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Supply Chain Management: Is It a Must Course for Manufacturing Engineering Technology?

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Abstract:

Manufacturing organizations in the twenty first century are much more distributed than those of nineteenth century where companies used to be mostly vertically integrated. This has made the manufacturing planning works increasingly complex. On top of that, globalization and advances in information technology have added yet another layer of complexity to manufacturing and supply chain management. In this paper, we present results of an exploratory study of manufacturing engineering technology curricula of key select 4-year and 2-year colleges in the US. More specifically, this paper focuses on the institutes of those States that are among the highly ranked states with respect to manufacturing outputs in the U.S. The paper presents the results of two types of survey. First, through website exploration, it examines the curricula of the community colleges and 4-year institutes that offer manufacturing technology programs to determine if they offer any course on supply chain management and information technology systems. Secondly, the paper reviews the prior educational publications to identify the gap in existing manufacturing curricula. The main objective of this study is to create awareness in the manufacturing educators community thereby determine if there is a gap in the curricula that needs to be addressed.

Introduction

Due to globalized economy and ever increasing customer requirements such as shorter time to market, lower product cost, and higher quality, manufacturing functions such as engineering, sourcing, distribution have become tremendously complex in recent years. A study published by Deloitte[1] found that the continued pressure to lower the supply chain costs, to seek new and lucrative markets, and to enhance the speed of product development. More importantly, the same study reports that 15% of North American and 29% of European manufacturing firms produce their products outside of their home countries. The study goes on to report that 62% of the

manufacturing companies that participated in the survey were outsourcing their engineering operations. Majta[2] argues that supplier relationship is paramount to manage the risk in globalized manufacturing. Similarly, risk analysis and mitigation strategies are equally important tools and techniques that a manufacturing operations manager or manufacturing planning officer has to be equipped with.

This illustrates the importance of supply chain efficiency and reliability to ensure the timely launch of product and keep the cost under control. More importantly, it also underscores criticality of these skills such as procurement, logistics, and international trade set for today's manufacturing graduates. On the other hand, a report published by society of manufacturing engineering (SME) [3] describes that the manufacturing workforce is in short supply in the U.S. For example, per SME study, there were as many as 600,000 manufacturing jobs that could not be filled even during the height of great recession (2009-2012). SME's view is that manufacturing education itself is in crisis as there are very few students enrolling in STEM disciplines[3]. In addition to the lower enrollments, we believe that the manufacturing curriculum should be updated to cover the various aspects of globalized operations and supply chain management. While these courses are very common in business school, our research and experience shows that they are not always available in many manufacturing programs across the country.

The objective of this paper is to examine the need and availability for procurement and supply chain management related courses for manufacturing graduates in two year and four manufacturing engineering and manufacturing technology curricula in the U.S. Therefore, this study consists of two parts. In the first part, we review the curricular need of manufacturing programs with respect to supply chain management courses. It is done through review of prior literature. We also explore the growing need of manufacturing education and workforce development in oil and gas sector, a booming sector that has not been a key focus area for manufacturing in the past. In the second part, we discuss the survey of select universities and

junior colleges from high manufacturing activity states such as Michigan, California, Texas, Ohio, Indiana-to name a few.

What Skills set should be covered in Manufacturing Engineering and Technology Programs?

Talent development is an important function for any academic program including manufacturing. It is essential that all the manufacturing programs across the academic institutions prepare the students with adequate awareness, skills, and knowledge of the changing manufacturing landscape of the 21st century. To that end, based on the ABET accreditation criteria for manufacturing program, Society of Manufacturing Engineers (SME) has identified the four keys areas, all known as "the four pillars", that need to be covered in any manufacturing engineering or technology programs[4]. The Four Pillars are: Materials and Manufacturing Processes, Product, Tooling, and Assembly Engineering, Manufacturing Systems and Operations, and Manufacturing Competitiveness.

