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Proposal for a New Interdisciplinary Graduate Program Master of Engineering: Lessons learned

Devi Kalla

Dr. Devi K. Kalla received a PhD in Industrial Engineering from Wichita State University in 2008. He is the Program Director of Mechanical Engineering Technology and Professor in the Department of Engineering and Engineering Technology at Metropolitan State Univeristy of Denver. He has a strong experience on composite manufacturing, machining and modeling. His research interest includes environmentally conscious manufacturing, green manufacturing/Sustainable Engineering, energy efficient manufacturing processes and automated design and product development.

Zsuzsa Balogh

Julio Proano

Jeno Balogh

Fred Barlow

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Devi K. Kalla, Zsuzsa Balogh, Julio C. Proano, Jeno Balogh and Fred Barlow
Department of Engineering and Engineering Technology
Metropolitan State University of Denver, Denver, CO

Abstract: This paper describes an interdisciplinary Master of Engineering program that was proposed in 2017. The authors proposed this degree to address the needs of the community in the Denver area, as well as the needs of industry throughout Colorado. While that proposal was not approved by the university, and the program was not created, several lessons were learned from the experience of developing that program. This paper describes the proposed program as well as lessons learned through its development, the process required to seek approval of this program, and the subsequent denial of that approval. The authors discuss the potential benefits of this program, as well as the pitfalls associated with developing the necessary economic model to make it viable.

INTRODUCTION

Engineers interact in the workplace with technical peers in other disciplines at all stages of design, development, and application. The successful application of both established technologies and new technologies often depends on the interdisciplinary knowledge and abilities of the responsible engineers. The goal of interdisciplinary education should be to develop specialists who have interaction skills. The Department of Engineering and Engineering Technology (EAET) at a public university proposed the creation of a graduate degree, Master of Engineering (M.Eng.) with specializations in the areas of civil, electrical, and mechanical. The Master of Engineering is an interdepartmental degree program that would have focused on preparing students for careers in industry; and it would require engineering operational management courses designed to foster technology leadership skills. The proposed Master of Engineering program would have provided a graduate degree that focuses on the practice of engineering to better serve working professionals. The degree was designed for both the Engineering professionals who seek a career enhancement and for the new baccalaureate graduates who seek continued study to define and hone professional skills before entering the workforce. This degree would have accommodated the career goals of working professionals in a variety of engineering and technical occupations. Such a degree would enable EAET to serve a wider audience of professionals by providing a practice-oriented graduate program. Thus, many non-traditional students will seek to earn degrees like this proposed masters because of their need for continuing professional education.

ADMISSIONS CRITERIA and PROCESS

The proposed program's admissions were to be controlled by the program faculty in which the prospective student wishes to focus their program of study. However, there were some baseline requirements set as the nominal criteria for admission into the M.Eng. program:

- Candidates must hold a BS degree from an ABET accredited program (or equivalent if from an international university) in a corresponding engineering discipline and must provide official transcripts from the institution where the degree was obtained.
- Individuals with a non-ABET accredited engineering technology degree may be admissible and will be evaluated on a case-by-case basis. Pre-requisite work may be prescribed.
- The minimum undergraduate grade point average (GPA) of 3.0 / 4.0 or equivalent was required.
- Candidates would have been required to submit GRE scores, but this requirement would have been waived for domestic students meeting the above criteria.
- Two letters of recommendation were required.
- Prospective students would have been required to supply a statement of purpose.

International students were required to submit TOEFL scores. Students must have also met the minimum requirements established by the University. The TOEFL requirement would have been waived for international students that have earned a degree from a US institution, and for international students who earned a degree from certain countries where the medium of instruction is English. Individuals would have been able to request a waiver of some of the above requirements (e.g., undergraduate GPA less than 3.0) if they provide evidence to the graduate program director that they have sufficient basis to warrant a waiver. It would have been up to the program faculty to accept or decline this request.

PROGRAM EDUCATIONAL OBJECTIVES

The main rationale for proposing the M.Eng. graduate degree program was to contribute to Colorado's economic and social development by preparing engineering graduates to join a high-quality educated workforce in an area of national need. In addition, an increasing number of employers in consulting or industry consider the master's degree as the entry-level engineering degree. By providing advanced education for engineering professionals and technical managers in the areas offered by the EAET department, the program would have served as a key economic driver for Denver and Colorado. Furthermore, demand for graduate education is also created through advances in the professions represented by the EAET department programs and faculty.

