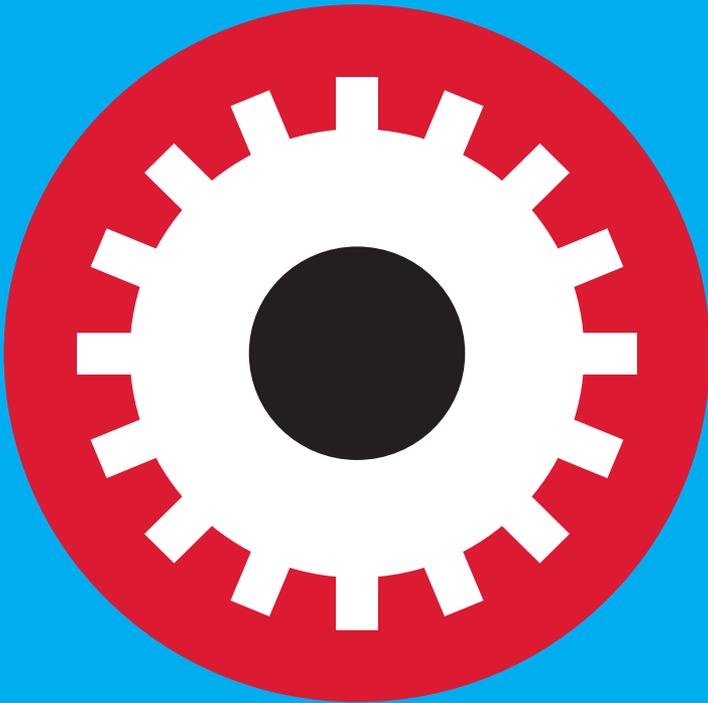




Creating a Skilled Manufacturing Workforce

Stacey Jarrett Wagner

STACEY JARRETT WAGNER
is the Manager of Workforce
Systems Development at
the National Institute of
Standards and Technology's
Manufacturing Extension
Partnership (MEP) program.



Creating a Skilled Manufacturing Workforce

Stacey Jarrett Wagner
Training

Slater Mill, built in 1793 in Pawtucket, R.I., is considered the starting point of America's Industrial Revolution. When Slater substituted water power for human labor, manufacturing output, distribution and profits improved. The modern manufacturing business model was ignited. This business model still required human labor, but not in the same way as before. During this period, American manufacturers capitalized on recent discoveries, using new materials and energy sources to support improvements in farming, textiles, goods manufacture and everyday activities. This allowed farmers to grow more, tradesmen to produce more, and both groups to sell more. It also changed the nature of work, the routines of householders and businesspeople, and society in general.

The goods manufactured in America at that time served the domestic market, but they were also traded abroad and provided a platform for local, regional and national economic growth. From the 18th through the 20th century, America's industrial production index increased over 460 times.

Those centuries were marked by a sensibility that continues to guide manufacturing in the century now unfolding. Manufacturing has unfailingly put new ideas to work, from those early water-driven spindles to the nanoparticles used in "intrinsic healing" coatings today. Scientists, artists and backyard inventors continue to play a starring role in manufacturing innovation. At the shop-floor level, manufacturing employees are often playing an analogous role, identifying process innovations.

The manufacturing paradigm continues to shift away from labor-intensive activities toward knowledge-based and technological problem solving, and from commoditized to customized production. Likewise, manufacturing logistics have progressed from horse-drawn carts and tall ships, through phone calls and fax machines, to digital supplier networks and online shopping.

While the United States has long had international trading partners, its enterprises now instantaneously source goods, materials, employees, capital and ideas from around the world. American businesses have dealt with world trade since colonial times, but today's globalization — and the digital technology that supports it — are rapidly and radically reconfiguring America's workplaces and workforce demands.

THE MANUFACTURING WORKFORCE REQUIRES A NEW FOCUS

In the 1950s, American manufacturers employed more than one-third of the country's private-sector workforce; in absolute numbers, manufacturing employment peaked in 1979, at 19.5 million. But by September 2012, the U.S. manufacturing sector employed less than 10 percent of the country's workforce. Historically, nations have moved from low-wage, low-value manufacturing to higher-value-added production as a prescription for maintaining or improving the competitiveness of their manufacturing sector.¹ The United States is no exception: It must continue to create innovation-intensive workplaces to ensure a high standard of living for its citizens. As it does so, manufacturing jobs are changing and many may be lost, but higher-wage jobs and careers are also being created.

