AC 2011-355: IMPLEMENTING THE MASTERS FOR ENGINEERING PROFESSIONALS DEGREE AT NJIT

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Implementing the Master's for Engineering Professionals Degree at NJIT

Abstract

This paper reports on a plan for implementing a Master's for Engineering Professionals at New Jersey Institute of Technology. The Master's for Engineering Professionals is intended for the early career development of engineers in industry. It teaches the skill sets and abilities required of these engineers. Skills include a working knowledge of business and ethics, teamwork experience, a solid grounding in engineering science as well as communication and presentation skills. The program develops abilities such as an appreciation of the basic principles of business, the profit motive, how to design and execute experiments, how to prepare project plans and regulatory documents, and how to carry out a real-life project within a company. Program emphasis is placed upon engineering creativity and innovation. with a strong emphasis on the needs of the nation to compete in the world market and maintain the strength of the U.S. economy. A second objective of the paper is to describe the current status of a recently developed Professional Science Master's (PSM) after which this program is modeled. For the past ten years the PSM program has been growing in popularity in US schools of engineering. It is designed for students who do not wish to continue on to a doctorate leading to an academic career but rather to enter the workforce with a master's degree, a degree now viewed by many as having displaced the baccalaureate as the terminal engineering degree. These programs put more emphasis on applied skills as opposed to those more theoretical in nature. The paper concludes with a detailed description of the NJIT proposed curriculum and the assessment process used to evaluate defined outcomes.

1. Introduction

Research engineering universities frequently emphasize long-term research as the process by which discoveries are made that eventually lead to the application of these principles to the development of innovative products and processes. This concept is often called the "linear model" for engineering education. However, this approach does not meet the immediate needs for development of America's technological strength through the innovation and development of new products that will have an immediate impact on the U.S. economy. The need for innovation has been called by the Council on Competitiveness as "the single most important factor in determining America's success through the 21st century" [1].

In "*Rising Above the Gathering Storm*"[2] a group of scientists was asked how well the US is doing in science and innovation. None said the nation was doing all right, 40% characterized the nation as being "in a stall", and the remainder said that the US was "in decline". The subject was also addressed in a July 2005 report *Tapping America's Potential: The Education for Innovation Initiative* issued by fifteen of the largest and most influential groups of CEO's and other business leaders.[3] The report states: "One of the pillars of American economic prosperity – our scientific and technological superiority – is beginning to atrophy even as other nations are developing their own human capital…If we wait for a dramatic event – a 21st-century version of Sputnik – it will be too late. There may be no attack, no moment of epiphany, no catastrophe that will suddenly demonstrate the threat. Rather, there will be a slow withering, a gradual decline, a widening gap between a complacent America and countries with the drive, commitment and vision to take our place."

2. The Professional Science Master's (PSM) Degree

In response to this need a new type of degree, the Professional Science Master's, was established at research universities beginning in the early 2000's using start-up funds provided by the Alfred P. Sloan Foundation. It is designed for students who do not wish to continue on to a doctorate leading to an academic career but rather to enter the workforce with a master's degree, a degree now viewed by many as having displaced the baccalaureate as the terminal engineering degree. These programs put more emphasis on applied skills as opposed to those more theoretical in nature.

As described by Rita R. Colwell in Science Magazine[4], "Most of these innovative Professional Science Master's (PSM) degree programs are interdisciplinary and provide hands-on learning through internships and team projects. They are not intended to displace traditional programs. Instead, they aim to engage students with professional goals and then become scientists uniquely suited to the 21st-century workplace, equipped with a broader scientific knowledge than that acquired with a Bachelor of Science degree and the skills to apply it."

The Council of Graduate Schools has published a guide for establishing Professional Science Master's programs[5]. It lists the following skill sets and abilities required of graduates of the PSM degree:

a. Skill Sets

- working knowledge of business and ethics
- solid science experience
- teamwork experience
- communications/presentation skills
- flexible training and career perspective

b. Abilities

- understand and appreciate the basic principles of business, the profit motive, and related ethical issues
- design and execute experiments with minimal supervision

- participate effectively as members of interdisciplinary teams
- prepare technical reports, project plans, and regulatory documents
- prepare and present information to a wide variety of constituents, from customers to stockholders to the general public
- apply their knowledge and skills to various areas of the company as needed during their career trajectory.

