

## Capstone Internships for Engineering Management Professional Science Master's Degrees Benefit Students and Employers

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Dr. Saeed Foroudastan is the Associate Dean for the College of Basic and Applied Sciences (CBAS). The CBAS oversees 10 departments at Middle Tennessee State University. He is also the current Director for the Masters of Science in Professional Science program and a professor of engineering technology at MTSU. Foroudastan received his B.S. in civil engineering, his M.S. in civil engineering, and his Ph.D. in mechanical engineering from Tennessee Technological University. Additionally, he has six years of industrial experience as a Senior Engineer and 20 years of academic experience as a professor, Associate Professor, and Assistant Professor. Foroudastan's academic experience includes teaching at Tennessee Technological University and Middle Tennessee State University in the areas of civil engineering, mechanical engineering, and engineering technology. He has actively advised undergraduate and graduate students, alumni, and minority students in academics and career guidance. Foroudastan has also served as Faculty Advisor for SAE, Mechanical Engineering Technology, Pre-engineering, ASME, Experimental Vehicles Program (EVP), and Tau Alpha Pi Honors Society. In addition to Foroudastan's teaching experience, he also has performed extensive research and published numerous technical papers. He has secured more than \$2 million in the form of both internal and external grants and research funding. Foroudastan is the faculty advisor, coordinator, and primary fundraiser for EVP teams entering national research project competitions such as the Formula SAE Collegiate Competition, the Baja SAE Race, the SolarBike Race, the Great Moonbuggy Race, and the Solar Boat Collegiate Competition. For his concern for and dedication to his students, Foroudastan received MTSU awards such as the 2002-03 Outstanding Teaching Award, the 2005-06 Outstanding Public Service Award, and the 2007 Faculty Advisor of the Year Award. He received the Excellence in Engineering Education Award and Faculty Advisor Award from the Society of Automotive Engineers (SAE). He was also nominated for the MTSU 2005 and 2009-11 Outstanding Research Award. He received two Academic Excellence awards from the Tennessee Board of Region in 2010-11. Foroudastan has also won many College of Basic and Applied Science awards. In addition to this, Foroudastan also reviews papers for journals and conference proceedings of ASEE, ASEE-SE, and ASME, and he has been a session moderator for several professional conferences.

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Carey Snowden serves as the Graduate Coordinator for the Master of Science in Professional Science (MSPS) programs at Middle Tennessee State University, which includes the Engineering Management M.S. program. His duties include placing students into their capstone internships, recruiting students into the programs, and coordinating with the MSPS advisory board. He received his B.S. in Biology from the University of Alabama and his M.S. in Genetics from the University of North Carolina at Chapel Hill. Carey's passion is STEM student development, with an emphasis on developing programming and mentorships for under-represented minority, first generation, female, and LGBT+ STEM students. In his career, he has worked to create and re-start student clubs for these cohorts to develop impactful outreach, mentorship, and professional development opportunities.

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## Abstract

Professional Science Master's (PSM) degree programs combine advanced STEM education with MBA-level business classes and a capstone internship. These programs produce successful graduates in the science and engineering management fields. Our Engineering Management PSM program is designed to provide students with an engineering management education both inside and outside the classroom through the region's booming manufacturing industry.

The capstone internships for the Engineering Management program greatly benefits both the student and the employer. For students, these internships provide an opportunity to put into practice both their engineering management and business management education. Additionally, over 70% of our students are offered employment at their place of internship after they have completed it. Since the Engineering Management program began, the internship has been consistently listed as the most popular part of the degree program and a primary reason for choosing to enter the program. The experience that PSM students get from internships is one of the reasons why their average starting salaries are often double those with just an undergraduate degree.

These internships are also of great benefit to the employers. Since these students have completed a majority of their classwork, the projects and expectations for their work can be at a much higher level than work expected of undergraduate interns or recent college graduates. Many industries in the region have projects that they would like to have completed, but due to labor and time shortages never get done. Engineering management interns provide them with a highly skilled worker who can complete the project at reduced labor cost. Furthermore, since these students have had additional coursework in business management, they have the professional skills needed to accomplish these projects independently with minimum supervision.