From the 1950s through the first decade of the new millennium, the manufacturing environment changed dramatically, and small and medium-sized American manufacturers often failed to keep pace. As the industrial cycle accelerated, companies sought an ever-bigger share of existing markets, which influenced the movement of operations in and out of the United States. Locally based manufacturers were eventually forced to choose either low-cost, labor-intensive production or high-tech,

innovation-based production. The many companies that made no choice, preferring to wait, are now facing a critical dilemma: whether to move to a foreign location where cheap labor and a relaxed regulatory environment support the manufacture of commodity products, or to adopt an advanced manufacturing system at home. By reinvesting in America, both small and large manufacturers will be positioned to create millions of high-wage manufacturing jobs, as well as jobs in other sectors of the economy.² To ensure that this occurs, new tax, trade, technology and talent policies need to be adopted.³

Nostalgia for “old-time manufacturing” has afflicted many Americans, who pine for the days when a person with little education but a lot of strength of character could hold down a good job with a Michigan auto-maker, an Ohio parts-maker, an Alabama shipbuilder or a California avionics supplier. America's middle class was literally forged in the manufacturing sector. But as times have changed, manufacturing has changed with them, so that not only new skills, but also new combinations of skills, are required of a manufacturing employee. Today's requisite manufacturing skills are still being defined and certified, and they will continue to evolve over the next several decades into some of the following:

- Sense-making (for dealing with complex situations);
- Novel and adaptive thinking (for developing innovative ideas and problem-solving);
- Social intelligence (to understand how best to connect and work with people);
- Trans-disciplinary facility (to work across multiple disciplines);
- New-media literacy (to know how to use many forms of media to find, analyze and use information);
- Computational thinking (for deploying a systems approach to an enterprise or sector);
- Cognitive load management (to manage information overload);
- Design mindset (to create new forms that meet function);

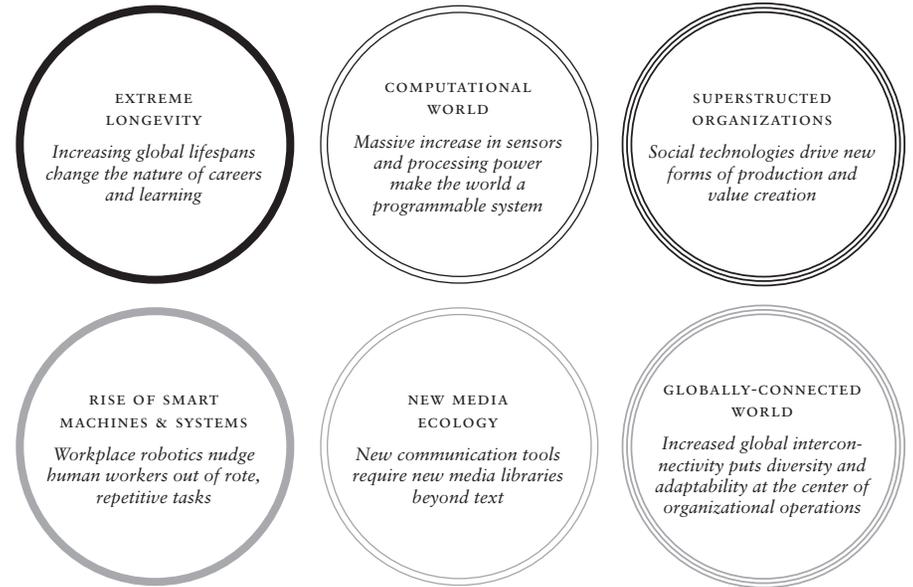
- Cross-cultural competency (to ensure global fluency); and
- Virtual collaboration (to be able to partner with others not seen in the flesh).⁴

As these new skill combinations suggest, manufacturing employees will need to be adept at maneuvering within a high-tech, information-loaded, fast-paced, multidimensional, multinational framework whose inputs may be sourced from anywhere in the world. These inputs include personnel. If there are gaps in critical areas and functions, manufacturers can be expected to source employees who have the right skills from wherever they are located, regardless of country or region.