3. Characteristics of Current PSM Programs

The CGS Guide further lists common characteristics of existing PSM programs. (The Council of Graduate Schools maintains an excellent web page at www.sciencemasters.com that reports that as of December 8, 2010 there were 229 PSM programs offered at 105 PSM-affiliated universities.) Some of these commonalities are given as:

- at least two years are required to establish a PSM program
- each program has a business/industry advisory board
- science and/or mathematics courses comprise the "core" of almost all programs
- ethics is a common course/module in many programs
- internships are required of almost all PSM programs
- a final PSM capstone, often with a "team" structure, is nearly universal
- most PSM programs are focused on full-time students taking many of their courses using a "cohort" structure
- most students take two or more years to complete a PSM program
- most PSM programs are growing; current enrollments significantly exceed total graduates.

4. The Master's for Engineering Professionals (MEP) Degree at NJIT

The following describes the steps that are being taken to introduce a PSM degree in the college of engineering at New Jersey Institute of Technology. Described as a Master's for Engineering Professionals or MEP, this degree places an emphasis on skills required of engineers working in industry. The degree is not intended to replace the traditional program but rather to provide a parallel track that places more emphasis on the practice of engineering rather than the current research-oriented degree.

The MEP will meet the demand from employers for engineers that can immediately contribute to the current needs of a company. These engineers will be trained in the skills of finance, communication, technical management, world marketing, systems engineering, innovation and entrepreneurship. Furthermore, they will gain a hands-on experience of applying these skills in practical industrial projects in various engineering disciplines.

5. Symposium at NJIT

Before finalizing the curriculum for the new program, employers, faculty, students, representatives from the military, and college administrators will be invited to attend a symposium to be held at NJIT. The purpose of this meeting will be to establish a consensus about the skills and knowledge required by MEP graduates. This information will form the basis for the courses offered by the new curriculum. The symposium will also help in learning about the various disciplines that are most in need of new professionals capable of filling these vacancies and technically prepared to meet the requirements of these programs. Furthermore, the meeting will inform employers about the new course offerings at NJIT and make them aware of a program that has the potential of filling their needs for new employees.

The purpose for including the military relates to a new GI Bill that will aid military personnel transitioning from military service to civilian jobs. There are approximately one-million veterans in the New York /New Jersey metropolitan area who can further their education by attending community colleges, undergraduate four-year colleges or universities offering advanced degrees. While the number of veterans qualified for entry into graduate programs such as MEP is relatively small, they too should have the advantage of learning skills that will prepare them for entering the workforce in areas that have a high demand for new employees.

One further objective of the symposium will be to form an advisory board for the new program.

6. Tentative Curriculum

The following tentative curriculum has been constructed to incorporate the skill sets and abilities previously outlined for the new program. Since the exact courses will not be finalized until after the symposium, this curriculum is primarily defined by course titles and brief descriptions of their content. Once the pilot program is determined the course contents will be given in much more detail. There will be 30 credits required for the degree.

Master's for Engineering Professionals (Tentative List of Course Offerings)

1. Competing in the Global Marketplace (3 credits)

An overview of international business concepts; the cultural differences between countries; global trade in the present investment environment and the global monetary system; the strategy and structure of international business and business operations.

2. Management of Technological Innovation (3 credits)

The assessment of competitive dynamics; methods for strategy formulation and implementation. Case studies are included as well as computer simulation of business enterprises.

3. Oral and Written Communication (3 credits)

The social context of scientific writing; recording as the basis for writing; the importance of digital electronics; a professional approach to writing; collaborative writing; your audience and aims; organizing and drafting documents; revising for organization and style; developing graphics; searching the literature; documenting sources; memos, letters and e-mail; progress reports; journal articles; oral presentations; instructions, procedures, and computer documentation.

4. Legal and Ethical Issues for Engineering Managers (3 credits)

Introduction to ethical and legal issues as applied to environmental, product liability and health and safety issues facing engineering managers; current state and federal laws and pending legal actions in these fields; case studies and advanced multimedia learning tools will used.

