Graduate Schools for Manufacturing Engineering

Kanak Chattopadhyay  
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This report investigates the prevalence of graduate programs for Manufacturing Engineering. Specifically, the report highlights academic institutions in the United States and abroad that provide opportunities for students to study Manufacturing Engineering. Core curriculums and unique features of various programs are explored throughout the discussion. Economic and business aspects of graduate programs are examined following the previous discussion of academic institutions and their programs. Additionally, a discussion on the relevance of graduate programs for manufacturing engineering for beginning and experienced engineers is provided for the reader. Lastly, an authored discussion is included to share key learnings from the project.

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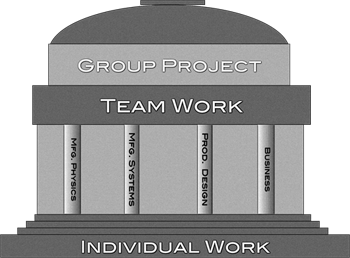
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*Introduction*

In the realm of higher education, engineering is a broad category that enables students to explore diverse disciplines. At the University of Delaware, for example, undergraduate students have the opportunity to pursue the following engineering disciplines: biomedical, chemical & biomolecular, civil & environmental, computer & information sciences, electrical & computer, and mechanical. Though most undergraduate curriculums provide a comprehensive skillset relevant to a certain engineering discipline, many students opt to pursue further studies to obtain a graduate degree in engineering. Master’s degrees enable graduates who either want to further specialize from their undergraduate studies or want to explore a different discipline in engineering. Interestingly, in a 2015 article from U.S. News, University of Delaware’s Dean of the College of Engineering Babtunde Ogunnaike emphasized that “Master’s degrees prepare students for careers in industry that don’t have a research focus.”1

While Dean Ogunnaike’s words resonate for a variety of graduate degrees, they hold true in particular to one graduate program: Manufacturing Engineering. Manufacturing Engineering is a technical, specialized discipline that builds off the fundamentals of core disciplines such as mechanical engineering. In addition to key engineering principles, Manufacturing Engineers are equipped to apply fundamentals related to business management and economics to “…focus on the design and operation of integrated systems for the production of high quality, economically competitive products”2. Manufacturing Engineering is a diverse discipline, and there is an equally diverse range of graduate programs offered in the United States and abroad which prepare interested students to excel in the field.

*Manufacturing Engineering Graduate Programs in the United States*

In the United States alone, there are a variety of high ranked graduate programs which students can apply for to study Manufacturing Engineering. One of the top ranked institutions for graduate programs in Manufacturing Engineering is the Massachusetts Institute of Technology (MIT) according to a 2018 report by U.S. News.18 At MIT, interested students can pursue a “Master of Engineering in Advanced Manufacturing & Design” degree. MIT’s one year program offers a balanced approach between engineering and business by focusing on manufacturing process and assembly physics, factor and supply chain systems, product design, and business fundamentals and operational excellence (Figure 1). While the technical coursework builds heavily off engineering fundamentals and challenges students to individually develop critical thinking skills, a large majority of the coursework is project based and revolves around team projects. In fact, students partake in an extensive integrated design project for upwards of three months with a leading industrial company to apply learned principles throughout their studies as a part of their graduate thesis. Industry projects are diverse and have included supply chain planning for semiconductor manufacturing, modifying processing for polymer cells, and implementing lean principles to reduce cycle time in ion implanter manufacturing.12 Graduates from MIT’s program have progressed to a variety of careers including developing technologies for soft-lithography, implementing inventory management layout plans for oil rig plants, serving as sales managers for metals companies, and more.[[1]](#footnote-1)Since MIT’s curriculum has a heavy project-based component, many leading manufacturing companies have noted that MIT’s graduates stand out as “outstanding team players, quick learners, and determined problem solvers”3. Though MIT’s graduate program is a fast paced 12 month experience, it immerses students in real world engineering challenges and prepares students to practice leadership skills with a technical mindset upon graduation.