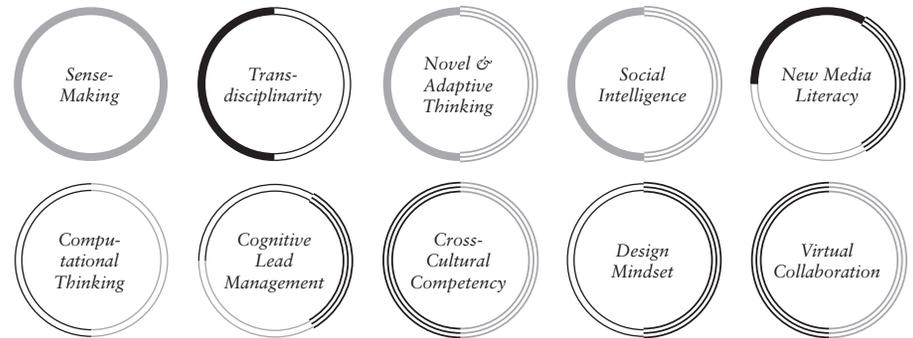
Offshore outsourcing, outdated education and training systems, and manufacturers who won't invest in training have been singled out as causes of America's current manufacturing-skills gap. Specifically, the last 20 years have so transformed the manufacturing workplace that it has become difficult to understand the skills or skill combinations that are necessary at any given moment or that might become necessary in future decades.

In the 1980s, few really understood the extent to which computers would change the workplace. Who knew that radio-frequency ID tags would revolutionize the supply chain to such an extent that any excess supplier capacity would be deemed a liability? Who could have predicted that atomic particles would be manipulated to create the high-capacity processors that are now taken for granted, or that the supply of rare-earth materials could restrict industrial growth around the world?

DISRUPTIVE SHIFTS THAT WILL RESHAPE THE WORKFORCE LANDSCAPE



KEY SKILLS NEEDED IN THE FUTURE WORKFORCE

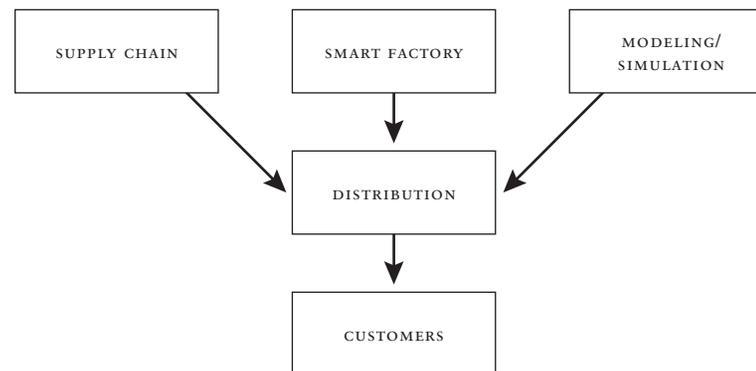


Education and workforce development are the bedrock of 21st-century manufacturing. If this is not well understood, then America will lack the commitment to educate its current or future employees so that they can lead, or simply keep pace with global manufacturing or industrial and scientific innovation. It is critical that the pioneering nature of advanced manufacturing be understood nationally, for only then will the education needed by its workforce be made available.

Advanced manufacturing “is driven by advances in science and technology that occur in university or industrial laboratories, on factory and shop floors or at business schools,” states a 2012 report from the Institute for Defense Analyses.⁵ There is often debate over the exact definition of advanced manufacturing, but the concept is clear: Advanced manufacturing embraces technology and innovation as the platforms from which it creates products for consumer, commercial, military and scientific markets. Location plays only a minor role. Innovation, supply chains, production, distribution and customers may be geographically co-located within an “industrial commons” or spread across the world.⁶

At each stage of manufacturing, from concept to delivery, the business components — supply chain, modeling and simulation, production, distribution, sales and end use — can be contiguous, but they need not be. Design may take place in California, manufacturing in Florida, and supply-chain management in Montana, while customers can be located around the world or right next door. “Manufacturing” will become a mixture of technologies that are characterized by high levels of innovation and collaboration. In emerging techniques such as additive manufacturing, less manufacturing knowledge will be needed at the production stage than in the design stage, which will depend upon advanced materials science.⁷ Automation will become a dominant force within the manufacturing environment, and employees will need to understand how to manage sophisticated robots and other automated technologies that are built upon information technology and advanced software.⁸

FIGURE 2: *Advanced Manufacturing Enterprise Concepts*



Source: Adapted from SMLC (2011)

Advanced manufacturing is fast becoming the dominant type of manufacturing in the United States, driven by the necessities of economics and national security,⁹ and the majority of manufacturing employees will soon be working in its fluid, computational, adaptive, digital world. New approaches to workforce development must therefore be initiated, implemented and institutionalized so that America can — in fact, not in rhetoric — build a pipeline of advanced manufacturing talent to fuel its economic growth. But there exist today many small and medium-sized manufacturers (SMEs) in America whose business models do not reflect the accelerating transformation of production. As a result, the U.S. must focus on its small manufacturing firms, which account for 98 percent of the U.S. manufacturing base,¹⁰ especially since SMEs create jobs at a higher rate than large firms.¹¹

