The Future of the Manufacturing Workforce

by Thomas H. Davenport
The Future of the Manufacturing Workforce

The manufacturing environment is changing dramatically. With the advancement of technology, it becomes difficult to find the talent with the skills to use it. Demand exists for well-trained, skilled employees, but a limited supply appears to be available. The solution won’t come from a single place. The topic requires a much broader perspective. Change will happen with the collaboration of employers, educators, associations, governments, and policy makers. The reports assembled in this research from Manpower offer valuable insights on the solutions needed to navigate through the transformations occurring with the manufacturing workforce.
Table of Contents

Technology and the Manufacturing Workforce: An Overview ........................................ 4

The Rise of the “Tech” in Manufacturing ....................................................... 12

Contemporary Manufacturing Technologies and the Talent to Use Them ............... 20

Approaches to Educating the Manufacturing Workforce on Technology ............... 26

Policy Prescriptions for the Manufacturing Talent Gap ........................................ 32
Technology and the Manufacturing Workforce: An Overview

The manufacturing environment is changing dramatically, and the technologies and the skills to use them are becoming critical to the success of manufacturing companies. This report highlights the necessity for multiple stakeholders to work together to yield an impact on the supply of well-trained workers.
We are now at a turning point in the manufacturing workforce environment in North America. There are major changes underway in the demand and supply for manufacturing workers – many driven by new technologies – that will require new strategies and tactics for both companies and employees. These changes could lead to some of the most dramatic shifts in the human aspects of manufacturing since the Industrial Revolution. Indeed, some elements of this shift are already taking place, including the demand for a new type of technology-intensive manufacturing workforce and the limited availability of that workforce. This report is the first in a series of related reports on the new manufacturing workforce, with a particular focus on manufacturing technology. This first report describes the current situation in the manufacturing workforce for North America. It also summarizes the results of a survey of manufacturing managers on these issues. Subsequent reports will address the following topics:

- The Rise of the “Tech” in Manufacturing;
- Contemporary Manufacturing Technologies and the Talent Required to Use Them;
- Approaches to Educating the Manufacturing Workforce on Technology;
- Policy Prescriptions for the Manufacturing Talent Gap.

Changes in Demand for the Manufacturing Workforce

Perhaps the most significant development in the demand for North American manufacturing workers is that the U.S. and Canadian governments, the business media, universities, and other institutions have arrived at a consensus that manufacturing matters to the economy’s and the society’s well-being. For many years it was argued that North America was heading for a “service economy,” and few observers worried about the movement of high-tech and other manufacturing jobs to other parts of the world. This trend amounted to a loss of 5 million manufacturing jobs between 2000 and 2010. Less than 10 percent of the U.S. workforce is currently employed in manufacturing, down from a peak of 30 percent in 1960, and 14 percent in 2000. Similarly, Canada lost one in seven – a total of 322,000 – manufacturing jobs between 2004 and 2008 alone. The United States still added 24 percent of global manufacturing jobs in the world economy in 2011, and Canada added an additional 1.5 percent. The global percentages for both countries, however, have been declining over several decades, and only a major effort can reverse the trend.

These dramatic declines in North American manufacturing may have put manufacturing occupations in a negative light for an entire generation entering the workforce. However, they also had one positive effect: they eventually led to the belated recognition that manufacturing jobs are critical to a prosperous middle class. The near-death of the U.S. automobile industry during the 2008-9 financial crisis also helped catalyze attempts to revive North American manufacturing. Our survey results below suggest that North American manufacturing managers believe that onshore manufacturing will be increasingly
important in the future, and there are occasional high-profile announcements of onshore manufacturing initiatives by companies such as Apple. However, to restore the manufacturing industry on U.S. and Canadian soil, companies, governments, and educational institutions all need to make more of a commitment to manufacturing talent development.

There is also an increasing awareness that in order for domestic manufacturing to prosper, a different set of skills is necessary to meet companies’ current needs.

Despite an anemic economy overall and weak employment growth in the U.S. economy, there are as many as 600,000 unfilled manufacturing job openings in the U.S. alone, according to a joint study by Deloitte and the Manufacturing Institute. Most of these jobs are for skilled production workers in roles like machinists, operators, craft workers, distributors and technicians. These jobs require extensive training and are difficult to fill. The unemployment problem is less apparent in Canada because of the natural resources boom there, but Canada has a similar shortage of skilled manufacturing talent.

The Deloitte/Manufacturing Institute study included a survey of manufacturing executives, who expressed concern about the workforce skills gap. Seventy-four percent of the survey respondents reported that workforce shortages or skills deficiencies in production roles are having a significant impact on their ability to expand operations or improve productivity. When the respondents were asked to look ahead three to five years, they ranked access to a highly skilled, flexible workforce as the single most important factor in their effectiveness – ranking it 20 percentage points more important than other factors such as new product innovation or increased market share.

Due to the aging North American workforce and a lack of younger talent to fill the pipeline, a generational skills gap also exists in manufacturing. Because of declines in domestic manufacturing, productivity gains, and a weak economy, many companies have hired few manufacturing workers of any type over the last couple of decades. As a result, many existing employees are nearing retirement. At Boeing, for example, 28 percent of the company’s employees are older than 55 and eligible for retirement. This generational shift will lead to even greater demand for new manufacturing workers for the jobs that remain.

Compounding the problem is that the nature of manufacturing jobs has changed dramatically over recent decades because of new technologies. Many manufacturing technologies – computer numerical control (CNC) machine tools, computer-aided design and manufacturing (CAD/CAM) programs, robotics, and cell-based manufacturing networks – are all heavily computer-based. These are complex technologies, and programmers and operators of them require substantial technical training.

93% of manufacturing managers agreed that:

“Manufacturing in North America will be increasingly important to my company’s future operations.”

– 2012 Manpower Manufacturing Workforce Survey
Computers and microprocessors not only control the detailed movements of machinery, but have also taken over the control and flow of manufactured goods through the entire process. Automated process control systems and robotics have, of course, been partially responsible for the reductions in manufacturing workforce levels (and improvements in productivity). But the remaining workers who can maintain and modify these complex automated systems need high skill levels. There may be only half the jobs for the manufacturing workforce in environments of high automation, but the workers in those jobs may have to be twice as skilled.

In addition to the need for technical and process automation skills, manufacturing workers are increasingly taking on traditionally management-oriented activities in the manufacturing process, including efforts to improve quality and address production bottlenecks. Diana Tremblay, Global Chief Manufacturing Officer at General Motors, noted her impressions of line manufacturing workers at the new Chevrolet Sonic plant in suburban Detroit at a Massachusetts Institute of Technology conference:

[In this plant] it is difficult to tell who is management and who is labor, who is working on the shop floor and who is the plant manager. Everyone is solving problems, doing fishbone diagrams, etc. I can’t tell the difference.  

In short, the demand for manufacturing workers is increasingly a demand for well-educated knowledge workers. Most companies today are not recruiting for manufacturing talent as if they were knowledge workers, and are not managing them as a knowledge workforce either. Treating manufacturing workers as knowledge workers promises considerable change not only in recruiting and retention practices, but also in labor/management relations, the role of unions, and other aspects of the work model.

Promising but Insufficient Changes in Supply

To cope with all these changes in the demand for skilled manufacturing talent, the supply factors for such workers need to change and expand dramatically. Indeed, there are impressive examples of programs of various types to develop workers with the necessary skills. The problem is that these programs are fragmented and limited in scope. In North America there is no equivalent, for example, to the well-established and pervasive German vocational training system, which mixes training, apprenticeship, and the accumulation of work experience. This system has been critical to the continued success of the German manufacturing sector.

