



MANUFACTURING THE FUTURE

EDUCATION FOR A
CHANGING INDUSTRY

UNIVERSITY OF PHOENIX WORKING LEARNER SPOTLIGHTS

MANUFACTURING
THE FUTURE EDUCATION FOR A
CHANGING INDUSTRY



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PREFACE

By Emily Stover DeRocco, J.D.

President, The Manufacturing Institute

Senior Vice President, National Association of Manufacturers

In his 2011 State of the Union address, President Obama recalled the often painful changes that have occurred in America's industrial landscape in recent years, changes marked by "the shuttered windows of once booming factories and the vacant storefronts on once busy Main Streets."¹ Though the decline of certain industries has hurt many communities, he observed, America needs to look to the future if it is to remain globally competitive. "We need to out-innovate, out-educate, and out-build the rest of the world,"² the President concluded, noting that high-tech industries such as renewable energy, information technology, and biotechnology—all of which require a sophisticated manufacturing base—show great promise for job creation in the future.

U.S. manufacturers are well aware of the need to evolve; in fact, they have been evolving for decades. By implementing new technologies and processes such as lean manufacturing, they have increased their productivity 103% over the years 1987–2008—almost double the productivity increase in the rest of the business sector.³ They have become truly global, working with colleagues all around the world. They have become smarter about their use of resources and production of waste, reducing their CO₂ emissions to 1990 levels by 2008, even while CO₂ emissions from the transportation, residential, and commercial sectors rose 27%.⁴

Manufacturing continues to drive innovation. Innovations born in the manufacturing field, such as personal computers, have created entire new industries and dramatically changed the way we work and do business. The manufacturing sector accounts for most patent development and about half of all public and private research and development in the nation.⁵

However, the manufacturing industry is suffering from a talent shortage that hampers its ability to innovate. Employers report that too many entry-level workers lack basic skills in mathematics, writing, communication, teamwork, and problem solving. These employees are not well equipped to operate the sophisticated, often computer-controlled machinery used even by floor-level workers. Nor are they prepared for the critical and analytical thinking that all workers require to implement lean manufacturing processes. A high school education or GED, employers say, is no longer sufficient preparation for many modern manufacturing jobs. Manufacturers are also having difficulty hiring skilled workers such as machinists and computer numerically controlled machine operators. The skills gap is hurting manufacturers' ability to achieve productivity targets.

Manufacturers, policymakers, and educators need to devise creative solutions to the talent shortage to keep the manufacturing industry innovative and globally competitive. One way The Manufacturing Institute has done so is through its educational partnership with University of Phoenix. We have worked with University of Phoenix to develop classes and programs that align with the U.S. Department of Labor Employment and Training Administration's Advanced Manufacturing Competency Model. By doing so, we have helped ensure that graduates of manufacturing-related programs at University of Phoenix have the skills and competencies they need to be successful in today's technologically advanced manufacturing workplace.

The Manufacturing Institute–University of Phoenix partnership and other initiatives for reducing the skills gap are described in greater detail in this book, which presents real-life stories and a wealth of facts and figures to demonstrate the ways manufacturers and educators can benefit from such partnerships. It makes evident the link between skills acquisition and productivity, innovation, and, ultimately, America's competitiveness in the global sphere.

Washington, D.C.
May 2011

INTRODUCTION

AMERICAN MANUFACTURING TODAY: IMAGE AND REALITY

When many Americans hear the term *manufacturing*, they picture factories being shuttered and thousands of workers being laid off when companies move their facilities overseas. They think of the crisis the automotive industry suffered during the 2008-2010 recession, culminating in the bailouts of General Motors and Chrysler. They shop at stores where most of the clothing, toys, and household goods for sale are made abroad, and conclude that American manufacturing faces a bleak future. Surveys show that many Americans hold an outdated view of manufacturing, viewing the industry as dirty, unsafe, and low paying.¹

Though manufacturing has undeniably faced difficult times in recent decades, losing 5 million jobs over the years 2001-2008,² the truth is that manufacturing remains a robust and vital part of America's economy. Manufacturing employs 18.6 million people and contributes 11.5% of the nation's GDP.³ One in every six private-sector jobs in the United States is in or tied to manufacturing.⁴ Manufacturing employees are well-compensated, earning an average of \$32 per hour in wages and benefits, 9% more than the average American worker.⁵