Strategic management, acquisition, development and retention of talent are the foundational components of a corporate workforce system. Large companies, those with more than 500 employees, have strategically

managed their talent for decades, but small companies have often lacked the wherewithal to manage their workers as part of their business systems. In small manufacturing firms, managing production and sales has ranked at the top of the “must do” list, while the “people side” has been managed in line with workforce regulations such as worker’s compensation or seniority, and without the benefit of such human-capital-concepts as knowledge sharing and pay for performance. Small manufacturers think more about minimizing personnel costs and risks and less about creating value through strategic talent management. This needs to change.

Standardized technology-sharing infrastructure such as Tin Can (formerly SCORM¹²) and the proliferation of software applications have democratized the capture and distribution of information, making analytics newly accessible to small businesses. As the cost of investing in technology has decreased, more firms have been able to put technology to work in their operations. In the late 1980s, technology for capturing and managing firm-wide data on human resources and corporate training was taking its baby steps. It’s now employed in all firms, from the neighborhood grocer to global businesses. Early human resource systems did little more than capture simple data, but today’s systems can manage a firm’s talent by using analytics to better understand how investments in human capital, from acquisition through training to retirement, affect an organization’s performance, create value and reduce liabilities. These new processes will likely only be successful, however, in an organizational culture that values, and wishes to enhance, its workforce capacity.

Inside SMEs, a workforce initiative is rarely considered to be a “system” that is integrated with other business systems such as production, distribution or finance. But incorporating system processes such as workforce alignment and planning, recruitment, career development, management, retention and succession can mean the difference between managing workforce-development risks and rewards successfully and facing the

unintended and costly consequences of hiring the wrong people, with the wrong skills, at the wrong time and for the wrong reasons.

The analytical tools for understanding workforce investments have never been better, but planning, analysis and evaluation of these investments among SMEs remains weak. A recent Boston College report describes how American manufacturers lag behind all other industries when it comes to planning for their workforces.¹³ Data from this report show that manufacturers are woefully unprepared when it comes to understanding their employees’ career plans, the changing demographic makeup of their companies’ workforces, the demands of succession planning, what skills their firms currently possess, what skills their firms will need over time and what ability their supervisors have to anticipate and plan for staffing requirements.¹⁴

WHAT AMERICA MUST DO AND WHY

America is home to the “innovative solution,” but in trying to fix the decades-old skills gap, it has created an overabundance of “solutions.” Manufacturers can find useful workforce development partners in community colleges and technical schools; polytechnic institutes; career academies; science, technology, engineering and mathematics (STEM) magnet schools; manufacturing and science summer camps; First Robotics competitions; vocational clubs for high-schoolers such as SkillsUSA; non-profits that promote engineering education such as Project Lead the Way; skills certification providers like the Society of Manufacturing Engineers or the American Welding Society; awareness campaigns such as “Dream It. Do It.”; and nationwide public-private technical assistance providers like the Hollings Manufacturing Extension Partnership.¹⁵ The National Science Foundation’s Advanced Technology Education (ATE) centers work with businesses, post-secondary schools and student outreach programs around the country to help revise curricula for advanced manufacturing professions, create a workforce supply for businesses and expand job opportunities for young people and adults. ATE centers in Washington and California are already teaching students about additive manufacturing and nanotechnology, and they will provide

credentials in those disciplines. Generally, community colleges enroll about eight million students, many of whom attend specifically for workforce training.

In 2010, federal legislation was signed providing \$2 billion over four years to fund the Community College and Career Training initiative with an eye toward workforce skills development.¹⁶ More recent legislation gives military veterans grant funding for retraining opportunities and provides tax exemptions for employers who hire them. In 2012, the White House promoted legislation that would align credentials for military and civilian occupations.¹⁷

There appears to be no dearth of organizations, programs and initiatives that intend to re-create America's manufacturing workforce. So, what could possibly be missing in the effort to close the U.S. skills gap? Why do SMEs have a continuing problem finding skilled manufacturing employees?