There are, of course, limited existing programs that are worthy of emulation on a larger scale.
Some German companies with operations in North America have imported some of the vocational training practices that are popular in Germany. Siemens, for example, has a program that President Obama mentioned in his 2012 State of the Union Address:

*Jackie Bray is a single mom from North Carolina who was laid off from her job as a mechanic. Then Siemens opened a gas turbine factory in Charlotte, and formed a partnership with Central Piedmont Community College. The company helped the college design courses in laser and robotics training. It paid Jackie's tuition, then hired her to help operate their plant.*

There are also other German companies that have imported manufacturing talent development programs. BMW, for example, has also created its own educational programs for advanced manufacturing skills in its South Carolina operations.

Other companies, regions and manufacturing industries have created their own skill development programs. Wichita, Kansas – a center for aircraft manufacturing – has created the National Center for Aviation Training in conjunction with Wichita Area Technical College to train aircraft manufacturing workers in new technologies. Similarly, the Automotive Manufacturing Technical Education Collaborative (AMTEC) aligns a set of community colleges in states with automobile manufacturing with Ford, GM, and Toyota representatives, and several auto component manufacturers. Rolls-Royce has an extensive apprenticeship program that encompasses its factories in the U.S. and Canada.

Certification of skills is also an important component of ensuring a supply of trained and capable workers. There are some efforts underway to develop certifications for particular manufacturing skills. The Manufacturing Institute is deploying the Manufacturing Skills Certification System endorsed by the National Association of Manufacturers (NAM). The Obama administration is attempting to certify veterans for manufacturing-oriented skills acquired during military service.

Each of these programs appears impressive, but all are piecemeal and small relative to the need. Few are national in scale or broadly implemented across the U.S. or Canada. It is unlikely that they can address the scope and nature of the manufacturing skills gap without considerable expansion or modification. It seems likely that there would need to be national government action or support for such expansion, and in the current political climate (at least in the U.S.), this seems unlikely.

Even if government and educational institutions mobilize to create more high-skilled manufacturing workers, there is another issue with the supply of workers that must be overcome. Large-scale layoffs, the use of labor arbitrage through offshore outsourcing, and the decline of labor union power and influence have all contributed to a distrust of the long-term intentions of manufacturing companies. In addition, many North American companies seem to feel that it is no longer their role to educate workers. If individuals’ trust that a manufacturing career can be stable and rewarding over the long term is to be restored, companies will have to both invest in their workers in the present, and reassure them about their future prospects.
Connecting Demand and Supply

There do exist, of course, short- and long-term mechanisms that can connect the supply and demand for high-skilled manufacturing talent. Longer-term approaches such as better training programs and government policies will be described in other reports in this series. In the short run, some of the following steps would be useful:

- A vendor-independent taxonomy of key manufacturing technologies, applications, and related skills;
- A national or even international directory of jobs in manufacturing technology;
- A similar directory of educational offerings in manufacturing technology;
- A variety of internship programs providing an introduction to manufacturing and manufacturing technologies;
- Programs allowing students and prospective employees to tour and observe manufacturing technology environments.

Some of these proposed initiatives would allow workers who already have the relevant skills to find and take jobs that use those skills. Others would simply motivate students and potential employees to acquire the needed skills.

Survey Results

In order to assess perceptions of these issues, Manpower conducted a survey of 353 North American manufacturing managers in the summer of 2012. The topics of the survey included the companies’ needs for skilled manufacturing workers, and the changes that are taking place in technologies for manufacturing and related skills. Substantial majorities of the respondents agreed with most of the survey questions, as seen in Tables 1 (Manufacturing Talent Survey Question Results) and 2 (Manufacturing Technologies and Skills Survey Question Results).

- The respondents were highly likely (over 90%) to agree that companies that successfully build a skilled workforce will be among the most prosperous in the future, that onshore manufacturing in North America will be increasingly critical to their operations, and that obtaining workers with the needed skills is critical to the success of onshore manufacturing.
- Over 90% also agreed that they view their manufacturing workers as knowledge workers, and that they are full partners in solving problems, improving processes, and satisfying customers.
- Over 80% agreed that they struggled to get the talent they need for manufacturing, and over 70% agreed that the talent gap issue is increasing in severity now and will continue to do so.
- Almost two-thirds (64%) agreed that their manufacturing processes require higher levels of skills than in the past.
• A minority (37%), however, went so far as to agree that the lines are blurring between management and labor in terms of technical skills and knowledge.

The survey respondents also voiced support for the perception that manufacturing technology is changing dramatically, and that workers need training to master it. About four out of five manufacturing managers in the survey agreed that educational institutions needed to do more to educate workers on manufacturing technologies, that their manufacturing processes increasingly generated data that needed to be analyzed, and that their manufacturing technologies were increasingly computer-based (and hence required more computer-oriented skills). More than 70% agreed that manufacturing processes were becoming more sophisticated and complex, and that certification in manufacturing technology skills was needed. Just under a majority (49%) agreed that “big data” would lead to competitive advantage in manufacturing, although a large percentage (39%) answered “not sure” to the question, suggesting a lack of familiarity with the concept of big data.

**Manpower Manufacturing Workforce Survey:**

**Table One – Talent Results**

% of respondents (N=353) stating they “strongly agree” or “agree” with statements

<table>
<thead>
<tr>
<th>Statement</th>
<th>Percentage Agreeing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Companies that can successfully hire, build, and retain a highly skilled workforce will be those that prosper over the next decade.</td>
<td>96%</td>
</tr>
<tr>
<td>I believe manufacturing in North America will be increasingly important to my company’s future operations.</td>
<td>93%</td>
</tr>
<tr>
<td>The skills of the manufacturing workforce will be a key factor in whether manufacturing returns as a key American industry.</td>
<td>93%</td>
</tr>
<tr>
<td>We increasingly view our manufacturing workers as knowledge workers.</td>
<td>92%</td>
</tr>
<tr>
<td>We view our manufacturing workforce as full partners in solving problems, improving processes, and satisfying our customers.</td>
<td>90%</td>
</tr>
<tr>
<td>My company struggles to get the skills it needs in our manufacturing workforce.</td>
<td>81%</td>
</tr>
<tr>
<td>The problem of insufficient manufacturing skills is increasing in severity now and will continue to get worse over the next several years.</td>
<td>71%</td>
</tr>
<tr>
<td>The manufacturing processes we use require workers with higher levels of education or expertise than in the past.</td>
<td>64%</td>
</tr>
<tr>
<td>The division between management and labor in terms of technical skills and knowledge is blurring in our organization.</td>
<td>37%</td>
</tr>
</tbody>
</table>
Manpower Manufacturing Workforce Survey:
Table Two – Technologies and Skills Results

% of respondents (N=353) stating they “strongly agree” or “agree” with statements

<table>
<thead>
<tr>
<th>Statement</th>
<th>Percentage Agreeing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational institutions in this country need to do a better job of educating the manufacturing workforce on new technologies.</td>
<td>84%</td>
</tr>
<tr>
<td>Our manufacturing technology increasingly generates data that should be analyzed to create optimum performance.</td>
<td>81%</td>
</tr>
<tr>
<td>Manufacturing technologies are increasingly computer-based, and require many of the skills to manage and operate as computers do.</td>
<td>79%</td>
</tr>
<tr>
<td>There is a need for certification that workers have the needed skills to manage and optimize specific manufacturing technologies.</td>
<td>77%</td>
</tr>
<tr>
<td>The manufacturing process/technologies we use in our operations have become much more sophisticated and complex in the past several years.</td>
<td>73%</td>
</tr>
<tr>
<td>Manufacturing will soon be an industry where “big data” is used to create competitive advantage. (Big data is data that is either too large or too unstructured to be managed through traditional means).</td>
<td>49%</td>
</tr>
</tbody>
</table>

Summary

There remains little doubt, then, that the manufacturing environment is changing dramatically, and that manufacturing technologies and the skills to use them are becoming critical to the success of manufacturing companies. It is not difficult to envision the tactics that would accelerate the development of high-technology manufacturing skills, and other mechanisms that would connect people possessing those skills with companies offering relevant jobs. What is more difficult to imagine is how companies, government organizations, universities and community colleges, and individuals themselves, might work together to yield the necessary impact on the supply of well-trained workers. If they do not, however, the revival of manufacturing in North America is at substantial risk.