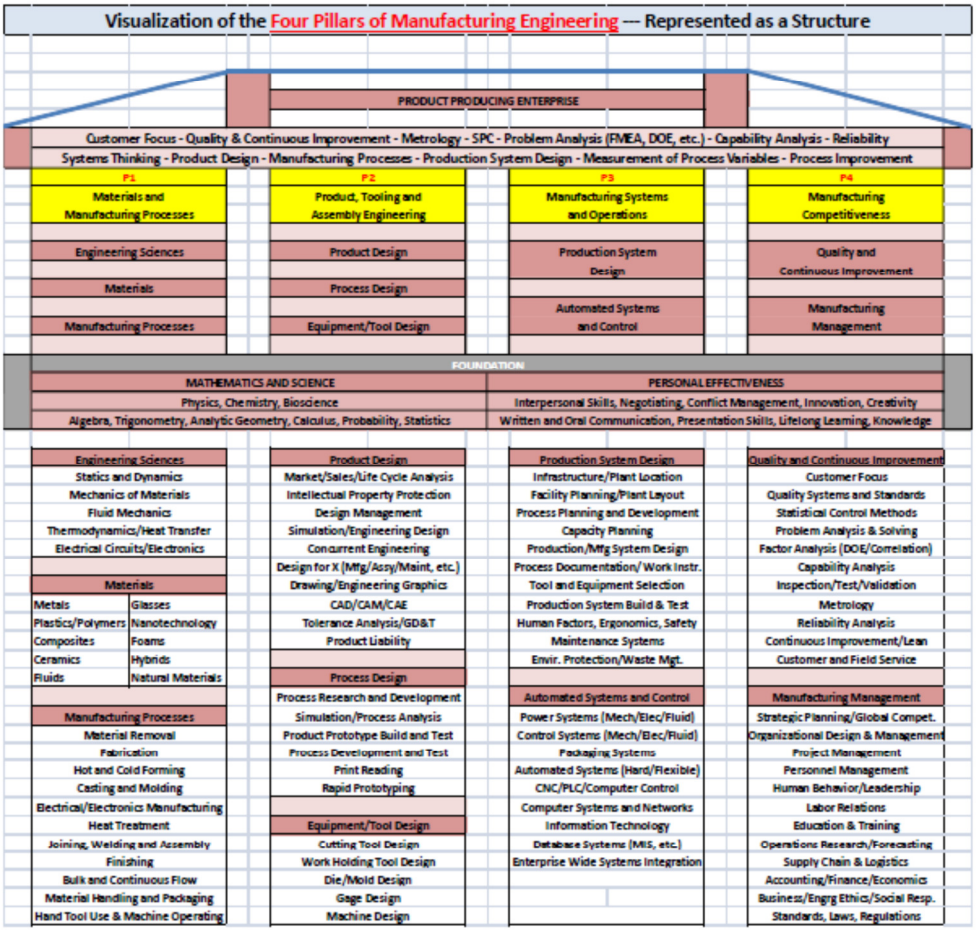

Figure 1: Four pillars of manufacturing engineering curriculum (source: adopted from Mott. et al[4].)

These pillars provide a guideline for curricular enhancement thereby meeting the need of the industry of 21st century. The Four Pillars can be used as an aid for schools and colleges for communicating the nature of the programs to university administrators, prospective employers, current and prospective students and the general public. The program administrators can refer to the Four Pillars document as they design curricula and individual courses to ensure that graduates are properly prepared in breadth and depth of the multiple aspects of the field. They can explore the interconnections among topic. Along with problem solving skills, manufacturing graduates are expected to have soft skills such as communication, leadership, and teamwork[5]. In addition, manufacturing engineers have to deal with multidisciplinary technical skills set such as those from electrical, mechanical, chemical, and electronics engineering and computer science

fields to be able to work on the shop floor. Similarly, for manufacturing planning, graduates need to acquire supply chain management and logistics skills sets. For example, Mohammed et al[6]. present a Manufacturing Engineering Technology (MfgET) program of a major university in north east Indiana which provides their graduates with solid knowledge and leadership skills in the area of manufacturing with an emphasis on process and systems design, manufacturing operations, maintenance, sales and service functions. Their curriculum also includes advanced skills like casting, forging, stamping, fabrication, plastics and CNC machining that are needed in the industry[6].