The main problem is that along with disruptive technologies comes disruption in skill requirements. New requirements take some time to fully understand and to teach — once they are even identified. Because the manufacturing sector has changed so dramatically from the Baby Boom generation to the Millennial generation, the long lag that has taken place in updating formal education and training has had a considerable, detrimental effect on the manufacturing competitiveness of smaller U.S. companies. Unlike most large companies, SMEs don't have corporate trainers, corporate universities or chief learning officers to negotiate changing skill requirements.

The second but no less critical problem is that innovation, exporting, supply-chain management and sustainability used to be for “the big guys.” These issues now shape the environment in which SMEs conduct business as well. Cost-reduction issues have already been pushed down to suppliers by the original equipment manufacturers (OEMs), and now small companies must move quickly beyond the general role of low-value, high-volume

supplier. To do this, American SMEs must now use the technology, brain-power, capital financing and flexible business-process approaches that, for a long time, were not necessarily critical to their ongoing success. To stay on top in today's high-stakes business environment, SMEs have begun using technology to monitor inputs, outputs, throughputs and revenue. Everything from design and production through marketing and distribution is run or monitored by advanced software applications that can help evaluate the costs and value of business processes. It is critical for manufacturers to invest in these technologies, for without them they will not be able to compete either domestically or globally.

U.S. manufacturers cannot hope to grow without seeing the world as their marketplace and without embracing innovation and the development of new products and services that place them above low-value providers. Yet, to date SMEs' adoption of new technologies has been uneven not only across sectors and regions but also at the operations level, making it hard for states to provide large-scale education and training solutions.

To address these issues, SMEs need to adopt a set of workforce system standards that will allow them to analyze their workforce needs; calculate investments in programs, training and wages; and make decisions about what works best for their business based on their unique data. This means that SMEs, like their big-company brethren, must identify their short- and long-term business goals, the technology and processes needed to meet those goals, the skills that will make this work, the best source of those skills, how to attract those skills, the business value they place on those skills and how best to support their workforce investments.

Interestingly, in spite of the urgency felt by American manufacturers to find skilled employees, investment in corporate training has been rather static during the last decade.¹⁸ Some of this can be attributed to the rapidly changing business environment and to a resulting uncertainty as to what kind of employees are needed, but it can also be attributed to a failure to integrate talent management with other business processes. Only 13 percent of the companies participating in the 2011 “State of

Industry Report” by the American Society for Training and Development said that they integrate technologies and share data when it comes to talent management, while 70 percent acknowledged that they should.¹⁹ Seventy-two percent said that they should use technology to better manage their talent, and 85 percent said that they should establish an organizational culture that supports talent management. But they don’t do these things.

Another report, from the American Small Manufacturers Coalition, states that while almost 77 percent of manufacturers rate the importance of human-capital acquisition, development and retention as highly important to their business success, only 24 percent have a measurement system for reviewing the return on their workforce investments.²⁰

For SMEs, employees have long been a fungible commodity that did not seem worth the “extra” investment. But that era is finished. Today’s advanced manufacturing workplace requires employees with a multitude of advanced technical skills, as well as emotional intelligence, communication facility, talent in cognition and analysis, imagination, a capacity for systems thinking and creativity in problem solving. An internal system of standard management metrics and evaluative functions, integrated alongside other business systems, is critical to successful talent management.

HOW SMES CAN COMPETE FOR HIGHLY-SKILLED EMPLOYEES

In today’s workplaces three generations work side by side: the Baby Boomers, the Gen-Xers and the Millennials.²¹ Each of these generational cohorts values specific attributes of their employers and specific benefits those employers offer. But Millennials are, and will continue to be, different from the other two groups. They have grown up in a world extraordinarily different from that of their parents and grandparents (who may still be young enough to work), and the expectations they have for their professional lives align more substantially with their personal aspirations than the expectations of the two previous generations. Among the Millennials’

expectations are:²²

- that they will be offered international opportunities;
- that they will have access to excellent training and development programs;
- that their employer will have a solid reputation for ethical practices;
- that their employer’s values will match their personal values;
- that the company they work for will have a reputation as an employer of the best people;
- that their employer will have a distinctive brand;
- that their employer will have an impeccable diversity and equal-opportunities record;
- that they will be afforded ample opportunity for career progress;
- that the wages and other financial incentives they are offered will be competitive; and
- that they will be offered good benefits packages.