There have also been discussions regarding the need for professional engineers to seek advanced education. For example, the National Society of Professional Engineers recommends 30 credits past the bachelor's degree requirement for professional license registration. Thus, students who graduate with bachelor's degrees in engineering and have earned Engineer-In-Training status will likely need to complete this additional requirement in the future. This recommendation (originally proposed by the American Society of Civil Engineers) of the master's degree or 30 graduate credits is likely to become the minimum education requirement for the professional license, representing the "Body of Knowledge" in the requirement for the professional licensure in engineering is projected to take affect by 2025.

In summary, the rationale for the proposal for establishing the M.Eng., which aligns with the mission of the program, was to 1) meet the challenges of emerging and identified needs of the community by developing new and relevant advanced academic and research programs; 2) meet the needs of employers in Colorado; 3) meet the needs of the profession; 4) educate students for

careers in interdisciplinary engineering practice or to pursue more advanced studies; 5) create a degree that may be offered through distance learning technologies thus serving working professionals who need access while continuing their careers; and 6) promote interdisciplinary collaboration among faculty from different engineering tracks.
The Program Educational Objectives (PEO) for the proposed M.Eng. program were established as graduates being able to:

- demonstrate professional proficiency by synthesizing engineering knowledge and applying it to solve professional problems in diverse careers as engineers, consultants, experts, entrepreneurs, researchers
- demonstrate innovation, leadership, and growth in engineering professional practice or research
- promote service to the profession and society

The PEO were supported by key features of the proposed master's in engineering program which include 1) a common core for all three specialty areas of the engineering degree; 2) specialty courses for the three areas chosen by the students; 3) industry partnerships and management applications; and 4) engineering applications in all three specialty areas.

STUDENT OUTCOMES

This program was proposed to provide the region with quality professionals that could fill the demand for educated and skilled engineers of excellent caliber in the various engineering disciplines (civil, electrical, and mechanical). A key outcome of this program would have been to provide interdisciplinary training at the master's level; this includes engineering management and systems engineering in addition to a graduate level scrutiny of new advances in technology in the key engineering disciplines.

Studies of the engineering population in medium and large companies in Colorado shows that around 25% of the engineers have master's degrees. They also show that engineers with master's degrees are chosen for supervisory and leadership positions. Frequently engineers with masters are responsible for large and complex projects and supervise or coordinate with engineers from other disciplines. Not only would the proposed master's program provide that interdisciplinary context, it would also have provided the industry with a diverse population of highly trained individuals ready to take technical leadership roles. A large percentage of the students that graduate with a BS in engineering from the university are Hispanic. These individuals are very likely to continue their education and obtain a master's degree and advance their technical careers in the region.

Supporting this program, we have a faculty with excellent competence, which is seen through such factors as education through the doctorate, diversity of backgrounds, engineering experience, teaching effectiveness and experience, ability to communicate effectively, enthusiasm for developing more effective programs, a high level of scholarship, participation in professional societies, and licensure as Professional Engineers and/or Professional Land Surveyors. The faculty are able to ensure that the proposed program's curriculum provides adequate attention and time to each component, consistent with the outcomes and objectives of the program and institution. In addition to in-person instruction, we proposed to provide computing and information infrastructures in place to support distance delivery of this degree.

Under the umbrella of the university, we are able to provide the institutional support, financial resources, and constructive leadership that can assure the quality and continuity of the program. These resources will be sufficient to attract, retain, and provide for the continued professional development of a well-qualified faculty. They will also be enough to acquire, maintain, and operate equipment appropriate for the program.

This program would allow our students to achieve the highest level of expertise in the specified field of engineering-mastery of the knowledge in the respective fields.

COURSES AND CURRICULA

The proposed Master of Engineering Program consisted of 30 credit hours grouped into core courses taken by all students in the program, track courses from the discipline of interest (civil, electrical, or mechanical engineering), elective courses that provide depth and interdisciplinary focus depending on the student's interest, and a graduate capstone project course to demonstrate applicability of skills and synthesis of knowledge. Table 1 shows the program courses for each of the three track options. Each course is 3 credit hours.