American manufacturing remains very competitive globally. The United States still has the world's largest manufacturing sector, and despite growing international competition during the first decade of the 21st century, its exports *increased* 60% from 2000 to 2008.⁶ If U.S. manufacturing were a country unto itself, its economy would be the eighth largest in the world.⁷

Moreover, U.S. manufacturing is a major driver of innovation. Manufacturers spend \$187.5 billion a year on research and development, and perform 70% of all industrial R&D in the nation.⁸ Manufacturing is responsible for 90% of all patents awarded.⁹

The Skills Gap: A Threat to American Competitiveness

Many media stories focus on the threat to American manufacturing from low-wage countries that can produce goods much more cheaply. Global competition is a major and growing concern for U.S. manufacturers, but they also face a lesser-known yet equally potent problem: finding and retaining skilled workers.

Despite layoffs and the recent economic downturn, manufacturers are having difficulty hiring the skilled workers who form the backbone of the industry: machinists, computer numerically controlled machine operators, technicians, scientists, engineers, and other specially trained employees. Many of these skilled workers belong to the exiting Baby Boomer generation, and there aren't enough new employees to replace them. Fewer young people are choosing careers in manufacturing, as many have grown up hearing the stereotype that manufacturing is a dying industry, and that manufacturing careers are monotonous and unsafe.

Manufacturers are also finding skills lacking among the people they do hire. They report that their entry-level employees struggle with math, writing, communication, problem solving, and even such basic employability skills as timeliness and attendance. A high school education or GED, many manufacturers now say, is insufficient preparation for a floor-level position in their field.

Skill requirements for manufacturing success have also risen as the industry has become more sophisticated. Widely used management systems such as Total Quality Management and lean manufacturing, which have improved firms' productivity, invite workers to think critically and autonomously and make informed decisions. Technological advances require employees to be computer literate and, often, also to possess mathematical and analytical skills. Manufacturing executives, too, must master more skills—cultural competence, critical and strategic thinking, economics, and foreign languages—to thrive in a fast-paced, international industry.

The skills gap is a serious threat to American manufacturers' global competitiveness. Eighty-three percent of manufacturers say it negatively impacts their ability to serve customers, and 53% say it hinders their ability to achieve production targets.¹⁰ Consequently, manufacturing companies and organizations and the U.S. government have taken steps to diminish the gap. Manufacturers are increasing the amount of training they provide,



launching outreach programs to draw high school and college students to the field, and improving their organizational culture to retain more employees. The U.S. Department of Labor Employment and Training Association created the Advanced Manufacturing Competency Model, an inventory of the skills and competencies needed for success in the manufacturing field, with assistance from such organizations as the National Association of Manufacturers (NAM), the National Council for Advanced Manufacturing, and the Society of Manufacturing Engineers.¹¹ The Manufacturing Institute, the education reform, workforce development, innovation support, and research affiliate of the NAM, has developed a framework called the NAM-Endorsed Manufacturing Skills Certification System, which benchmarks the skills needed to perform various manufacturing jobs and credentials employees who have demonstrated those skills.

Higher education also has an important role to play in reducing the skills gap for entry-level workers and building the skills of more experienced employees. Colleges and universities can offer manufacturing-related courses and majors, increase the flexibility of their course scheduling so that manufacturing employees can attend school while working, and partner with manufacturing companies and organizations to determine how best to serve the needs of the industry. The Manufacturing Institute and University of Phoenix have formed an educational partnership and have worked in tandem to develop curricula to teach the competencies specified by the Advanced Manufacturing Competency Model.

Overview of the Book

This book discusses the strengths of today's manufacturing industry and the problems it faces—notably, the skills gap—and outlines ways educators and manufacturers can work together to strengthen the current and future workforce and keep American manufacturing prosperous and competitive. Part I, *Challenge and Change in Today's Manufacturing Industry*, provides an overview of the manufacturing field. **Chapter 1** discusses the many reasons manufacturing is still a vital part of America's economy. **Chapter 2** puts American manufacturing in its global context, taking a brief look at how the industry became an international enterprise and detailing the reasons why U.S. manufacturing struggles to compete abroad. **Chapter 3** examines the causes and ramifications of the skills gap. **Chapter 4** presents best practices institutions of higher education can adopt to help manufacturers overcome the skills gap.