Zargari et al[7]. present a survey of SME fellows regarding the curricular need for undergraduate (B.S.) manufacturing engineering technology program. Their findings show that MfgET curriculum should include electrical/electronic technology, Manufacturing/Robotics Technology, Packaging Technology, Computer Technology, Design for Manufacturing and Architectural Drafting[7]. Career opportunities for manufacturing ET graduates also include other areas (beyond production shop floor jobs) such as manufacturing systems and operations. Furthermore, there is a constant need for the companies to update their product designs to introduce new products. This is due to the increasing competition and ever-evolving technology. Thus, engineers are always in demand to either optimize the manufacturing processes or increase productivity and work towards the development of new products and processes. Since these new jobs will require a higher level of advanced skill, it means that new and innovative educational approaches will need to be followed in order to prepare the manufacturing professionals for meeting the challenges facing the industry. Zagari et al[7]. report that the SME conducted research to determine the competency gaps of newly graduated engineering students by surveying those engineers upon which the honor of Outstanding Young Engineer had been bestowed. According to the study, of the 18 respondents, 16 felt there was a lack of competency because of the distance between the education and real world applications[7]. The SME also stresses on improving the manufacturing curricula to accommodate the new technologies to better prepare students for the employment in the 21st century manufacturing[3]. Similarly, Bennett and Millam[8] suggest that the manufacturing educators find ways to integrate leadership education, consulting, negotiation, and innovations into the programs. These are basic skills needed for manufacturing engineers as they may also

become the technical representative in a customer-supplier relationship thereby leading people and possessing the ability to foresee the consequences of their decisions. Likewise, supply chain is an important aspect of manufacturing, and the demand for the most talented supply chain professionals will continue to rise. According to Dittmann[9], a supply chain leader must possess five basic characteristics: global orientation, systems thinking, inspiring leadership, technical savvy and superior business skills.

New Opportunity for Manufacturing Graduates in Oil and Gas Sector

Traditionally, state of manufacturing has always been linked with that of products that are directed used by the people, for example, automotive, electronics, furniture, food and beverage, and construction equipment. However, due to recent boom in oil and gas due to newer drilling technology (such as hydraulic fracturing and sub-sea drilling), a lot of manufacturing activities over the last few years are happening in oil and gas industry. For example, as a country, US current crude oil production is about 4 million barrels per day which is expected to increase to 10.2 million barrels per day by 2040[10]. Nearly eighty percent (i.e, 3.2 million bbl/d) of today's crude oil production in the US is coming from tight oil and shale gas formations. Eagle Ford Shale and Permian Basin in Texas are the largest contributors of the Texas production. States of Texas and North Dakota are the major producers of the oil and gas in the U.S. If we just look at the State of Texas, nearly 80% of Texas counties are involved in oil and gas production. There are 26 oil refineries in Texas that can process 4.8 million barrels of crude oil per day. A study published in 2013 by American Petroleum Institute shows a significant economic impact of oil and gas industry in Texas. According to this study, there were 1.9 million jobs in the oil and gas sector in Texas in 2012, generating $144 billion in labor income and over $300 billion in value added activities in that year[11]. Manufacturing industry serves oil and gas sector in many ways. The direct applications of manufacturing in oil and gas sector are in refineries and petrochemical industries. On the other hand, manufacturing of machineries and fabricated metal industries supply to upstream exploration and production (E&P) operations of oil and gas industry. For example, pumps, compressors, drill pipe, drill bits, and other machined products are necessary to run the E&P operations.

According to a study done by *PricewaterhouseCoopers*[12], the oil and gas industry supports about 9.8 million jobs (including both direct and indirect employment opportunities) in the US. While the employment opportunities continue to grow, industry fears a big challenge in terms of fulfilling those jobs. A study published in *Bain Industry Brief* reveals that nearly 50% of the skilled workforce in petroleum industry retires within next five years[13]. American petroleum institute claims that there will be a shortage of 1 million skilled workforces in this sector by the year 2015[14]. Among others, there will be significant number of oil and gas jobs will be in manufacturing/machine/welding technician and logistics & supply chain management. Furthermore, renewable energy sectors like including wind, solar, and biomass are investing in newer manufacturing technologies to improve productivity thereby becoming cost competitive against the low cost producing countries like China, especially in the renewable sector.