9 President Barack Obama, 2012 State of the Union Address, January 24, 2012.
The Rise of the “Tech” in Manufacturing

This report explores the critical role of the “tech,” or manufacturing technical worker, in the contemporary manufacturing industry. There are not enough techs available to fill the current need, and the requirements for these roles will only increase.
here have historically been two distinct groups in manufacturing environments, often contrasted as “white collar vs. blue collar,” “management vs. labor,” or “exempt vs. nonexempt.” One of these groups, the “white-collar” category, consisted of managers and engineers, typically with four-year university degrees. This group designed and ran the manufacturing plants. The blue-collar group consisted of factory floor workers who operated the machinery and performed any necessary physical work. Most were designated as unskilled labor and had high school degrees, although the blue-collar ranks also sometimes included members of skilled trades such as electricians or plumbers.

Today, however, a third group has emerged in the contemporary manufacturing environment, and is poised to eclipse at least one of the two traditional groups in importance. It is also a category that has grown, even in a manufacturing context, that has seen shrinking numbers of workers. Creating, finding, and retaining workers in this third category are already becoming critical factors in the success of advanced manufacturing.

Often called technicians or “techs,” it is the job of this category of workers to program, operate, troubleshoot, and maintain the increasing number of computer- and network-driven manufacturing devices in the contemporary factory. These devices include CNC (computer numerical control)-driven routers, stampers, and drill presses, robots, additive manufacturing devices such as 3D printers, and devices in manufacturing cells that communicate through local area networks. These devices have proliferated in manufacturing, not coincidentally at the same time that many traditional blue-collar factory jobs have been outsourced or automated out of existence. Therefore, jobs for techs are rising as overall manufacturing job levels fall.

The Growing Importance of Techs in Manufacturing

A number of manufacturing company executives described the importance of techs to their companies’ manufacturing strategies. For example, David Kohler, President of the plumbing fixture company Kohler, noted:

Techs are a big issue for us. We and many other companies in the U.S. are expanding manufacturing labor in two forms. One is entry level, lower-skill classifications, which are typically a contingent workforce, but sometimes permanent. The other area involves workers with higher skills – techs doing machine setup and CNC programming, and skilled tradespeople. Those jobs are the ones we definitely want to be market-competitive for in manufacturing compensation. More and more of our products have embedded electronics, systems, and connectivity, which also raises the demand for techs with skills in those areas.

73% of manufacturing managers agreed that “The manufacturing process/technologies we use in our operations have become much more sophisticated and complex in the past several years.”

– 2012 Manpower Manufacturing Workforce Survey

Often called technicians or “techs,” it is the job of this category of workers to program, operate, troubleshoot, and maintain the increasing number of computer- and network-driven manufacturing devices in the contemporary factory. These devices include CNC (computer numerical control)-driven routers, stampers, and drill presses, robots, additive manufacturing devices such as 3D printers, and devices in manufacturing cells that communicate through local area networks. These devices have proliferated in manufacturing, not coincidentally at the same time that many traditional blue-collar factory jobs have been outsourced or automated out of existence. Therefore, jobs for techs are rising as overall manufacturing job levels fall.
Todd Teske, the CEO of engine and outdoor power equipment manufacturer Briggs & Stratton, described the long-term dynamic leading to greater use of technical workers:

*Over the last ten years especially, our plants have become very different. We always looked at the tradeoff between human and fixed capital. When we had access to a lot of affordable labor, it didn’t make sense to put fixed capital in to take out human capital. But as labor cost has gone up and fixed capital down, the environment has shifted. Now we have lots of robots – as many in a single manufacturing cell as we once had in the whole factory. The skill levels required to work in our plants have gone up substantially. We need people who can program the robots and CNC machining centers, operate them, and fix them. The jobs involve much less manual transfer of material, and more technology.*

Marty Thomas, Senior Vice President of Operations and Engineering Services at Rockwell Automation, a manufacturing automation company, notes that both the company’s products and their own factories are increasingly electronic and automated:

*The products we create are all modular and based on programmable logic, and the technicians in customer factories must be aware of how to interpret the data they produce. It is like an auto mechanic today, with all the electronics in cars. Our own factories are the same way. Our manufacturing is on fire in the U.S. today, but if you want to do manufacturing in a high-cost area, you have to automate. The technician role is the key. It is not the traditional hourly role, or the salaried role, but something in between.*

Finally, Bruce Los, the Senior Vice President of Human Resources and Information Technology at Gentex, a leading manufacturer of electrochromic mirrors and systems for automobiles and airplanes, commented on the nature of manufacturing automation in his firm and the implications for skills:

*We are very highly automated in manufacturing, primarily making circuit boards. We get more automated every day. We originally got into it for quality reasons, not efficiency. We call it “flexible automation” – it involves small batches, with CNC, and robotics. To operate that kind of manufacturing requires a high level of functioning hourly team members. Our biggest challenge is finding those techs – the people who can program and maintain the manufacturing devices. We use a hybrid model of engineers working with non-degreed techs that we train in very specialized areas, similar to the apprenticeship programs in Germany.*

The comments of these executives in leading manufacturing firms attest to the growing importance of and need for manufacturing technicians. Of course, not all manufacturing companies face a shortage of or need for such people. Ken Goodson, Executive Vice President of Operations at office furniture manufacturer Herman Miller, commented that the company had been working for many years to reduce the skill levels needed in the manufacturing process, and had reduced the need for a high number of skilled technical
positions. And Michael Greenwood, Senior Manager of Boeing Commercial Airplanes Manufacturing and Quality Workforce Management and Integration, said that the company had many qualified applicants for any opening, including jobs involving manufacturing technology. Additionally, Paul Grangaard, CEO of Allen Edmonds Shoe Corporation, noted that shoe manufacturing had changed relatively little over recent years, and that finding first-line manufacturing leaders was more of an issue for his company than hiring techs. There are, then, some exceptions to the trend of both requiring more techs and finding them difficult to hire.

Specific Education and Skill Requirements for Techs

It is apparent from most of our interviews that tech workers in manufacturing need to have skills involving the programming, operation, and troubleshooting of a variety of electronic manufacturing devices, including CNC-based machines, robots, local area networks, and other programmable logic devices. These are typically quite specialized skills, and require a combination of publicly-available education (typically in community colleges or technical schools), vendor-based education, and on-the-job training.

The tech jobs in contemporary manufacturing will also require data interpretation skills. Current manufacturing devices tend to capture and throw off data, which must be interpreted and acted upon to create an effective manufacturing process. In addition, process improvement requires an understanding of statistical process control approaches. Dave Lilak, Director of Human Resources for Manufacturing at General Mills, commented on this set of skills:

_We’ve never had so much data in our plants. There is a need to turn information into insight on the plant floor. The key to phase progression [the company’s approach to process improvement] is using data to really find out what the sweet spot is on the cereal, yogurt, and dough lines – what is the center line. You use the data and analytics to find it so it runs at that same rate day in, day out. To do this our workers had to build their skills to understand and analyze data._

Pam Kimmet, Senior Vice President of Human Resources for Coca-Cola Enterprises, Western Europe’s largest Coca-Cola bottler, mentioned that logistics expertise is critical to her organization:

_Our business success is heavily driven by the capabilities of our supply chain organization. In order to support our customers, our supply chain team needs to have a deep understanding of the end-to-end logistics of our business, from procurement through distribution._

81%
The number of manufacturing managers who agreed that “Our manufacturing technology increasingly generates data that should be analyzed to create optimum performance.”

– 2012 Manpower Manufacturer Workforce Survey
The Rise of the “Tech” in Manufacturing

We analyze data to understand how to optimize our production and distribution, and our manufacturing workers play a key role in ensuring processes are optimized and line utilization is as high as possible. The key goal is to ensure our customers have their orders “on time and in full,” and we need everyone to be fully engaged and working as efficiently as possible.