Part II, *On the Front Lines: Manufacturing Success Stories*, consists of real-life stories and testimonials that illustrate the ways higher education helps manufacturing companies become more knowledge-based and competitive. The stories in **Chapter 5** reflect the broad range of manufacturing employees who seek higher education, from veteran workers looking to update their technology and management skills, to doctoral graduates performing research to improve their companies' processes. **Chapter 6** focuses on diversity, presenting the stories of women and minorities who have found success in the manufacturing field.

PART I **CHALLENGE AND CHANGE
IN TODAY'S
MANUFACTURING INDUSTRY**



1

Still Strong: Manufacturing
Is Vital to the U.S. Economy

EXECUTIVE SUMMARY

The U.S. manufacturing sector is more robust than most Americans believe. Manufacturing is vital to the American economy, producing 11.5% of the nation's GDP.

One of out every six private sector jobs is in or tied to manufacturing.

The United States still has the world's largest manufacturing sector and produces 21% of all manufactured goods worldwide.

Manufacturing facilities, contrary to popular belief, are clean, safe, and high-tech.

Manufacturing jobs are well-paying and intellectually stimulating.

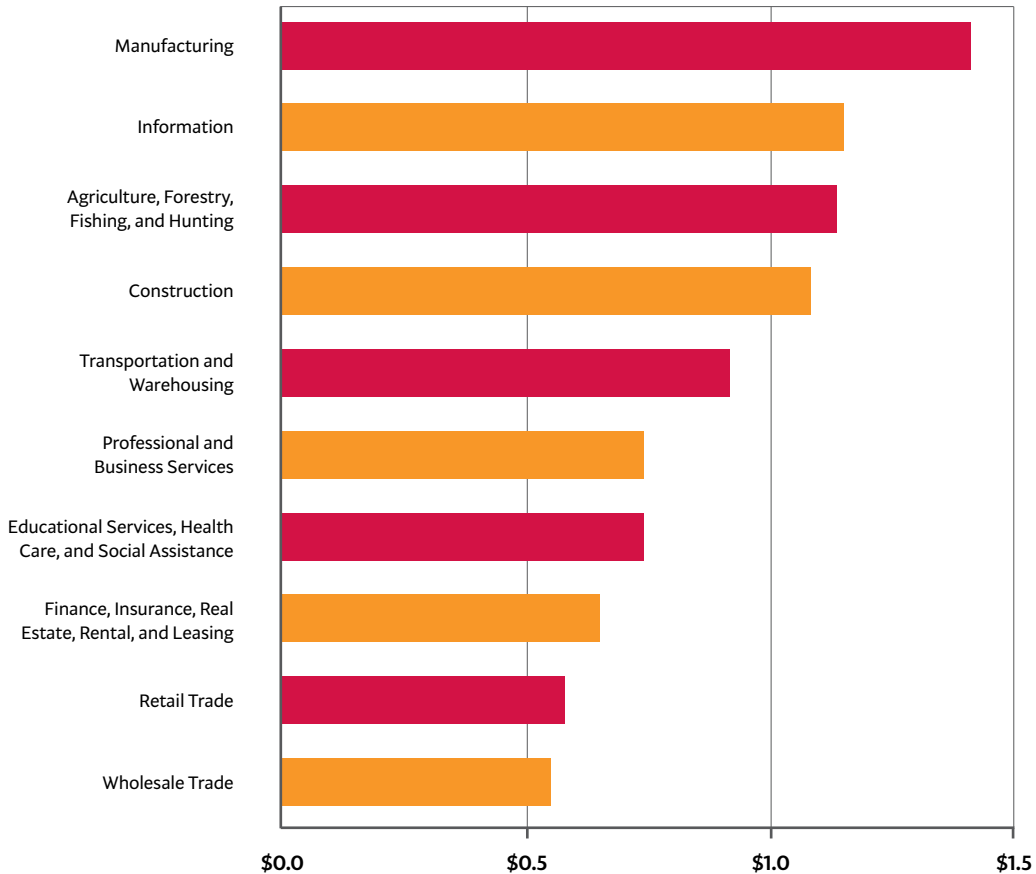
Manufacturers perform 70% of industrial research and development, thus driving innovation and the creation of new products, services, and industries. Other countries, especially China and India, are increasing their technological and R&D capabilities, endangering America's innovative edge.

Manufacturing has become more environmentally friendly in recent decades, as manufacturers have made efforts to reduce waste and consumption of resources to keep costs down and comply with stringent environmental standards.

