Educating the Manufacturing Technologist: Current Trends and Gaps in Curricula *(Best NAIT 2007 Convention Paper)*

Dr. R. Neal Callahan
Missouri State University, Springfield, MO 65897, 417-836-5160, nealcallahan@missouristate.edu

Mr. Rathel R. Smith
Missouri State University, Springfield, MO 65897, 417-836-6972, rathelrsmith@missouristate.edu

Dr. Martin Jones
Missouri State University, Springfield, Missouri 65897, 417-836-5121, MartinJones@missouristate.edu
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Introduction

Graduates of Industrial Management and Manufacturing Technology Programs are constantly challenged to meet the demands of a rapidly changing business and technological environment. Changing and emerging technologies along with the ever-increasing competition brought by globalization have altered and added to the required skills of the manufacturing professional. To meet the expectations of employers, graduates must draw on a broad range of knowledge that often requires a blend of management and technical abilities. This skill set tends to change with the evolving competitive pressures of the industrial environment. In order to prepare students for the expectations placed upon them as they enter their profession, educators must identify current knowledge requirements and trends in industry. This paper reports the results of an industry survey relating to career opportunities and needed skills for manufacturing professionals. Based on survey results, recommendations are made for curricular improvements at the college level.

Background

As globalization accelerated over the past decade, numerous manufacturing jobs left the United States for cheaper labor markets in developing areas such as China and the Pacific Rim. As those jobs left, some were replaced by positions in smaller start-up companies. Those smaller organizations along with the remaining traditional manufacturers face strong global competition as they strive to survive and grow.

Although fewer people are working in manufacturing in the United States, this sector still accounts for about 22-25% of the gross domestic product as it has for the past 50 years. (Shinn, 2004). The remaining manufacturing professionals such as manufacturing technologists and manufacturing engineers play an increasingly important role in improving the efficiency and competitiveness of the company. Manufacturing professionals in the United States are increasingly asked to perform new and different tasks. It is no longer acceptable to only understand the technical components of the operation. A broader understanding of the overall business environment, competitive forces, and trends is necessary in order to properly apply technical knowledge (Sinn, 2004).

Various continuous improvement tools are widely used in industry today as a means for meeting the additional expectations placed on manufacturing professionals. Lean and Six Sigma methodologies are prominent examples of these tools which strive to eliminate waste, improve quality and reduce production time. Implementing these types of programs can improve value for the customer while increasing profits for the company (Summers 2007). According to one recent survey conducted by Industry Week and the Manufacturing Performance Institute, 40% of manufacturers have implemented some form of lean manufacturing program. Another 12% have implemented a combination of Lean and Six Sigma (Katz 2007). Some companies considering outsourcing have found that they can stay competitive and meet financial goals by implementing lean concepts while remaining in the United States. Small-to-mid sized companies in particular may be better off implementing lean concepts rather than migrating offshore (Langer, 2007).

Rapidly changing technology is also a factor in educating the manufacturing professional. New high-tech industries are developing and expanding as a result of advances in material science, health care, and electronics. Microtechnologies and nanotechnologies typify the trend toward converging technologies where several disciplines such as material science, biology, chemistry, engineering,

and physics are all critical in the development and manufacture of a product (Kalpakjian and Schmid, 2006). These new and developing industries require the same process improvement and efficiency skills as traditional manufacturing organizations. Examples of products currently being developed around the convergence of disciplines include microsensors for healthcare testing, automation applications using intelligent software, and high-performance materials using carbon nanotubes (McCann, 2006). These new industries and technologies bring expectations and challenges to skilled professionals that must be addressed by both continuing education and traditional college degrees. Plaza (2004) proposed developing some core college technology courses around a topic involving several disciplines and instructors. This integrative approach could be particularly helpful at the introductory or capstone level in demonstrating the importance and application of the convergence of technology. Continuing education may also play an important role in updating the working professional on new technologies and applications.