## Introduction

In its 2017 report on professional development for STEM graduate students, the Council of Graduate studies recommended, "Greater alignment among employers and universities to ensure that the professional development experiences provided to advanced STEM graduate students are relevant, and where possible tailored, to employer needs."<sup>1</sup> They also recommended greater partnerships between STEM graduate programs and employers to better prepare students who were going into non-academic careers, and that professional development complement the students' academic coursework.<sup>1</sup> Professional Science Master's (PSM) degree programs were started in the late 1990's to meet industry's demand for STEM graduates who also had business professional skills.<sup>2</sup>

The Master of Science in Professional Science (MSPS) program at Middle Tennessee State University (MTSU) was started in 2004 to provide students in middle Tennessee a pathway towards management in science careers.<sup>3</sup> For these PSM programs, roughly 2/3 of the coursework is in advanced STEM, while the other 1/3 consists of graduate-level business

management “core courses” designed for STEM students. Part of the core courses is a complex, 250-hour capstone internship, where students must put into practice both their hard science and engineering knowledge and their professional business skills.

The Engineering Management (ENMA) MSPS program was started in late 2013 to provide students with science and engineering bachelor’s degrees a successful path towards management in manufacturing and other industries (such as healthcare). Courses were offered at night to allow full-time workers the opportunity to return to earn a master’s degree to enhance their career. A typical full-time student can finish the degree in 2 years or less. However, many of our students are currently full-time employees and require longer to graduate. Enrollment has grown to around 25 current students (not counting those who have graduated), with the total enrollment of all MSPS programs currently around 130 students.

In order to maximize the ENMA students’ value to potential employers, students in this program become certified in the process improvement methodologies of Six Sigma, lean manufacturing, and project management, along with additional coursework in safety and engineering management principles. The addition of the core courses provides students with the business skills they will need as they move up in management, covering topics such as accounting, leadership, communication, statistics, and legal issues. All but one of these core courses were developed and are taught by the MTSU Jones College of Business graduate faculty, the exception being the statistics course (which is taught by our statistics graduate faculty). This partnership ensures that the professional development of these STEM students is on par with that of an MBA-type program and adds additional value for students and employers.

Data collected from ENMA students and their internship employers demonstrates how both the core business courses and the engineering management curricula benefit the employer and the student in their internship. Students report a high satisfaction with the internship process, with a significant number being offered jobs at their place of internship. Additionally, employers report a high satisfaction with these students and the internship.

## **Methods**

The internship course is a 3-credit hour course administered by the Jennings A. Jones College of Business at MTSU. Students work with the MSPS graduate coordinator to find an internship for their last or second-to-last semester of study. The MSPS graduate coordinator works with our industry Advisory Board and other community members to help place our students, although most of them find their internships on their own through networking. The internship must be 250-hours long, and the internship project must utilize both their science and business education. After being offered an internship, students must then have it approved by both their faculty academic advisor and by the internship course administrator.

Before MSPS students complete the course and present their work, students are provided a survey which asks them to rate their experiences with all of the aspects of their degree program, including their satisfaction with the coursework, program, and advising. Employees are provided a survey to rate students at both the mid-term and at the end of the internship. These surveys cover their opinions of the students science and business knowledge, as well as their

satisfaction with the student’s performance overall. The data is from the surveys for 15 of the ENMA who completed their internships between 2014– 2017.

**Student Internship Benefits**

ENMA students benefit from their capstone internship by being able to put their engineering and business skills into practice, and by getting experience in the field that can advance their careers. Exit interviews were conducted for each student at the end of their internship. Students self-report on a survey their satisfaction with the coursework, program, and advising. Data collected from 2014–2017 on ENMA students’ opinions on the core coursework and major coursework in regards to their internship are reported in Table 1.

Question	% Agreed	%Agreed/Neutral
Major courses in your area of study enhanced your role as a science professional during your internship experience.	93	100
The core courses provided information needed to succeed in a business environment.	80	100
The business core courses enhanced my role as a science professional during my internship	80	93

*Table 1 Internship exit survey results from ENMA students from 2014–2017.*

During the exit interviews, no students surveyed were dissatisfied with their internship; and almost all reported that their internship was a positive experience.

In 2016, the MSPS program completed a 5-year review. In its survey of the impact of the internship on students and their careers, it found that

- 70% of all MSPS students (including ENMA students) were offered positions at their place of internship employment and
- 95% of all MSPS students were employed at time of graduation.<sup>3</sup>

These results demonstrate that both the professional development and the concentration coursework benefits the students’ internship experience, and that the internship benefits the students through experience, job offers, and employment.