Table 1. Proposed Program Courses (program total 30 credit hours)

Core Courses 9 credit hours (Choice of 3)	• EAET 5000 Engineering Modeling • EAET 5001 Design Optimization • EAET 5002 Reliability of Engineering • EAET 5003 Engineering Project Management
Track Courses 12 credit hours	Civil Engineering Track • CENG 5100 Bridge Design • CENG 5200 Reliability of Structures • CENG 5300 Structural Analysis by Finite Elements • CENG 5400 Seismic Design Electrical Engineering Track • EENG 5100 Linear Systems and Topics in Control Theory • EENG 5200 Advanced Analog-Digital Control • EENG 5300 Digital Signal Processing and Control • EENG 5400 Manufacturing Computer Control Systems Mechanical Engineering Track • MENG 5100 Design and Analysis of Experiments • MENG 5200 Design for Manufacturability • MENG 5300 Solid Mechanics • MENG 5400 Machine Design by Analysis
Elective Courses 6 credit hours (Choice of 2)	Civil Engineering Track • CENG 6100 Nonlinear Structural Analysis • CENG 5310 Advanced Steel Design • CENG 5330 Advanced Concrete Design Electrical Engineering Track • EENG 5310 Digital Signal Processing and Control II

	• EENG 6100 Power System Operation and Control Mechanical Engineering Track • MENG 6100 Mechatronics • MENG 5310 Thermal Fluid systems
Capstone Project 3 credit hours	EAET 6000 Graduate Capstone Project

The proposed graduate program would have been offered during the daytime, evening, weekend, online, and in a hybrid class format to provide students with a range of options.

LESSONS LEARNED

As with any project of this scope, there were many lessons learned including the following:

- The program would have offered an abundance of flexibility for students and during the initial period this may not lead to an efficient use of the available resources from an enrollment perspective. Therefore, the number of the electives offered should consider the expected initial enrollment while still allowing for specialization within the track. For this M.Eng. program the electives could have been reduced from two to one course and consequently the core can be increased to 12 credit hours, to include all four core courses offered, which would have helped with the enrollment in the respective courses.
- A more detailed plan for incorporating assessment of aggregate student performance and closing the loop in the program development process and ongoing improvement of the program should have been developed and communicated to the university leadership.
- This proposed graduate program is an example of outcomes based curricular design developed to fit very local needs, goals, and constraints. It cannot simply be adopted in entirety and dropped into another institutional framework.
- The design of programs like this should consider creating a pipeline between undergraduate and graduate engineering education, such as the 4+1 model which provides a streamlined path for students planning to pursue graduate degrees in their career.
- The program should have emphasized the substantial difference of ethnical diversity within the population it would have served when compared to similar programs from local universities. A large percentage of the students that graduate with a BS in engineering from the university are Hispanic. These individuals are very likely to continue their education in a program that aligns with their undergraduate training.
- The program should have further pointed out the mechanism by which it would have become self-supporting without the need of hiring many faculty members in the short term. It also should have included a plan for expansion as the program grew.

CONCLUSION

The authors proposed an interdisciplinary Master of Engineering in 2017. While that proposal was not approved by the university and the program was not created, several lessons were learned from the experience of developing that program. The program itself consisted of 30 credits hours which is very common for this type of degree, and this was to be a professional master's degree focused

on courses work, rather than a thesis-based master's degree. All students would have been required to complete a nine-credit hour core, and a three-credit hour capstone experience. What sets this program apart from many others is that it would have provided three tracks for the remaining 18 credit hours: one in Civil Engineering, one in Electrical Engineering, and a third in Mechanical Engineering. The admission requirements are summarized above and are typical for most master's level engineering programs.

This program would have been effective in meeting the evolving and increasing demands placed on engineers today in terms of expanded expectations for technical competency and interdisciplinary collaboration. It would have also more effectively tapped into minority populations that university serves when compared to most engineering program and therefore promoted equity and inclusion. That inclusivity would have been bolstered by the wide range of delivery options and course scheduling to meet student were they are and enable them to maintain their current careers and family obligations.

In the end this program was not approved, and some of the lessons learned from the development of it include the need for a more complete financial model, plan for the growth and expansion of the program, as well as the need to manage the cost of the program during the early phases of growth through a limitation of the course offerings.

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