Advances in software and internet applications can play an important role in the success of a manufacturing organization. Software to support lean concepts that required a major investment in the past is now available incrementally in much more affordable packages. Internet-enabled software is also now available in specialized segments allowing cash strapped companies to purchase only what they presently need as they begin to implement a lean or continuous improvement program (Peake 2003). Knowledge of these tools along with the training and skills needed to use them can provide companies with a significant competitive edge.

Educational Needs of Manufacturing Professionals

To better understand the current and future educational requirements for manufacturing technology programs, a survey was administered to a wide range of manufacturing professionals working in a variety of manufacturing and process-related industries in the United States. The survey was e-mailed to approximately 6000 individuals, with 261 responding. The addresses were supplied by the Society of Manufacturing Engineers (SME) and were selected from a database that consisted of both members and participants in SME events. This database generally represents manufacturing professionals who often have a technical component associated with their jobs.

The survey initially addressed the role of the respondents by asking them to identify their current job function. Table 1 summarizes this data.

Table 1. Job Function Data From Survey

What best describes your job function?	
Engineer	64.0%
Management	21.1%
Technologist/Technician	5.0%
Foreman/Group Leader/Supervisor	3.1%
Not listed	2.3%
Owner/CEO/Executive	1.9%
Machinist/Machine operator/Other Skilled Trades	1.5%
Other	0.8%

This information indicates that most of the respondents are placed in an engineering role while only 5% consider themselves technologists. At first glance this seems to indicate that manufacturing professionals with a technology education have a very limited presence in industry. However, a closer look at the data reveals a much different conclusion. Participants were also asked to list their highest level of education: 27% indicated either a two or four year technology related degree and 26% indicated a 4-year engineering degree. Only 5% of participants responded as being in technologist positions, indicating that most of the respondents with technology degrees have actually been working in engineering related positions. The data also indicates that the pool of manufacturing professionals is roughly made up of equal numbers of engineering and technology educated individuals. This clearly reflects the major contribution and position of technology educated graduates.

The survey also asked participants what technologies they were currently required to use. Lean process improvement tools, CAD/CAM, flexible manufacturing, integrated manufacturing systems, Six Sigma and automation were the top answers. These skills all relate to better efficiency and process improvement and have been utilized in industry for some time. Technology and engineering students are typically exposed to CAD and automation topics, but often see less exposure to soft skills such as lean concepts and Six Sigma methods. These process improvement skills are often taught through employee training initiatives on the job or through

seminars and special classes. The survey reports that lean process improvement tools are the most commonly required skill in today's industrial environment.

The survey addressed the issue of future trends. Participants were asked to indicate the tools and technologies they believed would increase in importance in the future. Again, lean process improvement tools led the responses. Six Sigma, integrated manufacturing, sensor technology, flexible manufacturing and CAD were also prominent answers. The results for this question are shown in Table 2.

Table 2. Tools and Technologies Expected to Increase Over the Next 10 Years

In your opinion, which technologies do you see increasing in importance over the next ten years?	
Lean Process Improvement Tools	10.6%
Six Sigma	8.6%
Integrated Manufacturing Systems	8.5%
Sensor Technology, Vision Systems, etc.	8.5%
Flexible Manufacturing Systems	8.4%
CAD, CAE, CAPP, or CAM	8.2%
Advanced Inspection Technologies	7.4%
Automated Material Handling	7.1%
Expert Systems, Artificial Intelligence	7.1%
Simulation	6.7%
Laser Applications	6.4%
Design of Experiments	5.1%
Composite Materials	4.0%
Other	3.3%

Continuing Education Needs

Recognizing that the rate of change in technical knowledge is significant and that manufacturing professionals often need to update their education after they have entered their careers, the survey also sought to gain information with regard to continuing education. The participants were asked to identify areas of training or continuing education that are important in today's industrial environment and what areas are expected to be important over the next ten years. The results for this question are listed in Table 3.