The American public is pessimistic about the future of manufacturing. A recent survey by Deloitte revealed that, although 78% of Americans believe manufacturing is important to the nation's economic prosperity, 55% think the sector will weaken in the long term, and only 60% think it is globally competitive. Younger Americans are even less optimistic about manufacturing, with only 55% saying it is important to America's standard of living and economic prosperity.¹

Yet the headlines about factories closing and the store shelves stocked with foreign-made goods only tell part of the story. In reality, manufacturing is a thriving sector that makes a substantial contribution to America's economy.

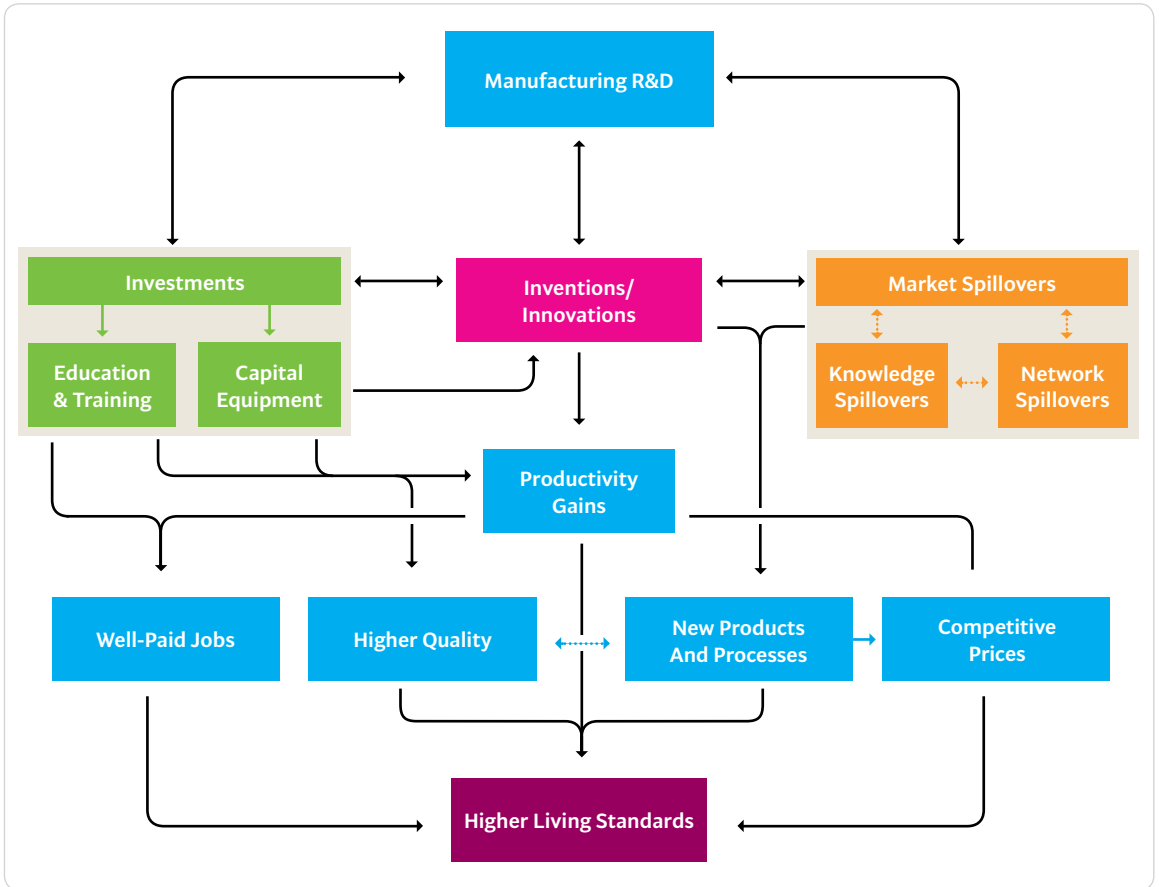
Manufacturing Generates More Economic Activity than Other Sectors



Economic activity generated by \$1 of sector GDP

Source: The Manufacturing Institute. (2009). *The facts about modern manufacturing* (8th ed.). Retrieved from http://www.nist.gov/mep/upload/FINAL_NAM_REPORT_PAGES.pdf

How Manufacturing Creates Wealth



Source: Popkin, J., Kobe, K., & The National Association of Manufacturers and Council of Manufacturing Associations. (2010). *Manufacturing resurgence: A must for U.S. prosperity*. Retrieved from <http://documents.nam.org/CMA/PopkinReport.pdf>

