Manufacturing Engineer - Manufacturing Technologist: Exploring the Similarities and Differences

by

Rathel R. (Dick) Smith, MS
RathelRSmith@missouristate.edu
Missouri State University
Springfield, Missouri 65897

Martin P. Jones, Ph.D.
MartinJones@missouristate.edu
Missouri State University
Springfield, Missouri 65897

R. Neal Callahan, Ph.D.
NealCallahan@missouristate.edu
Missouri State University
Springfield, Missouri 65897

Abstract

Manufacturing companies within the United States continue to be faced with global competition. These companies rely heavily on a group of manufacturing professionals often referred to as "manufacturing engineers" to help them remain competitive. The present paper explores the data from a survey conducted through the Society of Manufacturing Engineers (SME) regarding the roles and responsibilities of manufacturing professionals. This survey was prompted when SME noticed that many of its members carried the title of manufacturing engineer but were academically trained as manufacturing technologists. The present study distinguishes between the manufacturing engineer and the manufacturing technologist and explores the similarities and differences in roles, responsibilities, and technologies utilized by these two professional groups. In general, the study found no significant differences in the roles and responsibilities between the two groups. There were no significant differences in the technologies utilized. Conclusions drawn from the study can provide valuable input into curricular development for both schools of technology and engineering.

1. Introduction and Background

In the world of manufacturing, adopting reliable and appropriate technologies, continuously improving manufacturing practices, and outperforming the competition in both quality and cost have become the very basics of survivability. Leading this challenge is the manufacturing engineer and manufacturing technologist. Over the past several years, schools of engineering and schools of technology have brought together facilities, equipment, and curricula to prepare individuals to meet that challenge. Manufacturing technologists (MT) are educated through technology-based curricula whereas manufacturing engineers (ME) are educated through engineering-based curricula. These curricula share common content yet have distinct differences.

Among manufacturing professionals, there is generally a good understanding of what manufacturing engineers and technologists need with respect to tools, skills, and education. However, it would be useful to quantify those needs in order to provide efficiently for career development of manufacturing engineers and technologists. One manufacturing-focused professional organization reviewed their membership database and concluded that the ME and the MT often share similar roles and responsibilities, utilize the same technologies, and carry the same job title in their respective manufacturing workplaces [1]. Based on data from this same review, recommendations were given for the career paths and certification of manufacturing professionals[2].

2. Purpose of Research

Because of the above apparent similarities, further research was needed to quantify the comparison of the ME and MT with respect to education, job responsibilities, and technologies utilized in the manufacturing workplace. To this end, research was initiated with the following objectives:

- Compare and contrast the roles and responsibilities of the ME and the MT.
- Compare and contrast the technologies utilized by the ME and the MT.
- Explore the curricular implications of the study findings in the roles and responsibilities and the technologies utilized by the ME and the MT.

3. Review of the Literature

A review of the literature reveals that the above question and resulting objectives are similar to those that have been discussed by other researchers [3-12]. Similar to the comparison between technologist and engineer, is the discussion of the comparison of technician and technologist. Braddock [3] points out that there is an increased trend for machine operators to have job titles such as production technician. He suggests that the title of technician is being used for factory workers as their jobs become more comprehensive; thereby requiring multiple skills and roles. Braddock observes that the job titles of technician and technologists are being used interchangeably. He offers the following descriptions to distinguish between the technician and technologist:

> "… the term technologist implies a worker who is more highly skilled than a technician. Often, a technologist has more autonomy and theoretical knowledge than a technician. For example, many engineering technologists have a bachelor's degree and are considered engineers by their employers. Technicians rarely have bachelor's degrees." [3].

As can be seen, by trying to distinguish between the technician and technologist, Braddock blurs the line between technologist and engineer. The difficulty in making such a distinction goes beyond considering technologists as engineers. Conversely, engineers are increasingly being asked to take on the role of a technologist. Hutchins [4] remarks that manufacturing engineers are, more than ever before, being asked to take responsibility for technology. Roman [5] argues that engineers must be agents for technological change to make their companies globally competitive. He points out that over 60 percent of the United States' annual economic growth is a result of technological change. Termini [6] advises that the future manufacturing engineer must select equipment to meet the challenges of competitive technologies.