Table 3. Continuing Education Requirements

What areas of continuing education or training are important to the manufacturing professional in today's environment and over the next 10 years?	Today	10 yrs.
Lean Manufacturing	15.4%	16.2%
New Processes or Technologies	15.2%	16.6%
CAD or Modeling	12.2%	10.9%
Six Sigma	12.0%	11.7%
Statistical Analysis	10.4%	9.6%
New Materials	9.9%	11.4%
Quality Management	9.4%	9.7%
Leadership or Supervision	9.1%	8.5%
Facilitator/Train the Trainer	6.5%	6.4%

The data indicate that lean manufacturing concepts are a major factor in continuing education now and are expected to also be important in the future. Process and efficiency improvement efforts typically include a variety of tools including lean manufacturing, Six Sigma, and statistical analysis. Summing these three results from the survey reveals that about 38% identify process and efficiency improvement methods as an important area for continuing education both now and 10 years into the future. New technologies and materials also rank high in this survey question: 15.2% of respondents indicate new processes and technologies and 9.9% indicate new materials as currently important areas for continuing education. The survey also indicates a slight upward trend in these areas as they relate to continuing education over the next 10 years.

Topics where employees lack exposure or depth of knowledge even after their formal education can be addressed through continuing education. Some areas requiring additional training may have developed after individuals finished college such as new materials, new methods, and continuous improvement tools including lean manufacturing and Six Sigma. In these situations employers may develop an in-house training mechanism or send employees to specialized training elsewhere. Another possibility is to fund additional formal education such as completing a two- or four-year degree or even completing a degree on-line. Training and assisting with formal education are expensive activities for employers. They are willing to absorb these expenses realizing that an even bigger reward will be realized through improved performance and efficiency. Continuing education activities are a major factor now and are expected to remain so in the future. The survey addresses this issue by asking how much time employers should devote to training manufacturing professionals over the next ten years. The response to this question is summarized in Table 4.

Table 4. Quantity of Training Required Over the Next 10 Years

In your opinion, over the next 10 years, the amount of time devoted to training for a manufacturing engineer/technologists will:	
Increase dramatically	15.7%
Increase somewhat	36.0%
Stay about the same	33.3%
Decrease somewhat	8.4%
Decrease dramatically	4.6%

The survey indicates that about 52% of respondents predict that time spent on continuing education will increase over the next 10 years and only 13% predict it will decrease. This result demonstrates the emphasis companies place on continuing education now and the expectation that it will continue into the future.

Conclusions

More than ever, the rapidly changing global manufacturing environment places demands on manufacturing professionals. Advances in technology and ever-increasing competition require expertise in business, efficiency, and technology. With a significant number of manufacturing professionals being supplied by two- and four-year technology programs, these institutions play a significant role in educating future industry leaders to meet the challenges of modern industry.

The survey described in this paper identifies critical skills and knowledge needed by manufacturing professionals. Lean process improvement tools and Six Sigma methods top the list as major areas of importance both now and in the future. Based on this information, technology programs should emphasize these topics wherever possible in their curricula. Production management and quality courses often include components of these continuous improvement methods; however, additional and more in-depth coverage should be considered. Based on the level of interest shown concerning these topics, perhaps an additional course or courses should be offered that focus primarily on continuous improvement and efficiency methods.

New processes and materials were also indicated as a major concern both now and over the next 10 years. Including these topics in technology curricula is critical in preparing manufacturing professionals to enter the workplace. Adding an emerging technologies component to traditional manufacturing materials and processes courses could help instill this knowledge. Based on the trend toward converging technologies, creating a multidisciplinary capstone course that includes several areas such as technology, physics, materials, and biology may prove beneficial.

Continuing education will also play an important role in preparing manufacturing professionals for the changing demands of industry. Lean manufacturing, new processes or technologies, CAD, and Six Sigma topped the list as needed areas for continuing education. Technology programs can help meet this need by offering completion degrees, and certificate programs that emphasize these skills. In addition, internet courses that address continuous improvement and new technologies can be a critical resource for those working full-time and unable to attend live courses.

A significant number of manufacturing professionals are being supplied by two- and four-year technology programs. These institutions play a key role in preparing manufacturing professionals for current and future challenges. By adjusting the curricula to further emphasize continuous improvement skills and new technologies, these programs will provide a major resource for competing in the global manufacturing economy.

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