**Figure 1**. Visual Representation of the Organizational Structure of MIT’s curriculum.12

In addition to MIT, the University of Michigan is another well-established institution which offers a degree for a Master of Engineering in Manufacturing. Michigan’s one year graduate program has a core focus on quality and equips students to improve the overall efficiency of manufacturing systems. Beyond standard application requirements such as having an undergraduate engineering degree and taking the Graduate Record Examination (GRE), an interesting prerequisite requirement is to have taken a college course in manufacturing processes.13,**\*** Michigan’s Manufacturing Engineering curriculum includes 70% of technical engineering courses and 30% business courses4. Courses such as “Operations Analysis and Management” and “Principles of Managerial Accounting” within the business aspects of the program emphasize developing strong management skills for degree candidates. From a technical standpoint, students can select from over 80 engineering courses such as “Advanced Biomedical Manufacturing” and “Quality Engineering Principles and Analysis” to name a few.4

Students also have the option to complete the entire degree online so they can work full-time while studying. While Michigan’s program offers a lot of flexibility to students, one of the requirements for the degree is to complete a capstone manufacturing project course that’s carried out either at the student’s current place of employment or another industry. Though Michigan’s graduate program offers a balance of business and engineering courses, the university also offers a dual program where students can obtain a Master’s Degree in Manufacturing Engineering and a Master’s Degree in Business Administration (MBA) in under three years.13 This dual program may be ideal for candidates who already have a full-time industry position and are seeking to rise in their institution’s leadership. Based on the diverse range of program tracks for graduate students, it’s no surprise that current students at the University of Michigan have praised the program for not only having an interdisciplinary balance but also providing a flexible schedule that allows students to creative explore the field and develop innovative solutions to revive American manufacturing4.

On the west coast, in the heart of Los Angeles the University of Southern California (USC) offers a Master of Science degree for Manufacturing Engineering that is also focused on preparing graduates to address the twenty-first century challenges associated with today’s manufacturing industry (Figure 2). USC’s program has a large technical focus and exposes students to traditional topics such as materials selection and handling and more current topics such as designing using advanced equipment and software. Though the program offers students flexibility to take elective courses in specialized areas such as additive manufacturing, required courses like “Advanced Computational Design and Manufacturing” and “Mechatronic Systems Engineering” challenge students to build off mechanical engineering fundamentals and apply computer programming skills for manufacturing systems design projects.14 Additionally, required courses such as “Design of Experiments” teach students understand the relationships between different manufacturing process designs and performance requirements. From a business standpoint, USC students have the option to take classes to obtain Six Sigma and Lean Certification. While obtaining lean certification is an extensive process, students can complete courses to obtain the Six Sigma Green Belt for Process Improvement, Six Sigma Black Belt, and Lean Six Sigma White Belt. Throughout these courses, students learn about statistical process control, root cause analyses, value stream mapping, and more lean concepts.19 Beyond lean principles, USC’s program heavily emphasizes entrepreneurship courses for students5. Considering the growing nature of start-up businesses and new technologies introduced in the west coast in areas like Silicon Valley, it’s not surprising that USC’s degree has an entrepreneurial focus and wants to produce graduates that create innovative manufacturing designs which benefit others.

Figure 2. University of California Viterbi School of Engineering

While the above mentioned institutions are merely a few of the many universities in the United States who specifically offer graduate programs in Manufacturing Engineering, there are many other institutions which offer similar tracks that allow students to learn more about the discipline. For instance, Virginia Tech offers two tracks for Manufacturing Systems Engineering. Students intending to work in industry can pursue a non-thesis degree and take a variety of courses in manufacturing systems engineering to diversify their skillset. At Virginia Tech, students also have the option to take manufacturing systems courses and conduct independent research in areas such as computer-integrated manufacturing or automation to complete a thesis in conjunction with their degree. This curriculum track is beneficial for students determined to pursue advanced industry positions or work to earn a Ph.D. degree.6 While Virginia Tech’s program allows students to take courses in a variety of manufacturing topics such as machine vision and materials handling, there are noticeably less business and economics courses. In fact, a course titled “Lean Manufacturing” is one of the few required courses that is primarily business-oriented.15 Therefore, Virginia Tech’s program could be a sensible choice for an engineer who’s perhaps practiced in industry for a few years and truly wants to expand their technical knowledge.

