. However, it is understood that the

launch of the online degree program will bring about new problems and opportunities – these must be addressed as they occur in order to preserve the integrity of the program.

Because the program originated in the classroom environment, there has been significant feedback from students regarding what is effective in the current program. One of the most frequent comments about the classroom program is that the classroom discussions are of great benefit to everyone. Students are encouraged to reflect on their industrial experiences in light of the topic at hand. One of the goals in developing the on-line degree program is to emulate these discussions through on-line bulletin board postings about particular topics [4]. In the courses that are now offered online, students are given a number of readings on a particular topic, from texts, peer-reviewed journals, and other publications. After completing the reading assignments, the students participate in weekly discussions about the topics, with the discussion moderated by the professor. The students are graded by the professor and rated by one another as to the quality and quantity of their contributions to the discussions. Students are reminded that their efforts in online discussions should mirror the level of discussion that would take place in a three credit hour classroom course.

Another method for encouraging interactivity and dynamic content in the on-line program is through the planned use of podcasting. A podcast is similar to a radio show, but it is broadcast over the World Wide Web. Using technology called Really Simple Syndication (RSS), listeners subscribe to a podcast and automatically receive new episodes as they are published. For those courses that are currently being taught in the classroom, a professor may digitally record the lecture using a digital voice recorder, then post the podcast for future on-line students to listen to.

A third means of enhancing the on-line course environment is through the use of on-line groups within the courses. These groups would be assembled by the professor, and those students would work together on papers, projects or assignments in the on-line environment. The distance learning interface used by this particular institution is the Blackboard platform. Blackboard allows a professor to form groups within an on-line course; those groups are then given their own private discussion boards, e-mail conduits, and other tools to facilitate interaction between the members of the group as they work on common tasks.

Another issue that is addressed in the on-line program is that of providing real-world, hands-on assignments and projects for students to complete. Because engineering and engineering technology programs tend to be applied courses of study, it is necessary to consider methods of instruction and student work that engage students in this regard. A majority of the students in the program are employed full-time in manufacturing careers and can be given assignments to complete in the manufacturing environment. Examples of such assignments include: using manufacturing simulation software to model a production process; analyzing financial reports or budgets from the workplace; or mapping the local area network at their own workplace.

Discussion of Current Graduate Program

The current enrollment in the program is approximately 12 students taking courses consistently from one semester to the next. There are about an equal number of students who thus far have

taken one or two courses but are not participating in the program consistently from semester to semester. Most members of the student population have been in the manufacturing workforce for at least seven years and hold managerial positions. By and large, the students have expertise in machining, electronics, and automation, while a few of the students have degrees or experience in only business, engineering, or occupational safety. Of those students who are active participants in the program, most are working full-time while others work part time or have taken a leave of absence from the workforce in order to take more courses and expedite their graduation dates. Most students are taking two courses per semester.

Some students have taken a handful of classes but are not regularly enrolling from one semester to the next. Based on the feedback received from those students, the reasons for inconsistent enrollment range from scheduling issues between work and school to family commitments during class meeting times. Many students state that they are not in a particular rush to complete their degrees, but are satisfied with taking their classes at a slower pace.

Based on feedback from current students, it seems that the program is fulfilling its goals of preparing students with both technical expertise and managerial practices necessary for effective industrial leadership. Said one student, “I have been very pleased with the relevance of every class that I have taken. As a result of this program, I consider myself to be more informed and a better manager. I recommend this program to anyone who is a supervisor in a manufacturing facility." Another student commented on the skills being learned throughout the curriculum: “Our program prepares us to properly address and correct issues within the manufacturing environment. It promotes the development of new ideas and strategies that will benefit all areas within an organization. The analytical skills we arrived with have matured greatly through the lectures and assignments included within the program. Rather than applying an impromptu fix to a problem, we are developing the skills to thoroughly analyze a situation before reacting – we’re using fact-based decision making.”

As of December, 2007, two students have successfully completed the program and graduated. Three students have completed the industry project requirements. The topics for the industry projects completed thus far include:

- One project focused on a lean manufacturing initiative for a local specialty products company. The student selected a particular machine shop and worked with the employees there to facilitate quick changeover and Single Minute Exchange of Die (SMED) techniques, develop a 5S program, and lead training for the employees and management in Toyota Production System methods.

- Another project involved the development and execution of a machine vision system for an automated work cell within the Technology Department of the University. The student procured equipment, designed the layout for the cell, programmed the components of the cell, and assimilated all of the components together in a functioning cell that may be used for industrial consulting or educational applications.

- The third completed project was a workplace improvement initiative at a local foundry. The graduate student studied a particular work cell, then suggested changes and modifications to the work cell using simulation software to illustrate the options to management. The student prescribed, with the input of employees, changes to assembly operations to make the tasks performed more ergonomically correct. The student worked alongside plant management and employees to provide consultation regarding improvements that would make the work cell more efficient.

Conclusion

The Master of Science with a major in Manufacturing Systems Technology is a program designed to prepare management oriented technical professional for the ever-evolving global manufacturing environment. The program balances academic instruction with practical applications in manufacturing systems to provide graduates with a broad base of knowledge and skills needed to effectively manage and control production in manufacturing facilities. This program is available regionally by traditional classroom instruction and worldwide via a complete online program. This paper serves as an example for developing such a graduate program in manufacturing systems technology including problems encountered and opportunities for success.

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