Manufacturing's Economic Impact

The U.S. manufacturing industry employs 11.8 million people directly and 6.8 million people in related industries,² and in 2008, produced \$1.64 trillion worth of goods, or 11.5% of the nation's gross domestic product (GDP).³ Manufacturing also supports other economic sectors: Its demand for raw materials, software, transportation, healthcare, and financial and legal services contributes to multiple service sectors' growth. In fact, it generates more economic activity per dollar of production than any other business sector.⁴ An estimated one out of every six private-sector jobs is still in or tied to manufacturing.⁵

An estimated one out of every six private-sector jobs is still in or tied to manufacturing.

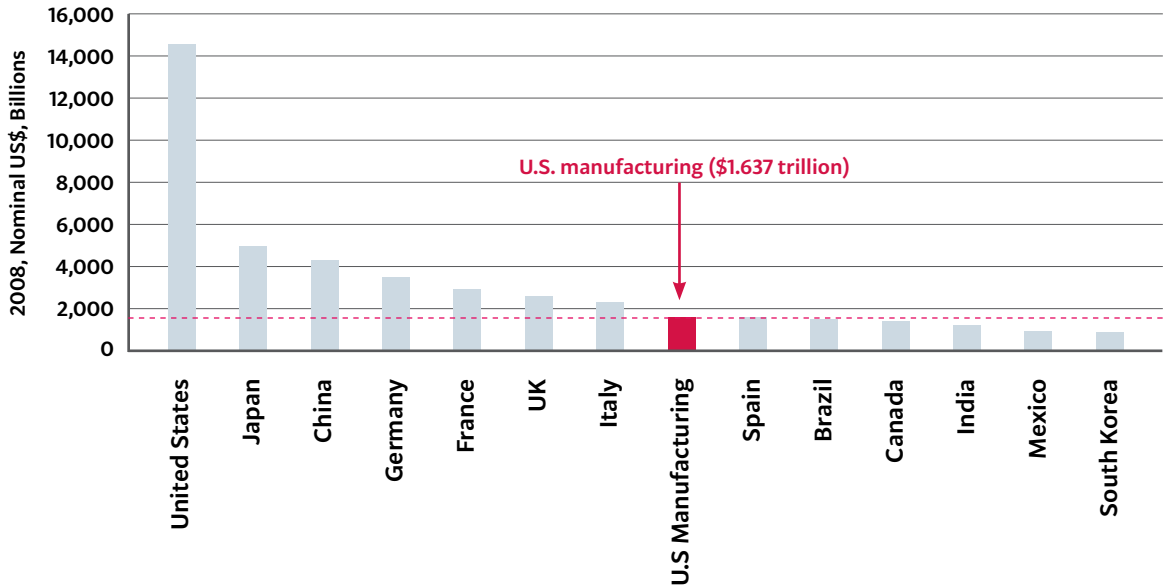
Technological advances and more efficient processes have made manufacturing one of the most productive and profitable industries in America. Between 1997 and 2008, its productivity grew by 103%, almost double the 56% productivity increase in the rest of the business sector.⁶ Since 1947, manufacturing productivity has kept pace with overall economic growth; both manufacturing and GDP have grown about sevenfold over the past 60 years.⁷ This high productivity makes goods less expensive to produce, thus reducing their cost and creating a higher standard of living for American consumers.⁸

U.S. Manufacturing Still Competitive Worldwide

Although other countries, particularly in Asia, have ramped up their manufacturing capabilities in recent years, and although certain products are now manufactured almost entirely overseas, American manufacturing remains globally competitive. The United States has the world's largest manufacturing sector, produces 21% of all manufactured products worldwide,⁹ and is the third largest manufacturing exporter after the European Union and China.¹⁰

U.S. manufacturing has *increased* its exports in recent years despite the rise of Asian manufacturing. From 2000 to 2009 sales of U.S.-manufactured goods rose 60%, from \$649 billion to \$1.039 trillion.¹¹ The United States is also still the largest destination for foreign direct investment. About 1 in 12 U.S. manufacturing workers is employed by a foreign-owned firm.¹²

U.S. Manufacturing Sector Is the World's Eighth Largest Economy



Source: The Manufacturing Institute. (2009). *The facts about modern manufacturing* (8th ed.). Retrieved from http://www.nist.gov/mep/upload/FINAL_NAM_REPORT_PAGES.pdf