Along with Virginia Tech, the University of California, Los Angeles (UCLA) is another top ranked institution that offers different types of Manufacturing Engineering graduate programs. Through the Mechanical and Aersopace Engineering Department, UCLA offers a comprehensive program called Design, Robotics, and Manufacturing. UCLA’s program is much more technically focused than other programs and highly emphasizes student research. Topics of study include design methodology, computational geometry and geometrical modeling, and beam and plasma assisted manufacturing. Though UCLA gives students the option to take a capstone course and work with an industry sponsor, the alternative option is to complete and pass three written exams for three different graduate level courses that are held concurrently with the final exams of those same courses.7 Evidently, UCLA’s graduate program is better tailored towards those who perhaps already have a strong business background and are simply passionate about developing innovative technical solutions in the manufacturing industry.\*[[2]](#footnote-2)

While many institutions in the US explicitly offer graduate programs for Manufacturing Engineering, other universities give students the option to concentrate on manufacturing without directly pursuing a degree in that field. For instance, at Purdue University interested graduates students can pursue a degree in Mechanical Engineering and concentrate their research on manufacturing and materials. Through research, students have the opportunity to explore a variety of manufacturing applications in consumer and commercial industries. In addition to independent research, at Purdue students have the opportunity at world class facilities to study manufacturing. For instance, the Birck Nanotechnology Center on campus includes the world’s largest academic cleanroom for nanofabrication applications (Figure 3).8 Purdue University’s graduate programs exemplify how students can core engineering disciplines such as mechanical engineering and supplement their experience with research in manufacturing at the graduate level.

Figure 3. Researchers at Birck Nanotechnology Center8

*International Manufacturing Engineering Graduate Programs*

Beyond the United States, students have many options to study Manufacturing Engineering at the graduate level. Renowned institutions abroad that give students the option to study manufacturing at the graduate level include the University of Cambridge, the University of Oxford, the Imperial College of London, Tsinghua University, the National University of Singapore, and ETH Zurich – Swiss Federal Institute of Technology.9 The reality is that students can not only obtain reputable degrees abroad but can furthermore have a diverse educational experience which they may not experience otherwise through the US educational system.

For instance, at the University of Cambridge in the United Kingdom students can obtain a Master of Philosophy degree in Industrial Systems, Manufacture, and Management (ISSM) over the course of eleven months. The ISMM curriculum is unique in that unlike other curriculums students are required to complete four different projects with industry sponsors throughout the course of the program. Aside from working with sponsors, students also work within the university’s Institute for Manufacturing and take initiative on research projects in areas like digital manufacturing and learn how to develop leadership skills in a manufacturing context.16 Beyond industry projects and research, students are required to complete a thesis. For a thesis, students must conduct literature reviews, which are essentially in-depth analytical essays, to organize information throughout their research process.11 Evidently, the University of Cambridge’s graduate program is distinct from others because it heavily emphasizes developing effective communication skills through intensive literature reviews. Furthermore, since Cambridge’s program includes four different industry sponsored projects versus one, students have the advantage to not only network with others but also explore a variety of industries before settling into their careers.

Since each academic institution is subject to have their own set of guidelines, it’s important to note that US students should not assume that academic guidelines are universal abroad. Rather, students interested in studying abroad should be prepared to encounter different academic norms and should embrace different schools of thought. Students should also note that language barriers should not restrict them from enrolling in graduate programs abroad since many international students now offer to teach major curriculum courses in popular languages such as English, even if that differs from the native language of the host institution.10

*Economic Aspects of Graduate Manufacturing Engineering Programs*

Through researching curriculums for a variety of academic institutions, economics and business clearly are significant in graduate Manufacturing Engineering programs. In fact, as mentioned in the above discussion, programs require students to complete a minimum set of business courses focused on topics such as supply chain economics, finance, and management to develop a fundamental business sense. Since many students take business courses concurrently with technical manufacturing classes and hands-on classes, they quickly learn to draw connections between the business and engineering applications of the field. Additionally, through industry sponsored projects, students learn firsthand about how factor economics into manufacturing designs. Beyond coursework that prepare students to thrive in established operational facilities, many institutions such as the University of Michigan and UCLA also offer classes specifically based on entrepreneurship. For degree candidates interested in launching their own businesses, graduate level entrepreneurship courses are valuable since they provide students with the savvy to develop business models, conduct market assessments, identify customer segments, and weigh out the financial pros and cons of trying to start a new business in the manufacturing space.