Millennials are history’s first “always connected” generation. They have grown up with digital technology and social media; in fact, they may be seen everywhere multi-tasking on hand-held devices. They are expected to become the U.S.’s most-educated generation.²³ They believe they are distinct from previous generations because of their use of technology, while Baby Boomers say their distinction is an intense work ethic. More Millennials than Baby Boomers say that most businesses should balance profit making and social justice and that they want to work for a company that mirrors their civic beliefs. If manufacturers are often heard to lament that younger workers don’t understand the manufacturing opportunities available to them, perhaps the trouble lies in a failure by prospective employers to portray the career opportunities they have to offer so that they are in sync with Millennials’ aspirations.

UNDERSTANDING THE VALUE OF

ORGANIZATIONAL CULTURE IN A GLOBAL WORLD

As work life and personal life become ever more-tightly interwoven, it is important for manufacturers to understand how their operations attract and keep the right talent. Because individuals with talent will be able to work anywhere around the world, American manufacturers must create a work environment that encourages invention. Thus, SMEs must:

- promote effective collaboration, teamwork and access to knowledge sharing;
- nurture good communication among staff;
- eliminate barriers to staff performance;
- define jobs clearly and allow staff to do them well;
- engage in continuous improvement in their operations;
- demonstrate outstanding professional values at all times;
- plan on an annual basis for innovation and growth;
- match job profiles and staff skills;
- use job profiles to support innovation and growth goals;
- adopt human-resources policies that are fair and equitable;
- make a leadership program available to staff;
- assure that a succession plan is in place; and
- analyze the workforce's tangible and intangible value to the business.

Not only is it crucial to attract and retain the right talent, an organizational culture must support an environment of invention and creativity. It is not for nothing that the successful technology companies of Silicon Valley provide a stimulating work environment with flexible human resources policies that offer such benefits as continuing education, sabbaticals, skunk works and an attitude of fun.

UNDERSTANDING RESOURCES AND PARTNERSHIPS

In the interconnected world Americans now inhabit, SMEs will need to make better use of partnerships to gain access to existing resources and additional resources that may be created in the future to support them. The federal government's Manufacturing Extension Partnership (MEP) program, which is approaching its 25th year in operation, was

instituted to act as a catalyst for strengthening American manufacturing and accelerating its ongoing transformation. In its early years, MEP focused on lean manufacturing and the production of quality products in the small manufacturing environment. Now it is driving growth through innovation, using five "Next Generation Strategies": continuous improvement, technology acceleration, supply-chain management, sustainability and workforce excellence.

All of these strategies require the use of outside resources to capitalize on change. The MEP centers partner with federal and state agencies, community and technical colleges, universities, governors' associations, think tanks, workforce investment boards, chambers of commerce and others, and they encourage SMEs to take advantage of the technical assistance they offer. Examples of partnership resources include skills certification through the National Association of Manufacturers' Skills Certification System and the National Governors Association Policy Academy; layoff aversion programs with local Workforce Investment Boards; and grant funding opportunities available from the Departments of Labor, Commerce, Energy, Transportation and Agriculture to develop models of regional advanced-manufacturing activities that focus on strengthening American manufacturing and encourage OEMs to "buy American."

CREATING A CORPORATE WORKFORCE SYSTEM

MEP is currently developing a talent-management tool to support the investments of small and medium-sized manufacturers in aligning

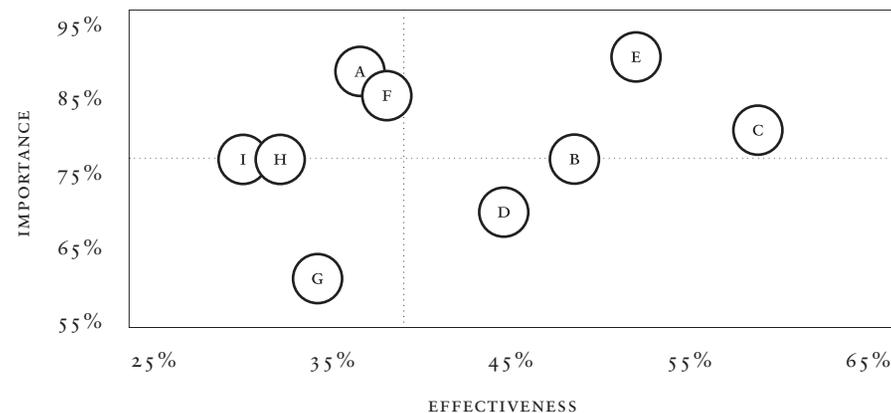
workforce planning and development with specific business drivers. The overall system will include strategic planning and alignment, recruitment, retention, management and succession planning. MEP is creating this tool, to be piloted in 2013, with the intent that it will provide automated data analyses and analytical guidance for manufacturers in their workforce planning and implementation.²⁴