In addition, U.S. manufacturing is far more efficient than many other countries' manufacturing industries. U.S. workers are twice as productive as workers in the next 10 leading manufacturing economies.¹³ In the U.S., for example, 1 ton of steel requires 15 man-hours to produce; in China, it takes 110 man-hours.¹⁴ Since 1986, America's unit labor costs—the average cost of labor per unit of output—declined by 40% relative to competitor countries.¹⁵

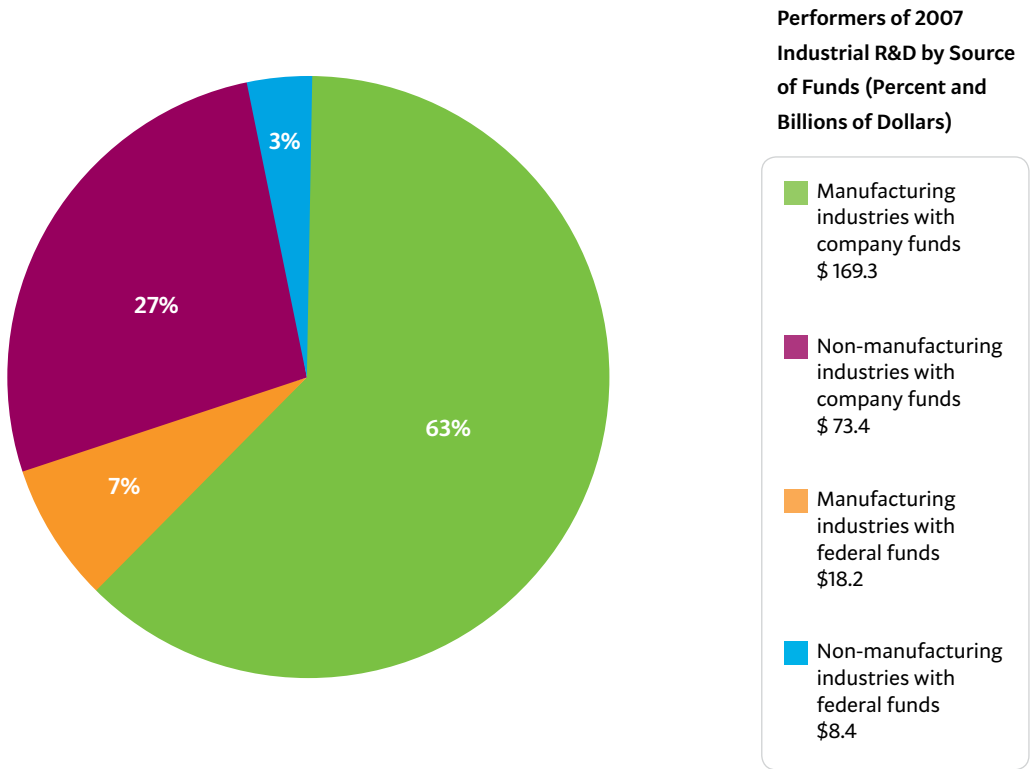


Manufacturing Supports High-Quality, Well-Paying Jobs

Manufacturing also contributes to the economy by providing employees with stable, well-paying jobs. In 2009, the average manufacturing worker earned \$74,447 annually in pay and benefits, compared to the \$63,507 earned by the average non-manufacturing worker.¹⁶ These jobs require not only hands-on skills, but also problem solving, analytical thinking, and technological proficiency. In manufacturing, the “thought becomes the thing” and employees have the opportunity to see ideas take physical form. Manufacturing workers use their intellect and manual skill to help solve global challenges and craft products that change people’s lives.