In addition to these technical and data interpretation skills, techs need the ability to work closely with other factory floor employees and with managers and engineers. Several manufacturing executives commented that factory workers are increasingly members of integrated teams, and increasingly take on tasks that were once reserved for management.

Programmatic Approaches to Developing or Finding Techs

Many of the manufacturing executives said that they were working closely with community and technical colleges to identify and develop tech workers. Some said that they were experimenting with apprenticeship programs, or with approaches to identifying talented hourly workers with the potential to become techs. Several commented, however, that the environment for identifying and training workers of this type is very fragmented, and that it does not approach the programmatic and well-institutionalized approaches used in some other countries like Germany.

Techs are a relatively new category for many manufacturing companies in North America, and companies have thus far employed localized and tactical approaches to this job category. There are some other good reasons for the use of these localized approaches. As David Kohler put it:

We do not have a comprehensive structured approach for the higher-skilled jobs, either for internal development or recruiting. We handle them at the facility level, where we typically look at compensation strategies and other approaches to retain and attract them. The localized approach works for us because the tech workers work in a lot of different process areas, and labor markets are very different country by country. But this could possibly be an area where corporate would get involved in the future. We could at least have a toolbox of tactics and a structured approach that you can apply in different situations.

It is possible, however, for firms that are relatively centralized geographically to select a few schools or universities with programs related to specific technician needs, and to cultivate them. Rockwell Automation, for example, has done this with several universities – endowing chairs, developing curricula, and nurturing relationships with
faculty. Their approach has largely focused on engineers rather than techs, but there are some examples of close collaboration with technical colleges as well. As Marty Thomas, Senior Vice President of Operations and Engineering Services at Rockwell Automation, put it:

*Talent is either a passion or it is not. I believe that you have to give responsibility for the issue to line management, rather than HR. The line managers are the most likely to be passionate and accountable for talent.*

In addition to focus on identifying and developing external talent, it is also possible for techs to be internally developed. When factory floor workers show some interest and expertise in relevant technical subjects, and demonstrate an appetite for learning, they have a strong potential to become techs. General Mills is one of the companies that has adopted this approach. Dave Lilak explains:

*At some of our manufacturing plants, we have taken people in front-line factory roles and turned them into techs. These locations have a clearly-identified tech track providing an opportunity for our employees to improve their technical mastery.*

**Changing the Image of Techs and Manufacturing**

Given the growing importance of techs in manufacturing, what can be done to create more of them? Many of the executives we interviewed believe that there are cultural obstacles to putting more people into these roles. Todd Teske, CEO of Briggs and Stratton, described some of them:

*One reason why the quality and quantity isn’t there for tech workers is, I think, that there is a stigma against going to a tech school vs. getting a four-year college degree. We have misdirected our youth. High schools have become prep schools for college, and not industry. There is less industrial arts education. Everything is geared toward four-year bachelors degrees and jobs related to them. People don’t seem to know that there are good jobs available that pay good wages off technical degrees and certificate programs. When people with four-year degrees fill a tech job, they believe they are overqualified.*

Bill Symonds, the Director of the Pathways to Prosperity program at the Harvard Graduate School of Education, describes this cultural problem:

*Across the country, people have a negative view of manufacturing. They are aware of the automobile assembly line and steel mill, and think that’s what manufacturing today is like. They also think that a lot of the jobs have been wiped out. We’ve created a negative legacy; people don’t know what the opportunities are now, or what you can make in manufacturing jobs.*
The Rise of the “Tech” in Manufacturing

Symonds and some other experts in manufacturing talent have suggested, only half in jest, that if there were a popular television program that dramatized tech jobs in manufacturing, then people would flock to them. He commented that:

The CSI (Crime Scene Investigation) shows on television have glamorized the job of the forensic analysts. I’ve heard that because of these shows, community colleges say there is tremendous demand for CSI-related degree and certificate programs, even though there is little actual demand.

Others have even suggested that a video game might also help in this regard.

Short of the development of such popular cultural products, however, there are other avenues to pursue. One is to embed manufacturing tech options in the career counseling process in schools. Although diminished in many cases in the U.S. by lack of funding, more effective career counseling could expose students to the opportunities offered by tech jobs and the paths to getting them.

Some companies are beginning to reach out to schools – even middle schools – and expose students to these opportunities. Kennametal, a specialty metal goods firm in Pennsylvania, has outreach programs for middle school students to expose them to tech jobs and STEM careers. The company believes that by high school, students are usually too far down other educational and career paths to be able to change their occupational aspirations.

Perhaps the ideal situation would be to develop a glamorous fictional movie about tech careers and show it to middle schoolers. Whatever the specific method used to overcome these cultural barriers, it is important to recognize that they exist. We will not see North American students flocking to these important tech jobs – and getting the preparation they need to perform them successfully – without dealing with current stereotypes about manufacturing and jobs in it.
Summary

This report has explored the critical role of the “tech,” or manufacturing technical worker, in the contemporary manufacturing industry. The rise of computer-based devices and manufacturing automation in plants has led to a need for sophisticated technical workers to program, operate, and maintain these technologies. They also create data that needs to be analyzed and applied on the factory floor – another role for techs. There are not enough techs available to fill the current need, and the requirements for these roles will only increase. Leading companies are beginning to work closely with educational institutions to develop programs that would train techs. There also need to be changes in the image of manufacturing and techs in order to attract more students into the field.


2 Unless otherwise specified, all quotations are from telephone interviews arranged for the purpose of this study, and completed in mid-to-late 2012.
Contemporary Manufacturing Technologies and the Talent to Use Them

The trend of integrated and more computer-driven MT devices can be observed across a variety of different technologies. This report will address the specific technology types and how they are changing with regard to integration, the talent required to employ them, and the training required by that talent.
We are now quite familiar with the rapid pace of increases in computer processing power and storage. Manufacturing technologies (MT) may be changing at a less rapid rate than other forms of information technology, but there is still considerable evolution. In general, manufacturing and information technologies are converging, in that computers and microprocessors are increasingly being used to control, monitor, and support decisions about manufacturing devices. This means that the manufacturing “tech” worker will need to become more like the better-known info-tech worker, including computer programmers, network technicians, and data center operators.

Overall, while manufacturing technologies are likely to become somewhat easier to implement and operate over the next several years, they are also likely to become much more widespread within manufacturing environments. This suggests that the demand for techs will rise, and that they will have to play a more hands-on role in installing, adjusting, and maintaining MT devices within their organizations.

In addition, the rise of cellular manufacturing – environments in which workers in relatively autonomous teams manufacture entire products or complex product components – as well as the increased ease of use of MT devices, suggest that there will be less of a distinction between factory-floor manufacturing workers and techs.

Cellular manufacturing, sometimes called cellular or cell production, arranges factory floor labor into semi-autonomous and multi-skilled teams, or work cells, which manufacture complete products or complex components. Properly trained and implemented cells are more flexible and responsive than the traditional mass-production line, and can manage processes, defects, scheduling, equipment maintenance, and other manufacturing issues more efficiently. Cellular manufacturing workers already must be able to work with multiple processes and functions within the cell. If MT devices are more integrated with manufacturing processes, it is likely that cell workers will also begin to program and maintain them. This trend would mirror the rise of personal technologies in office environments, where each worker becomes an IT worker of sorts.

“Manufacturing technologies are increasingly computer-based, and require many of the skills to manage and operate as computers do.”

According to 79% of manufacturing managers

– 2012 Manpower Manufacturing Workforce Survey

This trend of integrated and more computer-driven MT devices can be observed across a variety of different technologies. The sections below address several specific manufacturing technology types, and how they are changing with regard to integration, the talent required to employ them, and the training required by that talent.