Murray [7] considers the demographics of United States engineers by noting the decreased number of engineering degrees being granted. He suggests that one solution is to increase the use of technologists where job responsibilities overlap with engineers. Underlying this suggestion is the question: what is the difference in the roles and responsibilities between technologist and engineer? According to Sessions [8], traditional engineers are expected to have more interaction with customers than are technologists. What might have been traditional roles assigned to either the engineer or technologist are being reconsidered. Singh and Sohal [9] suggests that engineers should champion advanced technology. Nambisan [10] challenges U.S. technologists and engineers to develop a "broader perspective" capable of producing future innovative technologies. Dowling [11] describes an educational program that could enable technologists to use their workplace experience to become professional engineers. Recognizing the close relationship between technology and engineering, Dearing and Daugherty [12] propose incorporating engineering content into high school technology education curricula. Their proposal is aimed at both preparing the high school student for engineering and helping the technology student understand the key role of engineering in the technological world. The above references indicate that the roles, responsibilities, and technological needs often overlap among engineers and technologists. This overlap has future curricular implications for both schools of engineering and technology.

4. Research Methodology

The research project was conducted utilizing an online survey tool. The Society of Manufacturing Engineers (SME) provided the e-mail addresses and dispersion service. Approximately 5200 e-mail invitations to participate were distributed on a one-time basis. No pre-notification, reminder, or follow-up attempt was made. The addresses selected for the survey were picked at random from a larger database composed of both members of the Society and any individual who had registered to attend SME sponsored events such as trade shows and workshops. The survey resulted in 261 participants representing approximately a 5% response rate. Although a 5% response rate has traditionally been considered low, there are additional factors to consider that do support validity.

Based on findings from Sheehan [13] and Kent and Brandal [14] response rates for e-mail surveys have fallen significantly over the past two decades and currently average about 5%. Tanner [15] argues that an e-mail response rate of 5% is reasonable and workable in many cases. Wiseman [16] echoes this conclusion saying "In fact, non-response error is only a problem if a low response rate is achieved and respondents differ from non-respondents on one or more of the variables of interest". Although pre and post survey messages would have increased the response rate, this was not possible with the given arrangement with SME. The compatibility of demographics between SME membership and respondents supports the validity of the survey.

As the survey results indicate, the demographic profile of the respondents is compatible with the technical and managerial make-up that is being sought. According to Tanner [15], knowledge about the population from which the information is drawn can help support validity. The survey population consisted of SME members and others with similar interests. A demographic study of SME members indicates that approximately 40% are engineers, and 30% are managers. Engineers and managers respectively are the two largest groups by far for both the SME population and the respondents with all other groups smaller that 10%. This supports a reasonable level of compatibility between the SME demographics and the respondent demographics and indicates a proportionate representation of all job function types.

The survey contains 30 questions including those to determine participant demographics, those focused on roles and responsibilities, and those focused on what technologies are needed in today's manufacturing environment. Survey questions were developed by a taskforce of eight professionals actively engaged as manufacturing professionals and educators having an average of 20 or more years of experience. In effect, the taskforce was a focus group since they had similar professional backgrounds to the survey participants. According to Suskie, using a focus group for comparison to the responses of the survey participants, supports the validity of the survey [17]. The focus group had similar survey responses and similar demographics as those survey participants who responded online, thus supporting the validity of the survey and its results. In the survey, there is an attempt to distinguish between the ME and MT. Participants were provided with the following definitions to help them distinguish between the ME and the MT.

- ME-This person utilizes the theoretical body of knowledge and core principles of engineering.
- MT-This person applies the technology based on rules and directions derived from the core principles of engineering.

5. Data Analysis and Research Findings

Participant Demographics

Demographic information serves primarily to establish confidence that participants are knowledgeable relative to the questions being presented. Demographic information includes the educational level, degree emphasis area, time of service in a manufacturing related job, age of the participant, and type and size of the company.

The participant group represents diverse levels of education level and degree emphasis area (see Table 1). Of particular interest is that approximately 34.5% of the respondents reported an engineering-focused educational background, 42.5% had a technology or manufacturing-focused educational background, and the remaining 23% had other educational backgrounds. This relatively close balance between engineering and technology educated professionals suggests that this respondent group is an appropriate group to provide input into this survey.