But the MEP tool — or any technology, for that matter — will be only as good as its user. The nationwide network of MEP centers will therefore work with SMEs to help them not only understand how to put a corporate workforce system in place, but also to identify the kinds of questions they should put to themselves to ensure that the data they gather can shed light on their workforce-investment returns. An analytical method for understanding workforce risks and returns will raise the level of a SME’s competitiveness from that of local operator to one of global business enterprise. While the MEP tool will not be the only one available in the talent-management marketplace, it will be specific to the small manufacturing environment. This tool and others like it will support American manufacturing competitiveness by helping small firms define their workforce challenges; identify data requirements; define a workforce analytics platform that is common and therefore easy to use; and enhance the firms’ human-resources analytic capacity.

In a survey conducted by IBM during the recent recession, respondents were asked to rate the importance of human-capital challenges, as well as their organizations’ effectiveness in addressing each. FIGURE 3 lists how businesspeople rated their challenges and plots the challenges’ importance and the firms’ effectiveness in meeting them.

The chart shows that keeping talent in the organization is the most important of the challenges in talent management and that the programs used to accomplish this were the most effective programs the firms engaged in, while strategies for reductions in force were the least important and ineffective. Additionally, firms said that aligning knowledge, skills and abilities with business strategies is very important, as is evaluating talent in support of business goals.²⁵

FIGURE 3: *Reported Importance and Effectiveness of Strategic Human Capital Challenge*



ITEM		GAP
A	Defining knowledge, skills and capability requirements for execution of business strategy	48%
B	Determining headcount and FTE capacity requirements by job assignments and locations	31%
C	Sourcing and recruiting individuals	22%
D	Developing training strategies	35%
E	Retaining valued talent within the organization	38%
F	Evaluating workforce performance	46%
G	Determining strategies for reduction in force, redeployment and retraining	24%
H	Understand collaboration and knowledge sharing	48%
I	Developing succession plans and career paths	49%

RECOMMENDATIONS TO ENSURE COMPETITIVE U.S. MANUFACTURING

The recommendations here are not necessarily specific to small and medium-sized manufacturers, but SMEs are at the heart of America's manufacturing growth and innovation, and they need support. Large manufacturing companies, while significant contributors to manufacturing employment, have more resources from which to draw as they attempt to improve their competitiveness. However, OEMs are closely linked to, and dependent on, the quality of the small firms in their supply chains. Thus, an increase in the ability of SMEs to compete will boost the entire U.S. manufacturing network as it continues contributing to America's economic growth.

- *Support the Proposed National Network of Manufacturing Institutes (NNMI)*

President Obama announced a plan in 2012 to invest \$1 billion to create a national network of up to 15 manufacturing innovation institutes around the country. These would serve as regional hubs of manufacturing excellence to make manufacturers more competitive and encourage investment in the United States. The proposed network has been endorsed by the federal government's Advanced Manufacturing Partnership (AMP) Steering Committee. The AMP's final recommendations outlined a set of actions designed to enable innovation, strengthen the U.S. workforce and accelerate investment in America. These institutes and the network should be quickly established.²⁶

- *Promote Verified, Reliable and Standardized Skill Certifications to Create Reliability and Validity in the Recruitment Process*

The country needs to ensure that nationally portable skill certifications are aligned to secondary and post-secondary programs of study and to industry-relevant training needed for employment in advanced

manufacturing. And the alignment of military and civilian skill certifications must also be integrated into an agreed-upon certification taxonomy so that America's veterans can be placed in advanced-manufacturing jobs.

- *Expand the National Science Foundation's Advanced Technology Education (ATE) Centers and Connect Them to Education Providers*

Expanded funding for the ATE program would support community colleges working in partnership with industry, economic development agencies, workforce investment boards, and secondary and tertiary educational institutions — with an eye toward advanced-manufacturing disciplines. The centers should be linked with STEM programs at all educational levels and with industry-Ph.D. fellows programs to increase the quality of research and education.

- *Invest in High-Quality Job Training Such As Apprenticeships and Internships*

Companies, schools and training providers must ensure access to “real-world” manufacturing job experiences as part of the education process to demonstrate to prospective future employees the opportunities and excitement in advanced-manufacturing careers.

- *Support Initiatives That Help American Companies Make the Transition to Advanced Manufacturing*

Expand resources at the national and state levels for the Manufacturing Extension Partnership. MEP programs have made a considerable impact by boosting the innovation, productivity and competitiveness levels of small American manufacturing firms. New efforts focused on helping manufacturers be more strategic in their management, acquisition and retention of talent include the development of an automated suite of tools.