Computerized Numerical Control (CNC) Devices

Computerized or digital numerical control devices are becoming widely institutionalized in manufacturing settings. CNC devices control the motion of routers, drills, milling machines,
turning centers, and even automatic welding machines. They often allow substantial gains in productivity for manufacturers. As with most technologies, the price of CNC capabilities is declining, and there are even low-end CNC-based tools for hobbyists. There are also online businesses that allow remote customers to send designs and CNC instructions to metalworking services organizations that then create the desired parts.

With the rise in the prevalence of CNC, there has been a similar rise in demand for CNC programmers and machinists. Any search of online job boards reveals thousands of open CNC programming positions. Some of these positions are intended only to program a variety of CNC devices; others combine CNC programming with operations of the relevant devices. In either case, considerable education is required beyond what was traditionally required of factory workers.

CNC devices initially required the use of direct codes for the geometry of the cutting or drilling process, such as the following “G-code” and “M-code” instructions:

For example, the codes a CNC programmer might have to type into a machine might include:

- G54G90G0B0
- M7;
- G4X3.;
- G81Z-.829R.1F28

This code, of course, is even less understandable to the untrained observer than most other computer languages.

More recently, many CNC machines have begun to require less manual programming, and allow the use of conversational programming languages. This may lower the technical barriers to CNC programming somewhat, but the role will still require specialized education.

In addition to programming, operators of CNC and other high-tech machines need to understand complex math. The skills and background of one such operator, Luke Hutchins of Standard Motor Parts in Greenville, N.C., were profiled in a recent Atlantic Monthly article:

At Spartanburg [Community College], he studied math – a lot of math. “I’m very good at math,” he says. “I’m not going to lie to you. I got formulas written down in my head.” He studied algebra, trigonometry, and calculus. “If you know calculus, you definitely can be a machine operator or programmer.” He was quite good at the programming language commonly used in manufacturing machines all over the country, and had a facility for three-dimensional visualization – seeing, in your mind, what’s happening inside the machine – a skill, probably innate, that is required for any great operator.

CNC devices are also increasingly controlled by computer-aided design (CAD) tools directly from 2D and 3D blueprints, creating greater levels of integration between design and manufacturing processes. This may require CNC programmers to also understand CAD programs, which have historically been the province of engineers and architects. CNC programming education is typically offered in community colleges, for-profit technical schools, and in online and video formats.

It is difficult to overstate the importance of CNC technologies to the future of manufacturing and manufacturing workers in North America. As one National Public Radio reporter put it:

And that’s really the future of manufacturing in this country – smarter workers, smarter machines, with computer numerically controlled machines at the heart of it all.
Robotics

Robots have been discussed as playing a major role in the future of manufacturing for decades. However, their impact has been limited by their expense, by the difficulty of implementing and programming them, and by safety issues. The current generation of robots is generally isolated in cages or kept behind “light curtains” that limit the possibility of collisions with humans or other machines. Because of these constraints, robot application has been in the most highly repetitive and automated manufacturing environments, and the role of robots has been to replace, rather than augment, human workers.

Robotic programming has also limited the application of robots in manufacturing. The programming of robots is both complex and specific to particular robot vendors. Because of these difficulties, many manufacturers prefer that their robotic programmers have university degrees, typically in electrical engineering.

However, a new generation of robots could lead to dramatic change in how they are used in manufacturing and their relationship to human workers. A recent New York Times article, for example, describes a new robot from Rethink Robotics, a company headed by the former MIT Professor of Robotics, Rodney Brooks:

*The $22,000 robot that Rethink will begin selling in October [2012] is the clearest evidence yet that robotics is more than a laboratory curiosity or a tool only for large companies with vast amounts of capital. The company is betting it can broaden the market for robots by selling an inexpensive machine that can collaborate with human workers, the way the computer industry took off in the 1980s when the prices of PCs fell sharply and people without programming experience could start using them right out of the box.*

The first model of the Rethink robot, known as Baxter, can work directly alongside human workers, moves slowly, and stops automatically when contacting something. If Baxter or related robots are successful, they could lead to much more rapid adoption of robots, and much greater integration with manufacturing processes that also involve some human labor. It would also mean a much greater need for techs who can program and maintain such robots in a factory environment. It seems likely that if techs with specialized training can program and manage CNC devices, they could do so with Baxter-like robots.

Machine Vision Systems

Machine vision (MV) technologies are also important to the growth of automated manufacturing. MV is typically employed for automated inspection of products and components in manufacturing, as well as guidance of robots. Common machine vision applications include sorting of parts and components, material handling, guidance of robot movement and grasping, and optical gauging.

While MV devices are not as common as CNC in manufacturing, they are growing consistently in their application. Like CNC devices, they must be configured and programmed, and they have historically been programmed by software engineers. However, with increased ease of setup and programming, it seems likely that MV technologies can increasingly be managed by employees without four-year degrees.
Additive Manufacturing Technologies

The typical approach in manufacturing has been subtractive – to remove materials to make the final product useful, e.g., to cut or drill materials away, leaving only the desired substance. A newer class of tools, however, adds material in layers to create the desired three-dimensional product or component. Called “additive manufacturing,” the technology includes 3D printing and laser sintering. The desired components can be made of materials that can be sprayed as liquids (e.g., plastics or resins) or formed from melted powder (including metals and ceramics). The components are typically manufactured directly from a 3D CAD image.

These relatively new devices have been used primarily to create rapid prototypes of products or components, and then once refined or perfected, the products were manufactured in large volume by traditional means. However, today organizations are increasingly using additive technologies for rapid production of short-volume final manufacturing runs as well.

Like many of the other technologies described in this report, the price and scale of the tools has been falling rapidly. 3D printing, in particular, has entered the home and hobbyist market, for plastic printing in particular. As with CNC devices, 3D printing and other additive manufacturing tools are also available as a remote service. It is conceivable that operating and maintaining such devices in the future will be not much more difficult than operating a 2D printer, which most office workers do every day.

49% of manufacturing managers agreed that “Manufacturing will soon be an industry where “big data” is used to create competitive advantage.”

– 2012 Manpower Manufacturing Workforce Survey

Data-Driven Quality, Data-Based Products, and “Big Data” Manufacturing

In addition to new manufacturing technologies, there are three types of data-related manufacturing developments that promise to create a new and different environment for manufacturing talent. Each will require more data and technology skills on the part of techs.

Data-Driven Quality Approaches – A number of manufacturing approaches with the objective of quality and process improvement involve substantial use of data. Six Sigma, lean manufacturing, and other process analysis tools require an understanding of statistics and quantitative reporting. Manufacturing workers that fully participate in decisions about process improvement activities must have education and experience in quantitative analysis.

Data-Based Products – Several of the manufacturing executives we interviewed suggested that they are increasingly producing products with an information technology and data-based component. General Motors vehicles, for example, now have as much as 10 million lines of software code embedded in them. Gentex, a producer of mirrors and optics, embeds electronics and software in each mirror. While software engineers generally write the software and select and optimize the hardware for these data-based products, workers on manufacturing lines must be conversant with IT concepts and must be able to install and test IT products and capabilities on the line.

Big Data in Manufacturing – The business world is abuzz with talk of “big data,” or data that is too large, too lacking in structure, or from too many diverse sources to be managed in
conventional databases. Big data users come from a variety of industries, but manufacturing firms are participating in the trend. Some diverse manufacturing firms, such as General Electric, are viewing big data from sensors in manufactured products (including, in GE’s case, locomotives, jet engines, gas turbines, and medical imaging devices) as key to effective and efficient servicing strategies. In the same mode, automobile manufacturers such as General Motors (and third parties such as Google) are creating self-driving cars based on analysis of big data from sensors and machine vision technologies.

Big data manipulation and analysis is generally performed by highly-educated “data scientists.” However, it is likely that manufacturing and techs will need to be conversant with the types and uses of data that are created by manufactured products, and with the installation and configurations of sensor devices. Big data is also increasingly likely to be used in service processes for industrial products, so service and repair technicians must be especially conversant with the data and the analysis approaches for it.