5. Financial and Economic Environments (3 credits)

Issues related to interest rates and extraordinary rates of inflation; international fiscal and monetary policy; regulatory policy integrated with market structure; cost and production technology; pricing policy; cash flow; risk-return opportunities; capital budgeting techniques; decision making in companies.

6. Innovation and Entrepreneurship (3credits):

Principles of creativity; history of prominent inventors and their inventions; identifying markets with potential for large volume purchase of new products; product design process; group and individual techniques for generating ideas for new products; methods for choosing a small number of promising ideas for products; development of engineering aspects of new product ideas; final design of product; development of business plan for new product; the patenting process and development of provisional patents.

7. Introduction to Systems Engineering (3 credits):

Fundamental principles of systems engineering and their application to the development of complex systems. Topics include concept definition, system synthesis, design tradeoffs, risk assessment, cost consideration, interface definition, and engineering of total systems. Case studies will be used as well as computer simulation.

8. Multi-lifecycle Engineering (3 credits) – Prerequisite: Basic knowledge of applied probability and statistics.

Considers the fundamental aspects of multi-lifecycle engineering from a systems perspective forming a framework for industrial ecology and a pathway towards sustainable development. Topics emphasized include lifecycle assessment, remanufacturing systems, design for environment, reengineered materials, and environmental risk management and product stewardship. Assignments include working in a team setting and use of relevant software.

9. Industrial Project I and II (3 credits each):

Real-life projects in industry encompassing principles of professional engineering. These courses are capstone courses taken at the end of the MEP curriculum.

10. Elective or Independent Study (3 credits):

Can be substituted for one of the industrial projects. Approval of advisor required.

7. Implementation

It is anticipated that the first cadre will be made up of approximately 20 students. The program will be structured in an executive format. In this structure, professional engineers from industry or the military will remain together as one cohort and take courses in a prescribed sequence. Each course will be offered during the latter part of the week and during weekends and be completed in approximately ten weeks. A distance-learning format may be used for various topics within a course.

8. Assessment

Assessment will be an important component of the introduction of the new program. Assessment will be done on two levels; first, on a course-by-course basis; second, the entire program as a whole.

The first step in the assessment process is to define the learning goals of each course and how they contribute to the overall objectives of the program. Each of these goals will be defined in such a manner as to elicit descriptive responses to the objectives that may then be used as metrics to evaluate specific outcomes. These outcomes can then be used as a summative tool to judge whether or not the course as well as student met the required goals.

Various instruments and techniques will be used to assess student performance. These will include:

- A questionnaire given at the beginning of the semester to determine a starting point for student knowledge. This will be compared to a similar instrument administered at the conclusion of the course to measure student learning and retention.
- Performance on examinations
- Theses, papers, and individual or group presentations
- A personal portfolio that will contain examples and surveys of the student's work throughout the program
- Student participation in class activities
- Reports from student aids or tutors

Other types of assessment vehicles will be used to evaluate course and program goals. These include:

- Student evaluation of teacher performance and whether or not the student felt that their learning goals were met.
- Employer questionnaires
- Success in students finding employment in firms requiring employees with knowledge taught in the program.

- Average grades received in each course to determine if the course material is at an appropriate level and content.
- Comparison of in-class vs. distance learning formats for each course.

The results of these assessments will be used to improve the course offerings and the overall program objectives. They will be applied in a formative manner to measure and adjust objectives while the course is running. They will also be used as a summative tool to evaluate and correct any deficiencies with individual course goals or program results.

9. Summary

This paper describes the establishment of a new master's level program at New Jersey Institute of Technology. The program is designated as a Master's for Engineering Professionals or MEP. It is intended to meet the needs of working professional engineers rather than the preparation of students for a research-oriented PhD degree. A description of the current status of a recently developed Professional Science Master's is also included.

Bibliography

1. Council on Competitiveness, *Innovate America,* 2005

2. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,* National Academies Press, 2007.

3. The report is available at: www.uschamber.com/publications/reports/050727_tap.htm

4. *Science Magazine, Vol. 323, March 27, 2009.*

5. *Professional Master's Education, A CGS Guide to Establishing Programs*, Council of Graduate Schools, Washington, DC, 2006.