Table 1. Participant Educational Background

Participant Education	Percent
4-year (Bachelor's) engineering	25.7
2-year with technical focus	17.6
4-year (Bachelor's) manufacturing technology focus	9.6
Advanced degree manufacturing	9.2
Advanced degree other	9.2
Advanced degree applied engineering focus	7.3
Other formal training	6.9
4-year (Bachelor's) industrial technology focus	6.1
4-year (Bachelor's) other	4.6
No technical school or college training	2.3
Advanced degree theoretical engineering	1.5

In addition to educational background, the survey includes the participant's age and years of experience within the manufacturing community. Over 83% of participants reported greater than 10 years experience in manufacturing, with 56% of those having 20 or more years of service. In addition, 71.4% of participants were 40 or more years old. Obviously, the participants represent a group of individuals that, by both age and experience, were in a position to provide knowledgeable input regarding the questions presented in the survey.

Consideration is also given to the size of companies the participants represented (see Figure 1). While companies with 1,000 employees or greater represent 28.4% of the participants, there is still a wide distribution of participants in the various size ranges reported in the survey.

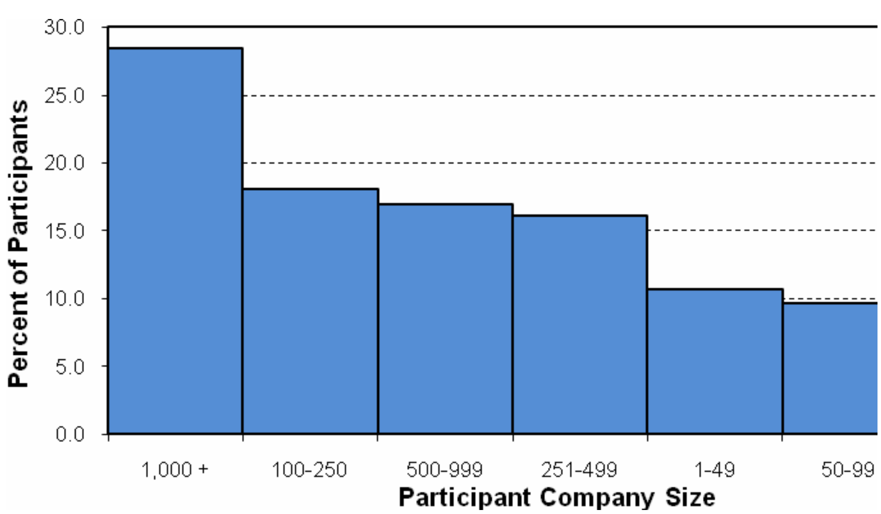

Figure 1. Percent of Participants by Company Size.

Participants worked for a variety of manufacturing company types (see Figure 2). Aerospace/aircraft participants represent the largest group, as analyzed by company type, with 19.5% of the total participants. This is followed closely by fabricated metal products and automotive/truck at 16.9% and 15.7%, respectively. Participants from these three industry groups make up 52.1% of the total participant group. The remaining participants represent twelve other distinct company types as defined by the survey. Although not an exhaustive list of company types, the data implies that participants represent a broad range of industries.

One indication of whether there are differences between the ME and MT is revealed by the job function this educationally diverse group reported. While only 34.5% of the participants reported an engineering-based education, 64% reported engineering as their job function. A significant percentage of the technologist-educated participants had the job functions of an engineer. Of the remaining participants, 21.1% reported management as their job function. The survey broadly defined management as operations, materials, purchasing, supply chain or quality.