Survey

During this study, we have reviewed select key schools in ten States that have high concentration of manufacturing activities. Table 1 shows the list of schools that were reviewed for this study. It should be noted that this is not an exhaustive list even for the represented States. However, we believe that this provides a good representation of major public universities and programs for this preliminary phase of study. The survey was done based on the information provided on their Websites.

Table 1: List of select universities that were reviewed during the survey

State	School	State	School	State	School	State	School
Texas	University of Houston	Georgia	Albany State University	Wisconsin	University of Wisconsin–Madison	Michigan	University of Michigan
	University of Houston - Downtown		Clayton State University		University of Wisconsin–Milwaukee		Michigan state University
	University of North Texas		Dalton State College		University of Wisconsin–Oshkosh		Michigan technological university
	University of North Texas at Dallas		University of Georgia		University of Wisconsin–Stout		Wayne state university
	Univeristy of Texas at Arlington		Georgia College and State University		University of Wisconsin–Whitewater		Bay College
	The University of Texas at Austin		Georgia Institute of Technology		Lakeshore Technical College	California	Stanford
	The University of Texas at Dallas		Georgia Southern University	Pennsylvania	Bloomsburg University of Pennsylvania		UC Berkley
	The University of Texas at El Paso		Savannah State University		Cheyney University of Pennsylvania		UC Los Angeles
	The University of Texas at San Antonio		Southern Polytechnic State University		Indiana University of Pennsylvania		UC San Diego
	The University of Texas at Tyler	Iowa	University of Iowa		Mansfield University of Pennsylvania		University of Southern California
	Prairie View A&M University		Iowa State University		Millersville University of Pennsylvania		UC Davis
	Tarleton State University		University of Northern Iowa		Shippensburg University of Pennsylvania		UC Irvine
	Texas A&M University		Southwestern Community College		Slippery Rock University of Pennsylvania		UC Santa Barbara
	Texas A&M University–Kingsville	Illinois	Governors State University		West Chester University of Pennsylvania		De Anza College
	Texas A&M University–San Antonio		Illinois State University		Pennsylvania State University	Ohio	Ohio State University
	Texas A&M University–Texarkana		University of Illinois at Urbana–Champaign		Temple University Ambler		University of Cincinnati
	West Texas A&M University		Northern Illinois University		Drexel University		Kent State University
	Texas Southern University		Illinois Insitute of Technology		Lehigh University		Belmont College
	Lamar University		Southern Illinois University Carbondale		Philadelphia University		Ohio University
	Texas Tech University		Western Illinois University-Quad Cities		Robert Morris University	Indiana	Purdue University
	St. Mary's University		Kankakee Community College		University of Pittsburgh		Indiana University - Indianapolis
	Del Mar College		McHenry County College		Community College of Beaver County		University of Notre Dame
	Midland College						Indina University Bloomington
							Ball State University

The objective of the survey was to identify if there was any gap in the current manufacturing curriculum with respect to supply chain management related courses (both engineering and technology degrees). The survey was limited to Mechanical Engineering and Industrial & Manufacturing Engineering departments, and Business School. First, we looked at the engineering department under study as to examine if it was offering any manufacturing related degree or not. If it were, then we reviewed course curriculum to see if they were offering purchasing and supply chain management courses. Secondly, we reviewed the business school of the same university just to see if they were offering the supply chain management courses. The main idea to check business was to make sure the manufacturing students had the opportunity to take those classes if they wished to do so.