*Relevance for Beginning and Experienced Engineers*

The significance of this topic for a beginning engineer is that while a four year undergraduate degree in a core discipline such as Mechanical Engineering provides a plethora of skills in fundamental areas such as machine design, fluid mechanics, and heat transfer, there are simply far too many manufacturing systems and processes to learn about than time permits in an undergraduate curriculum. Graduate programs in Manufacturing Engineering are beneficial to newer engineers because they provide a core set of engineering and business classes necessary for future careers but also offer exposure to a variety of specialized areas such as microelectronics fabrication, resin transfer molding for composites, pharmaceutical devices manufacturing, and more. Truthfully, graduate programs in Manufacturing Engineering are advantageous because they can help young engineers to hone in their professional interests through immersive coursework, network with industry professionals through capstone projects, and gain a competitive edge before settling into the work force.

The significance of this topic for an experienced engineer is that while manufacturing processes and systems have maintained a presence throughout various industries, these manufacturing systems have also continued to grow and evolve over time. Additive manufacturing techniques, for example, have evolved significantly to now provide the rapid visualization of proposed ideas and help get new products into the commercial market quicker.17 For experienced engineers who wish to learn more about newer developments in sectors such as additive manufacturing, or want to learn more about manufacturing processes or systems they haven’t encountered much in their careers, graduate programs can be an effective pathway to quickly gain technical knowledge. Additionally, for experienced engineers who are well versed in the technical aspects of manufacturing processes and systems, graduate programs in Manufacturing Engineering are still valuable because the core business courses can inform them of how to consider economic implications in manufacturing development to bring cost savings without comprising on quality and functionality. Furthermore, graduate programs are beneficial to experienced engineers hoping to advance in their existing careers in terms of management because many institutions allow students to complete the degree at their own pace while working a full-time position. Ultimately, graduate programs support continuous learning and can accommodate engineers at all stages of their careers.

*Learning*

Through this project, I learned that there are a variety of graduate programs in Manufacturing Engineering in the United States and abroad that provide students with theoretical and hands-on coursework pertaining to engineering fundamentals, specific manufacturing processes/systems, and business principles. To learn more about graduate programs in Manufacturing Engineering, I first started by searching online for a concrete definition of manufacturing engineering. After finding a few definitions from various academic sources and trade magazines, I then narrowed my search to find graduate programs for manufacturing engineering. Since one of the top results was the U.S. News World Report’s rankings for graduate programs, I used that resource as a benchmark. Then, I decided to further research schools on that list from different geographic regions to get a more overarching sense of graduate programs in the US. For each institution, I started by searching on the university or department’s website. I then proceeded to read more details about the curriculum of each institution and also examined course catalogs to see the types of courses available to students. When possible, I also searched websites to see feedback from alumni of the program. Since I know that it is not uncommon for students in other majors to attend graduate schools outside the United States, I decided to conduct a similar research process as stated above to learn about graduate programs in Manufacturing Engineering that were available to students abroad.

Truthfully, I did not expect to find many graduate programs in Manufacturing Engineering and thought that most universities would offer concentrations in manufacturing to supplement a degree in a core discipline such as Mechanical Engineering. While some universities followed my expectations, I was honestly surprised to learn just how many institutions explicitly offer graduate degrees in Manufacturing Engineering. Furthermore, I realized that all universities take an interactive approach and value having students step outside the classroom and troubleshoot challenges in the industry through completing sponsored projects. Considering that sponsored projects could be an excellent opportunity to network with professionals in the manufacturing industry, I realized that university location would actually be a very important factor to consider.

Ultimately, this research project not only helped me to learn a lot about different graduate programs for manufacturing engineering, but it helped me to learn more about my personal goals. Right now, in MEEG453 I’ve enjoyed learning more about the manufacturing industry and its associated processes and systems. Although I know that I would like to start my engineering career by working in industry, I’ve always been interested in continuing my studies and attending graduate school. This project helped me to realize that it’s valuable to focus as a beginning engineer and dive into hands on work in industry and gauge my personal passions first. By doing that, I can have a stronger understanding of my professional interests, capitalize upon the diverse array of educational opportunities, and perhaps find a graduate program experience that is right for me.