**Summary**

It is clear that manufacturing technologies are employing increasing amounts of information technology and are generating more data. Like information technology, the computer-controlled manufacturing devices are also falling in price, and becoming more feasible for personal use. This suggests a number of implications for techs:

- There will be an increasing need for techs who are trained in the relevant information technology tools and who can apply them in a manufacturing context;
- Tech work is likely to become somewhat more professionalized and better-compensated, and tech workers viewed as “knowledge workers;”
- Tech work is likely to become more integrated with line manufacturing work, which suggests the rise of more technically-literate manufacturing workers in general;
- Because the number of networked MT devices will rise considerably, there will be a need for more dedicated techs to install, operate, and maintain the networks and devices.

Some of these jobs, of course, will require highly educated engineers and data scientists, but a good number can surely be filled by techs without university degrees, but with specialized training. Of course, an infrastructure of educational and training offerings needs to emerge to provide the necessary educational content.

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Approaches to Educating the Manufacturing Workforce on Technology

Education and training are a key component to closing the manufacturing talent gap. There is also a need for substantial change in the cultural image of the manufacturing industry and of careers in it.
Clearly there are substantial skills gaps relative to manufacturing technology, and education and training will be the primary way to fill those gaps. Beyond that, however, there is little consensus within North America on the best path to create the required educational offerings and connect that education to the individual workers who need it. Existing educational offerings are limited and fragmented. Many community colleges, for example, offer no training at all on manufacturing technology. Despite a number of local innovations, in total there is not nearly enough education in manufacturing technology to support the need for trained employees.

One reason for the lack of manufacturing technology education may simply be the shrinking number of manufacturing workers. The loss of these jobs was described in earlier reports, but it means that educational institutions have less incentive to offer programs for manufacturing workers – particularly in advanced manufacturing technologies, which would appeal to an even smaller population of students. Of course, if workers cannot be trained on the needed manufacturing skills, the numbers in North America are likely to continue shrinking. Programs in manufacturing technology may appeal to a smaller number of students, but they are a disproportionately important group for the economy.

However, the primary problem in this domain is most likely a lack of coordination and collaboration among states, regions, educational institutions, and employers. While there is increasing discussion of the need for better-trained manufacturing workers in North America, this has not translated into coordinated programs at scale. Neither the U.S. nor Canadian national governments seem inclined to change this situation at the moment. The only positive aspect of this situation is that local innovations in manufacturing technology education – and there are many of them – can serve as models for a broader, more coordinated approach to the issue.

The Current Landscape of North American Manufacturing Training

Most technical training in North America takes place in two-year technical and community colleges. Few of the specific programs offered by each school are coordinated nationally or even regionally. Some programs are linked to industries and companies in their particular region; this is most likely in large and well-established industries such as automobile and aircraft manufacturing. If there is no dominant manufacturing industry in a region, it is much less likely that a two-year institution will offer programs in manufacturing technology.

The situation in Canada is little better. Canada has no junior colleges, and many of its community colleges are four-year institutions. As in the U.S., programs in manufacturing technology are somewhat rare. There are some programs supporting regional manufacturing foci, including spatial robotics in

84% of manufacturing managers agreed that, “Educational institutions in this country need to do a better job of educating the manufacturing workforce on new technologies.”

– 2012 Manpower Manufacturing Workforce Survey
Ontario and petroleum-producing processes in Alberta. Coordination at the national level is made more difficult by the absence of a federal ministry of education.

For-profit institutions would be another possible avenue to manufacturing technology education. However, while there are an increasing number of for-profit colleges in North America, they have limited offerings in manufacturing technology. Most seem focused primarily on replicating the degree programs offered by four-year colleges. These schools have also been criticized recently (particularly in a two-year investigation by the U.S. Senate) for low graduation rates and exploitation of U.S. government educational financing programs.

Online education from community colleges is another possible delivery mechanism for manufacturing technology education. However, while online educational offerings are widely available for computer programming, network management, and other IT-intensive topics, they have not yet been focused on manufacturing technologies – even when community colleges offer considerable numbers of online programs. New Hampshire, for example, has a well-developed two-year community college system, and many of its courses are offered online. However, while courses in psychology, sociology, and history are common, courses in manufacturing technology are nonexistent.

Despite these problems, there are some current bright spots in the education of manufacturing technologists. Some individual institutions have established excellent programs, and have close relationships with employers. In a few cases there are networks of institutions that are aligned with similar objectives and approaches.

One leading single institution, for example, is the Francis Tuttle Technology Center, with three campuses in the Oklahoma City area. The Center offers vocational and technical programs to high-school students and adult learners. It has 39 different career education offerings, online programs, and close relationships with local businesses. However, according to the superintendent and CEO, Tom Friedemann, there are two key reasons for the Center’s success. One is that the Center is funded by a legal entity called the “technology center district” that uses local tax dollars to fund career and technical education. The other is the availability of two college-prep programs for pre-engineering and pre-medical students. This adds to the prestige of the Center’s programs and avoids the blue-collar stigma of “vo-tech” schools. The Center offers programs in advanced manufacturing, precision machining and CNC programming, and welding, which lead to industry-recognized certifications. Students may also do some of their work online.

As an example of linked institutions, the Advanced Technology Education Centers are a network of 39 specialized education organizations focused on some form of technical education. The U.S. National Science Foundation has given some support to create and publicize the network. There are nine organizations focused on advanced manufacturing technologies, but each is either focused on a single industry or involves a single community college. Three of the nine organizations are focused on the automotive industry. For example, AMTEC (Automotive Manufacturing Technical Education Collaborative) is a collaboration of community and technical colleges and automotive manufacturing partners – located in areas with automotive manufacturing – who seek to better prepare highly skilled technicians and
manufacturing engineers for work in automobile manufacturing and technology. The automotive centers are a good match with the industry’s requirements and geographical locations. This network is an undeniable bright spot in manufacturing technology education, but unfortunately there are many industries and geographies not addressed by any organization at all.

In addition to the shortage of suitable education programs in manufacturing technology, there is also a culture and image problem that prevents many students from seeking out education and careers in the industry. I have described this problem in a previous report, and it is a critical issue for the entire industry to address.

Finally, it is also possible for employers to reach out across the fragmented educational landscape to recruit from targeted programs on manufacturing technology. There are certainly examples of this; Siemens Energy, a German company based in North Carolina, started an apprenticeship program modeled after the German system (mentioned in a previous report in this series as featured in President Obama’s 2012 State of the Union Address). Classroom instruction comes from Central Piedmont Community College’s Corporate Learning Program, with which Siemens established a close partnership.

One U.S. company that has taken an aggressive approach to educational relationships is Rockwell Automation, a leading manufacturer of systems for process automation. Marty Thomas, Senior Vice President of Operations and Engineering Services, commented on a major change in the company’s approach to human capital:

*Five years ago we had a major problem getting the people we need to do the custom engineering of our products. So, we developed a university relations approach. Now we work very hard to manage the upstream supply of talent. We have a world-class intern program, we’ve endowed a chair in supply chain management, we helped write the curriculum for the university. We do this at a variety of universities around the world where we have a major facility.*

Rockwell Automation has worked with four-year universities, but there is no reason why the same approach wouldn’t work with two-year institutions. However, most North American manufacturing companies have been somewhat passive in this regard. They desire better-trained students in manufacturing technology, but they haven’t undertaken collaborative efforts with educational institutions to produce such students. As Jennifer McNelly, President of The Manufacturing Institute, put it:

*Employers need to get more strategic about their workforces. There are long lead times involved in educating and training workers. In the past, the manufacturing workforce was plentiful and replaceable, and often treated that way. But that’s no longer the situation; our people are our most valued asset and we need strategies to support them.*
Technical Training Outside North America

The most well-institutionalized technical education programs in the world are in the German-speaking countries of Germany, Switzerland, and Austria. They incorporate the following attributes:

- Early triage of students into technology-based training;
- Extensive internship or apprenticeship programs in companies that combine on-the-job training with classroom education;
- Strong linkages with particular companies as employers – specifically those in the “Mittelstand,” or privately-owned, export-focused companies of medium size;
- A cultural tradition that supports students going into industrial and technical fields;
- Similar educational offerings across states (despite the fact that in Germany states have responsibility for developing their own programs).