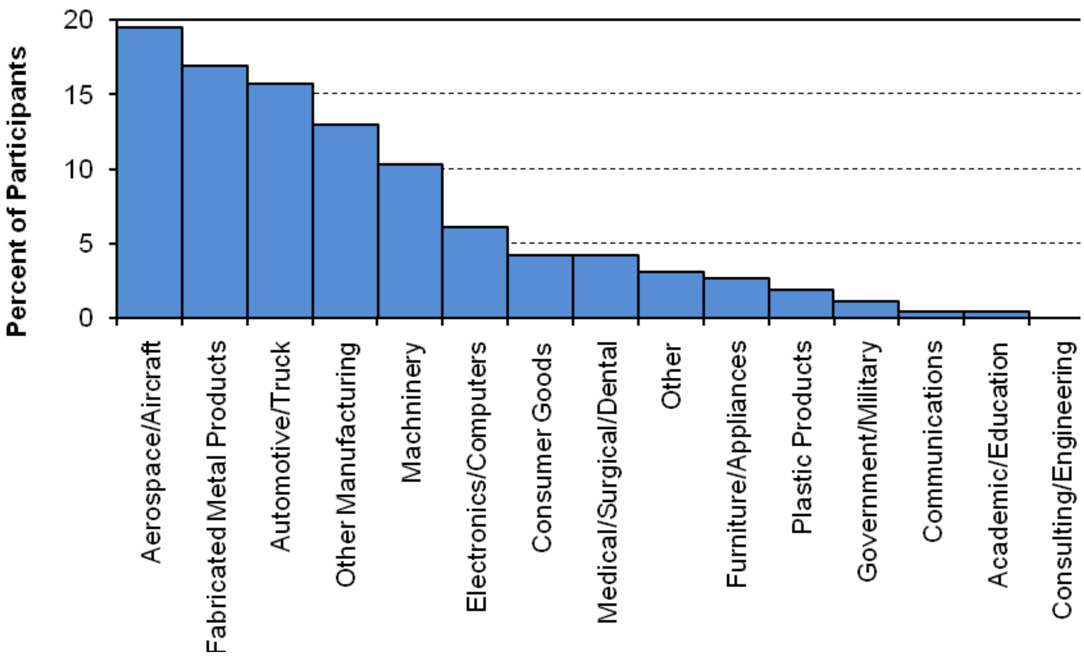

Figure 2. Percent of Participants by Company Type.

Roles and Responsibilities: ME versus MT

To compare and contrast the roles and responsibilities of the ME and MT, participants were asked to identify the most important areas where an ME or MT would be regularly involved. Participants were allowed to select multiple areas. Therefore, the information for each role and responsibility in Table 2 represents the percent of total responses. Table 2 provides insight into the importance of various roles and responsibilities through a rank order analysis, based on percent of total responses. These results are analyzed both separately and combined for the ME and MT. Notice that of the six top roles and responsibilities, five are shared in common among both the ME and MT as follows:

- Troubleshooting production problems
- Developing manufacturing methods, processes and systems

- Facilitating process improvement methodologies on the factory floor (Lean, TPS, Six Sigma, Etc.)
- Researching new methods/processes for improving future manufacturing performance
- Factory floor layout and design

Table 2. Roles and Responsibilities of the ME and MT

Survey Question: In your opinion, choose the most important areas where a ME/MT would be regularly involved and responsible.

Survey Answer Choices	% of Total Responses		Rank Order		
	ME	MT	ME	MT	ME + MT
Designing new products and product features	4.4	2.4	12	13	13
Developing manufacturing methods, processes and systems**	9.3	10.1	1*	2*	2
Troubleshooting production problems **	8.6	12.9	2*	1*	1
Selecting or designing equipment and tooling for manufacturing	8.3	6.9	4*	7	5
Supervising professional staff	2.8	1.0	16	18	17
Facilitating process improvement methodologies on the factory floor (Lean, TPS, Six Sigma, Etc.) **	8.0	10.0	5*	3*	3
Factory floor layout and design **	7.7	7.5	6*	5*	6
Financial analysis	4.0	1.3	13	17	14
N/C; CNC machine programming	4.9	8.5	10	4*	7
Interfacing directly with customers	3.2	1.7	15	16	15
Supervising production operations	2.4	2.8	17	12	16
Preparing capital spending plans and business-case justifications.	6.1	2.4	8	13	11
Researching new methods/processes for improving future manufacturing performance**	8.4	7.1	3*	6*	4
Interfacing with vendors/purchasing	6.2	5.0	7	10	9
Education and training	4.7	4.6	11	11	12
Quality assurance/quality control	5.4	6.4	9	9	8
Production scheduling/inventory control	1.7	2.4	18	13	18
Maintaining equipment and facilities	3.8	6.6	14	8	10
Other	.3	.2	19	19	19

Note: * = top 6 roles and responsibilities
** = those roles and responsibilities that are common to both the ME and MT within the top six
Spearman Rank Correlation Coefficient = .82, $p_s = .0003$

The top six roles and responsibilities for the ME represent 56.4% of total responses and for the MT the top six represent 56.1% of total responses. The above five roles and responsibilities amount to 41.9% for the ME and 47.6% for the MT of total responses.

While there are similarities, there are also reported differences in the roles and responsibilities between the ME versus and the MT. The participants' responses indicate the ME is more likely than the MT to prepare capital spending plans, complete financial analysis, design new products and product features, supervise professional staff, and select or design equipment and tooling for manufacturing. Note that "select or design equipment …" ranks high in Table 2 responses and echoes what Termini [6] envisions as a key role for the ME. Conversely, the responses indicate the MT is more likely to troubleshoot production problems, facilitate process improvement on the shop floor, do N/C or CNC machine programming, and maintain facilities and equipment.