References

1. Haynie, Devon. “Choose Between a Master's, Ph.D. in Engineering.” U.S. News and World Report, 16 Mar. 2015, 8:30AM.

2. Anonymous. “What Do Manufacturing Engineers Do?” College of Engineering, Oregon State University, 26 June 2012.

3. “Advanced Manufacturing and Design Innovation @ MIT.” Master of Engineering in Advanced Manufacturing and Innovation | Advanced Manufacturing and Design Innovation @ MIT, Massachusetts Institute of Technology.

4.“Master of Engineering in Manufacturing.” Integrative Systems + Design, College of Engineering, University of Michigan, University of Michigan.

5. “MS in Manufacturing Engineering.” USC Viterbi | Prospective Students, University of Southern California Viterbi School of Engineering.

6. “Manufacturing Systems Engineering.” Grado Department of Industrial and Systems Engineering | Virginia Tech, Virginia Polytechnic Institute and State University.

7. “Graduate Programs and Preliminary Exams.” UCLA Mechanical and Aerospace Engineering, UCLA Engineering, 2017.

8. “Graduate Programs.” Mechanical Engineering - Purdue University, Purdue University.

9. “Mechanical, Aeronautical & Manufacturing Engineering.” Top Universities, QS Quacquarelli Symonds Limited, 16 Mar. 2017.

10. Lee, Megan. “4 Myths About Americans Earning Graduate Degrees Abroad.” U.S. News, U.S. News & World Report LP, 26 May 2015.

11. “MPhil in Industrial Systems, Manufacture, and Management.” Cambridge Core, Cambridge University Press, 25 June 2015.

12. “MEngM Capstone: Industry Projects.” Massachusetts Institute of Technology, Massachusetts Institute of Technology, 2017.

13. “Dual Master of Engineering in Manufacturing and Master of Business Administration.” Integrative Systems + Design, College of Engineering, University of Michigan, The Regents of the University of Michigan, 2017, isd.engin.umich.edu/degree-programs/manufacturing-engineering-mba/prerequisites.htm.

14. “USC Catalogue.” Program: Manufacturing Engineering (MS) - University of Southern California - Acalog ACMS™, University of Southern California , 2017, catalogue.usc.edu/preview\_program.php?catoid=7&poid=6743&returnto=2081.

15. “Manufacturing Systems Engineering.” Grado Department of Industrial and Systems Engineering | Virginia Tech, Virginia Polytechnic Institute and State University, 2017, ise.vt.edu/academics/graduate/ms/mfg.html.

16. “IfM: New Thinking about Manufacturing.” About the Institute for Manufacturing - IfM, University of Cambridge, [www.ifm.eng.cam.ac.uk/aboutifm/](http://www.ifm.eng.cam.ac.uk/aboutifm/).

17. MEEG453 Course Notes, Dr. William Fagerstrom

18. “The Best Industrial / Manufacturing / Systems Engineering Programs in America, Ranked.”U.S. News & World Report, U.S. News & World Report, 2017, [www.usnews.com/best-graduate-schools/top-engineering-schools/industrial-engineering-rankings](http://www.usnews.com/best-graduate-schools/top-engineering-schools/industrial-engineering-rankings).

19. “Six Sigma & Lean Certification.” USC Viterbi | Executive Education, University of Southern California, 2017, viterbiexeced.usc.edu/engineering-program-areas/six-sigma-lean-certification/.

1. \* I found it interesting that an undergraduate course in manufacturing was a prerequisite for the University of Michigan’s since I’m currently taking MEEG453 (a technical elective at the University of Delaware which could satisfy that requirement). [↑](#footnote-ref-1)
2. \*While UCLA’s program could be beneficial to provide a stronger technical background to candidates who already have a engineering and business background, the program could also be beneficial to engineers who solely wish to gain a better technical understanding of the different types of manufacturing systems and processes. [↑](#footnote-ref-2)