- *Provide Business and Accounting Standards for Identifying and Capturing Both the Tangible and Intangible Effects of Workforce Investment*

New accounting standards are needed to redefine “investments” and “expenses” as they pertain to the value and outcomes of workforce investment. Workforce “expenses” could be recalibrated as workforce investments and amortized, and workforce investment categories customer service, risk reduction and knowledge sharing.

- I. Robert Atkinson, “Worse Than the Great Depression,” Information Technology and Innovation Foundation (ITIF), March 2012, <http://www.itif.org/publications/worse-great-depression-what-experts-are-missing-about-american-manufacturing-decline>.
2. “Manufacturing continues to generate more economic activity per dollar of production than any other business sector in the country,” *The Facts About Modern Manufacturing*, The Manufacturing Institute, 2009.
3. ITIF, Op cit.
4. “Future Work Skills 2020,” Institute for the Future, 2011.
5. Stephanie Shipp, “Emerging Global Trends in Advanced Manufacturing,” Institute for Defense Analyses, March 2012.
6. Gary Pisano and Willy Shih, “Restoring American Competitiveness,” *Harvard Business Review*, July-August 2009. The resurgence of the U.S.’s “industrial commons” should be strongly encouraged for advanced manufacturing.
7. Mark Rice, President, Maritime Applied Physics Corp., “Presentation to the White House Symposium on Additive Manufacturing,” August 20, 2012.
8. John Markoff, “Skilled Work Without the Worker,” *The New York Times*, August 18, 2012.
9. ITIF, Op cit.
- IO. Small Business Administration, according to the Bureau of Labor Statistics and the Census Bureau, March 2, 2012, <http://www.sba.gov/community/blogs/small-manufacturers-driving-job-creation-economic-growth>.
- II. Congressional Budget Office, “Small Firms, Employment and Federal Policy,” March 2012.
- I2. The Sharable Content Object Reference Model (SCORM) integrates a set of related technical standards, specifications and guidelines designed to meet high-level requirements for accessible, interoperable, durable and reusable content and systems for computer-aided information distribution. For information, go to the Advanced Distributed Learning website, <http://www.adlnet.gov/>.
- I3. Sloan Center for Aging and Work, “Talent Pressures and the Aging Workforce,” Boston College, 2009.
- I4. Ibid, figure 3.5, page 27.
- I5. The Hollings Manufacturing Extension Partnership is a federal grant program administered by the National Institute for Standards and Technology, an agency within the U.S. Department of Commerce.
- I6. Health Care and Education Reconciliation Act of 2010.
- I7. Hiring Heroes Act of 2011 (S-951, HR-1941). Read the report “Military Skills for America’s Future: Leveraging Military Service and Experience to Put Veterans and Military Spouses Back to Work,” The White House, May 31, 2012, http://www.whitehouse.gov/sites/default/files/docs/veterans_report_5-31-2012.pdf.
- I8. American Society for Training and Development, “State of the Industry Report 2011.”
- I9. Ibid.
20. American Small Manufacturers Coalition and the Manufacturing Performance Institute, “Next Generation Manufacturing Study Overview and Findings,” June 2009.
21. Baby Boomers were born between 1946 and 1964 and number 76 million; GenXers were born between 1965 and 1976 and number 51 million; Millennials were born between 1977 and 1998 and number 75 million.
22. PricewaterhouseCoopers, “Millennials at Work: Reshaping the Workplace,” Fall 2011. The list is not in rank order. Pew Research Center, “Millennials: Confident, Connected, Open To Change,” 2010.
23. Ibid.
24. This technology is being created “in-house” with expert talent management technologists and manufacturing subject-matter experts.
25. IBM, “Getting Smart About Your Workforce: Why Analytics Matter,” IBM, 2009.
26. A consortium of businesses, universities and community colleges from Ohio, West Virginia and Pennsylvania are co-investing with the federal government to create the National Additive Manufacturing Innovation Institute (NAMII) in Youngstown, Ohio. This new public-private institute for manufacturing innovation is the first institute in the NNMI. The site was selected through a competitive process led by the Department of Defense and includes \$30 million in funding matched by \$40 million from consortium members.



This is an excerpt from *ReMaking America*, the second volume on manufacturing policy from the Alliance for American Manufacturing. For more information and to order the book, go to www.remakingamericabook.com.