A Spearman Rank Correlation Coefficient analysis is used to determine if there is a correlation relationship between what participants reported as the roles and responsibilities for the ME versus the MT. The Spearman Rank Correlation Coefficient analysis result of 0.82 implies a correlation between the roles and responsibilities of the ME and MT. To determine the significance of this correlation, the following hypothesis is tested:

$$H_{o}\!:p_s = 0 \text{ (reject } H_{o} \text{ if } p_s \leq 0.05)$$
$$H_o\!:p_s \neq 0$$

Under the null hypothesis (H_o) of no rank correlation ($p_s = 0$), the rankings would be deemed independent and thus not similar. The standard normal random variable Z is used to test the null hypothesis which results in a $p_s = 0.0003$. Therefore since $p_s < 0.05$, the null hypothesis is rejected indicating there is a significant correlation between the roles and responsibilities of the ME and MT, as reported in this survey. This indicates that the participants considered the job roles and responsibilities to be similar for both the ME and the MT.

Technologies Required: ME versus MT

The survey also investigates what technologies are being utilized by manufacturing professionals. Participants were asked to select, from a list of common technologies, those technologies they believe are required for use in today's environment by the ME and the MT (see Table 3). Participants were allowed to select multiple answers. Analysis includes a rank order comparison of responses between the ME and MT. Notice that in this analysis, the top ranked five technologies are common to both the ME and the MT. They are as follows:

- Lean Process Improvement Tools
- CAD, CAE, CAPP, or CAM
- Flexible manufacturing systems
- Integrated manufacturing systems
- Six-Sigma.

These top five technologies represent 47.5% of total responses for the ME and 49.8% of the total responses for the MT. Therefore, the technologies used by the ME and MT were reported to be approximately equivalent by the participants. There are also some differences between the technologies utilized by the ME and the MT. The participants indicated the ME was more likely to use design of experiments, composite materials, and simulation compared to the MT. The MT was indicated as more likely to use lean process improvement tools, sensory technology, and flexible manufacturing systems.

Table 3. Technologies Required in Today's Environment

Survey Question: In your opinion, what technologies are required to be used in today's environment?

Survey Answer Choices	% of Total Responses		Rank Order		
	ME	MT	ME	MT	ME +MT
Expert systems, artificial intelligence, and networking	4.9	4.3	12	12	12
Automated material handling	7.8	8.2	6	7	6
Sensor technology, such as machine vision, adaptive control, and voice recognition	7.4	8.7	8	5*	7
Laser applications, including welding/soldering, heat-treating and inspection	7.0	6.5	9	9	9
Integrated manufacturing systems **	9.1	9.1	3*	4*	4
Advanced inspection technologies, including on-machine inspection and clean-room technology	7.6	7.8	7	8	8
Flexible manufacturing systems **	9.0	9.9	4*	3*	3
Simulation	6.0	5.2	11	11	11
Composite materials	3.7	2.3	13	13	13
CAD, CAE, CAPP, or CAM **	10.0	10.8	1*	2*	2
Manufacturing in space	1.2	.7	14	14	14
Bio-technology	.8	.4	15	15	15
Lean Process Improvement Tools **	9.9	11.5	2*	1*	1
Six Sigma **	8.5	8.7	5*	5*	5
Design of Experiments	6.9	5.4	10	10	10
None of the Above	.1	.4	15	15	16

Note: * = top 5 technologies utilized
** = those roles and responsibilities that are common to both ME and MT within the top five
Spearman Rank Correlation Coefficient = .996, p_s = .00012

A Spearman Rank Correlation Coefficient analysis is used to determine if there is a relationship between what participants reported as technologies utilized in today's environment by the ME and the MT. The Spearman Rank Correlation Coefficient analysis result of 0.996 implies a correlation between the technologies required in today's environment by the ME and MT.

To determine the significance of this correlation, the following hypothesis is tested:

$$H_{o}: p_s = 0 \text{ (reject } H_{o} \text{ if } p_s \leq 0.05)$$
$$H_{o}: p_s \neq 0$$

Under the null hypothesis (H_o) of no rank correlation ($p_s = 0$), the rankings are independent thus not similar. The standard normal random variable Z is used to test the null hypothesis resulting in a $p_s = 0.00012$. Therefore since $p_s < 0.05$, the null hypothesis is rejected indicating that there is a significant correlation between the technologies utilized by the ME and MT. This indicates that the participants considered the technologies utilized to be similar for both the ME and the MT.