**Employer Benefits**

Employers benefit from the internship process in a number of ways, including having lingering projects completed by skilled graduate professionals, bringing in fresh perspectives to help solve ongoing issues, and interacting with potential new employees. ENMA students’ Six Sigma, lean, and project management certifications also make them ideal candidates for efficiency and improvement projects beyond manufacturing.

Asurion	Nissan, USA
Feintool	Schneider Electric
Jonstens, Inc.	Siemens Medical Solutions, USA

*Figure 1 Partial List of ENMA Internship Employers 2014–2017*

ENMA students secured internships at a variety of employers (Figure 1). Internship employers completed mid-term and final assessments of ENMA students. Employers rated students on several factors, including their knowledge of concentration content (here ENMA coursework), interpersonal skills, quality of work, and overall performance. Additionally, employers were asked about the ENMA student’s ability to solve problems compared to a typical new employee. The results are reported on Table 2.

<b>Metric</b>	<b>Average Mid Term (out of 5)</b>	<b>Average Final (out of 5)</b>
Interpersonal Skills	4.6	4.6
Quality of Work	4.6	4.72
Knowledge of Concentration Content	4.6	4.6
Overall Performance	4.4	4.72
	<b>Better Than</b>	<b>Better than</b>
Ability to Solve Problems as Compared to a New Employee	80%	91%

*Table 2 Internship Employer Assessments of ENMA Students 2014–2017*

The results show that the employers were highly satisfied with the ENMA internship students, including both their professional skills (interpersonal) and their concentration knowledge. More importantly, employers benefited by having an intern who was more capable than an average new employee at solving problems.

One example of a successful ENMA internship involved an international student who completed a summer internship at a local manufacturer. This student applied Six Sigma and lean principles to a complex assembly line and was able to successfully reduce parts inventory while virtually eliminating shortages. The employer had not been able to assign anyone to this project, and an intern from our ENMA program was the perfect fit to complete it. The employer was so impressed with the student’s performance that a job offer was made, including working out the legal issues regarding a work visa for the student.<sup>4</sup> These types of experiences with employers demonstrates the benefit of hiring an ENMA intern both to complete complex projects and to recruit future employees.

## **Discussion**

The MSPS ENMA program was designed to help move students with engineering and science backgrounds from factory floors to management offices by providing them with the engineering management and business skills needed for a successful career.<sup>3</sup> A major part of this program is the internship, where students apply what these skills in a business environment. Both students and their internship employers report that the ENMA program coursework, including the business core courses, prepares students for a successful internship, and that the internship program is a benefit for both the student and the employer.

This kind of “win-win” for both the student and employer is the type of successful “alignment” of employers and universities recommended by the Council of Graduate Studies.<sup>1</sup> Based on our results, the argument can be made that providing STEM graduate students with professional

development and business skills is a critical component for building these alignments, providing a more meaningful internship experience for both the employer and the student.

A broader, more general national survey of PSM alumni found similar results, with alumni reporting high satisfaction with the coursework, professional development, internship, and experiential learning.<sup>5</sup> Interestingly, alumni nationally reported mixed results on the satisfaction with the internship in relation to job placement<sup>5</sup>, whereas our most recent review showed 70% of MSPS students getting offers for employment at their internship<sup>3</sup>. Internship placement seems to be the key factor in determining whether the internship is professionally beneficial for PSM students nationally.<sup>5</sup>

## **Conclusion**

Surveys completed by both ENMA students and their internship employers show that both benefit from the internship and from the MSPS business core courses. While the data gathered to date points to the effectiveness of our internship program for both the student and the employer, more data is needed regarding the long-term effect on the students' careers and salaries and with employer satisfaction and retention. In the Council of Graduate Studies report on professional development for STEM graduate students, their fifth recommendation is, "Assessment of professional development must evolve beyond student participant satisfaction to include evaluation of the effectiveness of training in participants' subsequent nonacademic and academic careers."<sup>1</sup>

To this end, the MTSU MSPS program will begin to reach out to survey alumni in order to capture career and salary data. Currently no STEM graduate program exists within our institution that requires or allows for internships without any professional development of its students, so comparisons of our students with ones with no business management training is not possible. Therefore, other methodologies will need to be developed to further measure the efficacy of the MSPS core courses and any future curricula changes. Many internship employers are part of the MSPS program's external Advisory Board. In the coming years, they will provide input on the long-term benefits of the MSPS internships and hired graduates, including employment retention and the value of the core course curricula.

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