Discussion of Results and Plans for Future Research

Our survey finds that out of over eighty schools (including both 4-year and 2-year institutions), only 41 institutes were offering supply chain management courses within the engineering departments (such as industrial, manufacturing, or engineering technology). On the other hand over 90% of business schools in the 4-year institutes were offering purchasing or supply chain management related courses. It shows a significant gap in the engineering schools in terms of offering similar courses. While it is true that universities do not allow the identical courses in multiple departments, each department has its own focus, therefore, similar course with little bit different scope can be offered. For example, the university the authors work offers two purchasing and supply chain courses- one in Engineering Technology and Industrial Distribution department and the other is in Business School. Each course has different focus, therefore, justifies the reason for offering.

Figure 2 shows a snapshot of supply chain courses offered at various academic departments in the surveyed school. It should be noted that manufacturing engineering or technology degree could be offered from various departments such as industrial engineering, mechanical engineering, or engineering technology. Therefore, our survey was based on the manufacturing or related major regardless of departments. As expected, majority of business school and

industrial engineering programs offer courses in supply chain management. On the other hand, very few manufacturing and engineering technology programs offer the purchasing or supply chain management related courses. Interestingly, if we tie this with contents of the Four Pillars of manufacturing, it shows a clear gap in the curricula of many schools. The part of the reason for a large number of "No's" is, some of the school such as Indian University or University of North Carolina do not have engineering college, therefore, do not have manufacturing engineering or technology programs.

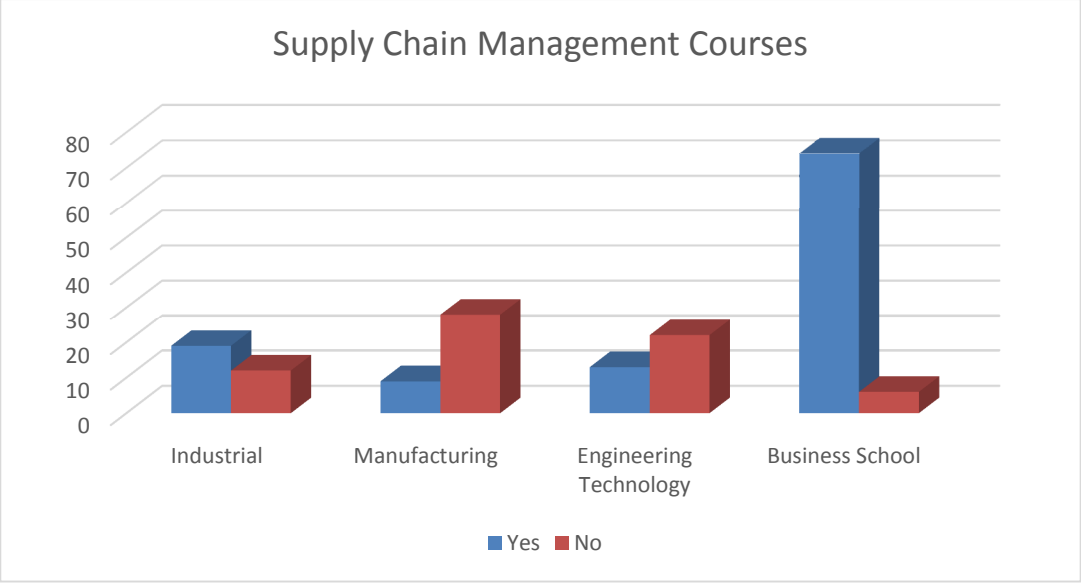

Figure 2: Availability of supply chain management courses in various departments

However, it must be noted that the objective of research was just to create awareness in the manufacturing educator's community. It is by no means an exhaustive analysis of every manufacturing degree granting program in the selected states. Therefore, we would like to caution our readers not to generalize the conclusions. Nevertheless, this research has uncovered the potential gap in current manufacturing engineering and technology curriculum with respect offering supply chain management courses. We firmly believe that such courses are required to prepare the graduates with the ability to tackle the globalized manufacturing issues of the 21st century. In future, we plan to conduct a more detailed survey by using a proper survey instrument to examine the current state of the manufacturing engineering or technology

curriculum. The future plan also includes industry survey to identify the skills gap facing the industry in the age advanced information technology and globalized marketplace.

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