6. Conclusions

Comparison of the ME and MT

Based on the analysis of data gathered through this survey, there appears to be several areas where there is little difference in the primary roles and responsibilities of the ME and MT. In addition, the technologies required to carry out these roles and responsibilities are also quite similar for the ME and MT. These similarities suggest that there is effectively an insignificant difference between the ME and MT as viewed by these manufacturing professionals (survey participants). This conclusion may be partly attributed to the fact that over 83% of the participants had ten or more years of experience. Typically the ME and MT work closely together to achieve the same goals. It is reasonable to expect that over time they learn from each other and share job functions and technologies.

Another possible reason for the above similarities is that employers often assign the job title of engineer to manufacturing professionals who have been educated in a technology school. Perhaps these employers have found that technologists can achieve the same goals traditionally assigned to manufacturing professionals who have been educated as engineers. The technologist who has the job title (and function) of engineer will most likely utilize the tools in which he or she were educated. In these cases, the engineer uses the tools of the technologist. Employers often assign to engineers the responsibility of implementing technology. It is reasonable to assume that engineers will often need to use the same tools that technologists would use to implement similar technology. While there can be many methods to achieve manufacturing goals, usually one method is most cost-effective. In a competitive world, the ME and MT must converge upon the most profitable manufacturing methods which necessitate the utilization of similar tools.

Curricular Implications

This survey and its analysis provide insight into the technologies, roles, and responsibilities utilized by both the ME and MT. First consider the roles and responsibilities reported by this participant group as additional input into curricular implications. Ranking from highest order in Table 2, based on the total of the ME and MT, are 1) troubleshooting production problems, 2) developing manufacturing methods, processes, and systems, 3) facilitating process improvement methodologies on the shop floor, 4) researching new methods/processes for improving future manufacturing performance, and 5) selecting or designing equipment and tooling for manufacturing. Secondly, while not being ranked as high, functions such as preparing capital spending plans, business case justifications, education and training, and interfacing with both customers and suppliers are still important. These nontraditional roles and responsibilities can be overlooked in an engineering or technology curricular design process.

Also consider the technologies required for the ME and MT in today's environment. Ranking from highest order in Table 3, based on the total of the ME and MT, are 1) lean process improvement tools, 2) CAD, CAE, CAPP, or CAM, 3) flexible manufacturing systems, 4) integrated manufacturing systems, and 5) Six Sigma. It is interesting to observe that the same technologies that rank in the top five for the MT are also ranked in the top five for the ME. The only difference being that the order of the first two is reversed for the ME, making CAD, CAE, CAPP or CAM their highest priority.

Schools of engineering and technology should evaluate curricular content to ensure that students are provided with practical skill-based instruction in these desired technologies and are prepared to handle the typical roles and responsibilities deemed important by the participants in this survey. This analysis of data, particularly the ranking by percent of response in Tables 2 and 3, will serve as a valuable tool for developing a priority list for inclusion of these identified technologies in curricular design. Due to similarities, both schools of engineering and technology should place these high on their curricular agendas. Conversely, care must be taken not to eliminate a technology based on its ranking by these participants. For example, bio-technology was reported by the participants as least required. Given the industry groups listed under company types, one could question the participants' awareness of the need for developing this new technology. Analysis of the rankings of the roles and responsibilities presented here has the potential to guide curricular design processes to include nontraditional skills (like spending plans) that are now being required of today's ME or MT in the workplace.

7. Implications for Further Research

There is a need for further research to quantify any gap that exists in curricula among engineering and technology schools as compared to the information provided here. The survey in this paper almost exclusively acquired the opinions of manufacturing professionals with respect to several issues that are related to education. Research is needed to acquire opinions from educators in both engineering and technology schools on similar issues that affect the job function and tools utilized by the MT and ME. A comparison of the opinions among manufacturing professionals and educators may be able to quantify any gap that may exist between education and job function.

This paper does not represent all the potential technologies currently needed by the manufacturing community nor predict all new technologies that may be required. The participants in this paper's survey were not representative of some industries. For example, very few of the participants represented the plastics industry whereas the aerospace industry was most represented. Further research is needed to identify both current and future technologies in specific industries.

This paper identifies a need for non-traditional skills by the ME and the MT such as preparing capital spending plans and training. Further research is needed to identify other non-traditional skills. In today's globally competitive economy and agile manufacturing environment, what has been non-traditional skills may become essential to the job functions of the MT and ME.

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