This system is extensive, and aspects of it have been established since the 19th century. In 2001, for example, two thirds of German students under 22 enrolled in an apprenticeship program. This set of approaches has certainly contributed to the strong positions of the German-speaking countries in manufacturing export marketplaces. However, they have been criticized (especially in Germany) for channeling students into a rigid educational track at too early an age, and for segregating students by social class. Switzerland has attempted to enable changes in tracks by students through a series of defined pathways.

Other countries that have developed national systems of vocational education include Australia, Finland, Mexico, Norway, and Sweden. Several of them have percentages of citizens who choose vocational education over other forms of education at 50 percent or higher.

The Changes That Are Needed

If education for manufacturing technology is going to take off and supply the needed number of educated students for a North American manufacturing rebirth, a number of substantial changes are needed. They address virtually all of the stakeholders in this area, and include the following:

- State, provincial, and national governments must coordinate their efforts to support and develop educational programs in manufacturing technology;
- Community and junior colleges need to reach out to local businesses to learn what programs they should be offering to facilitate manufacturing, and to place graduates in those businesses;
- Businesses need to reach out to community and junior colleges in their local areas and persuade them to offer educational content that is relevant to their manufacturing needs;
- Two-year public and privately-run institutions can offer considerably more online education in manufacturing technology;
- Parents, students, and vocational counselors need to learn about the career opportunities in modern manufacturing industries, and to prepare students for them;
• Manufacturing executives and manufacturing industry advocates (e.g., the National Association of Manufacturers) must embark upon a publicity campaign about the opportunities available in manufacturing careers.

The publicity and awareness issue is key. As a Fortune magazine article put it:

_The industry itself must work to change the public’s perception of manufacturing._

_Manufacturers are the best messengers, especially if they dispatch successful, well-spoken employees to spread the word. Bosses should advertise and send teams to schools, training centers, workforce development boards, local grassroots organizations, and places that draw job seekers to convey the kinds of coursework, certifications, and just-in-time training that is available on the job, in the classroom, at training centers, or online. Better yet, manufacturers should invite the public to visit their facilities and see what they can offer to prospective workers._

Of course, this won’t be an easy set of changes to bring about. However, there is little prospect that a renaissance in manufacturing can take place without large numbers of people who are educated and proficient in the latest manufacturing technologies.

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**Summary**

Education and training are, of course, the keys to closing the manufacturing talent gap. While there are several examples of innovation in manufacturing technology education by single institutions, they are still too small and fragmented to meet the demand levels of employers. There are also isolated examples of small networks of educational institutions, and of progressive employers. All of these need to be undertaken on a larger scale. The solution to this problem will require concerted – and connected – efforts by government, employers, schools, and individuals themselves. There is also a need for substantial change in the cultural image of the manufacturing industry and of careers in it.

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Policy Prescriptions for the Manufacturing Talent Gap

No single policy prescription is likely to bring about the closing of the talent gap, but instead multiple initiatives working in concert will bring about the needed changes. This report will dive deeper into each of the necessary initiatives.
If the U.S. and Canada are serious about bringing back manufacturing to their shores, there are a variety of policy initiatives they should be undertaking. The lack of needed skills in manufacturing technology is a problem that has developed over many years, and the problem will not be solved quickly. Given the time it takes to persuade people to change aspirations and to improve their skills, this human capital will take a while to build and to pay off.

**Federal Government Initiatives**

The federal governments in North America are only one stakeholder in the problem, but both the Obama administration in the U.S. and the Harper administration in Canada have been publicly supportive of manufacturing. Both leaders have publicly endorsed the importance of manufacturing to their countries’ economic growth and prosperity. In neither country, however, has there been major human capital initiatives related to manufacturing.

In the U.S., according to Jane Oates, the Assistant Secretary of Employment and Training Administration in the Department of Labor, a primary focus has been on ensuring that educational institutions that receive federal government grants have close relationships with employers, and on increasing the visibility of labor market information. The Labor Department has offered a series of tools to make such information available, including the “My Skills, My Future” website for people with no work history, and “My Next Move” and “My Next Move for Veterans,” in which a potential employee would list work experience and skills, and the tool would suggest geographic areas where related jobs are most available. The certification of returning military veterans has been another strong focus of the administration.

Oates commented that there are key manufacturing skills, such as welding, that were not taught or supported by government agencies for many years, and that this problem needs to be addressed. She also believes that parents are the key to reaching students and preparing them for manufacturing careers, and admits that the “parent channel” is currently not a well-developed one for the federal government.

In Canada, the Harper administration’s support for manufacturing has primarily involved a variety of tax and tariff incentives for companies in that industry. According to the Conservative Party’s website, the only initiative involving manufacturing talent directly has been an increase in the “Industrial Research and Development Internship” program, which is primarily intended to address high-level knowledge workers such as postdoctoral fellows and skilled graduate students. While the Canadian government offers moral support for manufacturing, considerably more attention and resources seem to be devoted to resource extraction industries, e.g., oil sands.

No single policy prescription is likely to bring about the closing of the talent gap. Instead, a variety of related initiatives that work in concert will bring about the needed changes. In the remainder of this report, initiatives ranging from education to funding to cultural programs are addressed.
A Race to the Top for Manufacturing Education

In the U.S., the Obama administration in its first term announced the “Race to the Top” competition, which provided substantial grants to states that demonstrated or proposed effective programs for K-12 education. Over $5 billion has been budgeted for the program in three phases. While it has been viewed as successful thus far, it includes no funding for secondary or vocational education. In fact, the meager level of funding for community colleges and vocational schools from the U.S. Department of Education has declined during the Obama administration. However, more than $200 million for technical education grants has been made available through the Department of Labor, some of which has gone to advanced manufacturing programs.

Manufacturing education needs its own “Race to the Top.” Such a competition would be well-suited to the current situation of manufacturing education, in which there are a variety of small, local innovations. If the leading programs in particular cities, regions, or colleges could be expanded considerably, they might begin to meet companies’ demands for well-trained manufacturing workers and manufacturing technologists. A competition of this type might also bring attention to the good jobs available for students who receive training in manufacturing technologies.

The idea of competitions could be extended from states to companies. For example, companies that do an effective job of providing advanced manufacturing training for their workers could receive either outright grants or tax credits for the human capital investments they have made. Identifying these leaders would make them sought-after employers. Local government organizations would benefit from these investments because they provide continued employment for citizens and maintain the local tax base.

Some people object that it is not the role of government to “pick winners” in terms of manufacturing technologies, industries, or educational approaches. However, it seems likely that there is already consensus on most if not all of the winning technologies and approaches. For example, when institutions do offer training on manufacturing technologies, it almost always involves CNC devices, complex machining, and welding. And virtually every person interviewed about education and training in manufacturing technologies spoke of the need for educational institutions to work closely with manufacturing businesses.
Institutionalized Funding at Many Levels

Federal funding, whether in the U.S. or Canada, is not going to meet all needs for manufacturing-oriented education. There will have to be locally-driven stable funding for community and junior colleges and specific manufacturing programs within them if these institutions are to turn out the requisite number of trained students. Funding will need to come from regional compacts, states, provinces, counties, and cities, and will undoubtedly retain a “patchwork” quality given the decentralized nature of funding decisions. However, stability of funding is particularly important. The Director of the Francis Tuttle Technology Center, a leading vocational training school in Oklahoma, noted that it is only because of a local tax-based funding mechanism created in 1979 (which provides 80% of its budget) that the Center has been able to succeed over time.

Local funding should be targeted to the manufacturing industries and technologies that are prevalent in the region. The National Center for Aviation Training, a Wichita, Kansas area school built by Sedgwick County, was mentioned in a previous report. Part of the Wichita Area Technical College, the Center has partnered with large employers such as Boeing and Spirit Aerosystems to create curricula and course content. In other cases individual companies (e.g., Siemens Energy in North Carolina) have received local government funding for manufacturing education programs that benefit only them, though they have to promise that a certain number of jobs will be created in order to receive the funding.

A Greater Degree of Sharing and Coordination

In addition to financing, manufacturing education programs need a better ability to share and coordinate their content – not only with each other, but with vendors of manufacturing technology and companies that apply it. There are relatively few faculty available who can teach such content, and sharing could increase the number. Smart vendors and users of manufacturing technology would create a clearinghouse or portal of content that could be used for instruction. While specific educational institutions may view such content as proprietary and leading to competitive advantage, it is likely that they could benefit from receiving content from other institutions.

There is also a commercial opportunity to exploit with regard to educational materials involving manufacturing technology. A few companies, such as Amatrol, have begun to service this market, primarily with online offerings. Amatrol has also partnered to provide content to certification organizations like NIMS (the National Institute for Metalworking Skills), as explained further in the next section. The University of Phoenix, a large supplier of online degree programs, has partnered with the Manufacturing Institute to create a Bachelor of Science in Management with a concentration in the manufacturing sector.
Certification Programs

A key aspect of connecting manufacturing talent needs to available workers is certification that workers have the necessary skills. There are already a variety of certification programs for other types of blue-collar workers such as plumbers and electricians; these are generally administered by U.S. states and Canadian provinces. The American Welding Society has national certification programs for welding. Some certification programs require a certain period of apprenticeship for workers to learn their trades.

However, certification programs for manufacturing technologists are only now emerging. NIMS is an example of an organization that has established certification for 24 different metalworking domains across three levels, but many employers do not yet require the certifications for hiring. Similar types of certification programs are needed in manufacturing technology areas outside of metalworking.

In order to address this issue, the Manufacturing Institute has compiled a Skills Certification System (incorporating a variety of previously-developed certifications, including the welding and metalworking certifications described above) that has been endorsed by the National Association of Manufacturers (NAM). It includes several different types of skills, including personal effectiveness competencies (showing up on time, working in teams), academic competencies (reading, writing, math), manufacturing competencies (safety, quality management) and industry-wide technical competencies (welding, machining, CNC). These certifications are still in the pilot stage, but the goal is to drive programs at a wide variety of community colleges across the U.S. If effective, they could transform the certification environment and make a major contribution to reducing the skills gap.

The U.S. and Canadian federal governments are not generally involved in certification programs, although there has been some activity in the U.S. relative to certification of returning veterans. The recently-passed Veterans Skills to Jobs Act requires the federal government to consider military training and certification for the relatively few civilian licenses and certifications that are controlled at the federal level, such as aircraft repair and air traffic control. While these do not relate to manufacturing, they could signal the beginning of a broader federal effort to certify veterans in order to reduce their unemployment levels. In fact, the Obama administration recently announced that it would work with the NAM to certify returning veterans using NAM-endorsed certifications in the Skills Certification System.

Vendors of CNC technology could also play a lead role in certifying workers on the programming and management of their technologies. IT vendors have played this role successfully for many years. For example, Microsoft has a series of certification programs that have been enormously useful in matching systems engineers and other IT professionals to jobs requiring a particular set of IT skills. As yet there are no such programs for manufacturing technology; perhaps this is because there is no vendor as dominant as Microsoft in this category.
Changing the Culture

Several of the company, education, and policy leaders interviewed for this study suggested that there is a major cultural barrier with regard to advanced manufacturing. Neither students nor their parents seem to be aware of the opportunities available in the field, and many have outdated ideas of what manufacturing jobs and careers are like today. The jobs are viewed as involving manual labor, dirty and loud work environments, and limited future potential – but advanced manufacturing jobs often offer quite the opposite.

One effort to change the awareness of contemporary manufacturing opportunities is the Dream It. Do It. Initiative, sponsored by the Manufacturing Institute. According to the Institute:

Dream It. Do It. is the national career awareness and recruitment program for manufacturers. It includes national and local activities to engage, educate, and employ the next generation of skilled manufacturing talent.²

The program already has affiliates in 18 U.S. states, with several more coming soon. It includes a website, “Manufacturing Days” to introduce students and potential employees to local manufacturers, community engagement programs, and research on perceptions of manufacturing. Whether it will lead to the needed level of cultural change is not yet clear.

Perhaps a more aggressive approach would be for manufacturers to band together (perhaps through the NAM or Manufacturing Institute) to fund television programs or movies – reality-based, dramas, or even sitcoms – that would accurately depict the current model of manufacturing jobs. One head of an educational institution for manufacturing noted that the proliferation of chef- and cooking-oriented reality shows and competitions on television had greatly increased the number of people training for careers in that industry – perhaps beyond the level at which they can be absorbed. There is perhaps nothing inherently more glamorous about a cooking job than a job in advanced manufacturing, so perhaps there is an opportunity for cultural redirection.

Who’s in Charge?

One of the primary problems with the manufacturing skills gap is that no one organization or sector is clearly in charge of addressing it. There are many stakeholders, including companies, educational institutions, and various levels of government. None of these groups can solve the problem on their own.

Many companies have been passive about the problem over the last few decades, presumably believing that they could move to other regions or countries if they couldn’t find the skilled labor they need. However, they will need to take a more aggressive approach if they are going to find the workers they require. As one executive of a
Policy Prescriptions for the Manufacturing Talent Gap

Nevada-based manufacturing company, Click Bond, put it on a 60 Minutes segment about the manufacturing skills gap:

_We just hoped that the education system would produce what we need and I think the recession... a lot of things have taught us, ‘No, you have to engage._\(^3\)

Click Bond has worked with Western Nevada College to develop relevant courses, and has also created an internship program for students enrolled at the college.

Government organizations cannot force companies or educational institutions to train workers, but they can incent them to do so through regulation, grants, and tax policy. Their incentives should also – as the Labor Department in the U.S. is doing with its grants – encourage colleges to work closely with potential employers. Local governments can also provide incentives to both employees and employers. In Nevada, for example, workers who are receiving company-paid instruction and internships do not forfeit unemployment insurance until they actually get jobs.

What is clear is that none of these stakeholders can expect that the skills gap will be solved by others. Each must engage in the problem and explore various alternative solutions. The skills gap took many years to create, and only through concerted and coordinated efforts over many years will it be overcome.

Summary

Neither U.S. nor Canadian governments are sufficiently focused on the problem of – and the solutions to – the manufacturing talent gap. As with educational programs, there are some “points of light” that are worthy of emulation and expansion. But there is a much greater need for competitions, certification programs, long-term funding mechanisms, and the sharing of approaches and content across branches and levels of government. Perhaps the most important job government organizations can perform is to convene the multiple stakeholders involved in this issue, and encourage them to cooperate and innovate through multiple concurrent approaches. Governments will not solve the problem of insufficient advanced manufacturing skills by themselves, but they are surely a convener and facilitator of those who can develop solutions.


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About the Author

Thomas Davenport has written or co-authored fifteen best-selling business books and over 100 articles. Tom earned a Ph.D. from Harvard University in social science and has taught at the Harvard Business School, the University of Chicago, Dartmouth’s Tuck School of Business, the University of Texas at Austin. He is currently a visiting professor at Harvard Business School, and the President’s Distinguished Professor in Management and Information Technology at Babson College. He has also directed research centers at Accenture, McKinsey & Company, Ernst & Young, and CSC.

Manpower asked Tom to research the manufacturing industry as it relates to workforce challenges and report the findings to be used as a starting point in identifying solutions for the talent shortage.
Learn more about how Manpower can help you with manufacturing workforce solutions at manpower.us.

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