Contrary to popular belief, manufacturing is no longer a dark, dirty, and dangerous industry. Today’s manufacturing workers, even those who work on the factory floor, use sophisticated equipment. Many machinists now use computer numerically controlled (CNC) machine tools. They train in CNC programming and may write, modify, or test programs or work with programmers to do so. Machinists may also cut materials with newer tools such as lasers, water jets, and electrified wires.¹⁷ Tool and die makers operate and program CNC machines as well, and often use computer-aided design software to develop products.¹⁸

Manufacturing Is the Largest Performer of Industrial R&D



Source: Popkin, J., Kobe, K., & The National Association of Manufacturers and Council of Manufacturing Associations. (2010). *Manufacturing resurgence: A must for U.S. prosperity*. Retrieved from <http://documents.nam.org/CMA/PopkinReport.pdf>

“The industry has changed dramatically from what it was 20 years ago,” says Emily Stover DeRocco, president of The Manufacturing Institute, an affiliate of the National Association of Manufacturers that promotes U.S. manufacturing through research, education reform, innovation support, and workforce development. “Manufacturing is a high-tech-driven industry, and many manufacturing careers require postsecondary education and advanced knowledge of integrated technology systems.”¹⁹

Christopher Glynn, director of talent development at Caterpillar, Inc., the world’s largest manufacturer of construction and mining equipment, and president of Caterpillar University, the company’s internal training program, observes, “People usually think of tractors as dirty and unsophisticated pieces of equipment. But our D-11 tractor has more computing power on board than was used during the first Apollo 11 moon landing. It uses satellites to allow an operator to establish the grade on a road to within half an inch over half a mile. The human eye cannot see that difference.”²⁰

The Importance of Innovation

One of the most crucial ways manufacturing contributes to U.S. business is through its investment in research and development (R&D). R&D leads to innovative new products, processes, knowledge, designs, and even entire new businesses and industries. R&D also has a considerable spillover effect, benefiting companies and sectors that do not perform research. Estimates of the rate of return on R&D vary widely—anywhere from 25% to 60%—but all are considerable.²¹

Manufacturers represent 45% of all private-sector companies performing research and development in the United States.

The manufacturing sector is a key driver of R&D. In 2007, manufacturing performed 70% of industrial R&D, spending \$187.5 billion, only \$18.2 billion of which was federally funded.²² Manufacturers represent 45% of all private-sector companies performing R&D in the United States.²³

Innovation is vital to America’s competitiveness on a global scale. American manufacturers cannot compete on cost alone with countries that have lower labor and production costs; instead, they must differentiate themselves by offering new and unique products. For now, the United States is still a world leader in terms of innovation, performing 40%



of all R&D in the industrial world. America spends twice as much on R&D—over \$200 billion—than the next highest spender, the European Union.²⁴

Despite its leadership in R&D, America may be in danger of losing its competitive edge. Thought leadership is no longer predominantly U.S. based, as many companies are moving R&D facilities abroad to capitalize on lower-cost scientists and engineers, or to be closer to international customers.²⁵ Also, other countries—particularly China, India, South Korea, Singapore, Taiwan, Brazil, and Chile—are rapidly increasing their technological capabilities.²⁶ China has developed a 15-year plan for science and technology, and India plans to increase its R&D funding by 40% per year.²⁷ The number of U.S. patents granted to Chinese inventors rose from 119 in 2000 to 1,225 in 2008, whereas South Korean inventors received 3,314 U.S. patents in 2000 and 7,549 in 2008.²⁸

Some troubling indicators also suggest that the United States may not be as innovative as it once was. Since 2001, for example, the nation has run a trade deficit in Advanced Technology Products (ATPs) such as biotechnology, life science, information technology, and aerospace products—goods that require the highest R&D intensity to produce. In 2008, ATPs made up 29.6% of U.S. exports, down from 32.2% in 2006.²⁹ Plus, the United States ranks only eighth overall on the International Innovation Index.³⁰ Its share of world R&D has fallen in the first decade of the 21st century, and the economic downturn during that time has hurt some of the key R&D-performing industries.³¹

Manufacturing Today Is Greener Than Ever

Manufacturing is not often considered an environmentally friendly industry, but the sector is more aware of environmental concerns than many people realize. “Manufacturers have a vested interest in using the least wasteful ways to produce and distribute their products,” DeRocco says. “Energy efficiency, waste reduction, and thoughtful use of natural resources are structural cost savings for manufacturers, and they’re also better for the environment.”³²

Manufacturers have had to be innovative to meet stringent EPA standards while keeping costs low. They have implemented technological improvements that enable them to produce more with less energy. Between 1987 and 2007, the real value of industrial output per unit of energy increased 43%.³³ By 2008, the manufacturing industry had met President Obama’s goal of reducing greenhouse gases to the 1990s level by 2020;³⁴ today, American industry generates fewer metric tons of CO₂ than it did in 1980.³⁵

A 2008 survey by EFT Research indicates the extent of environmentally friendly policies among manufacturers. Sixty-five percent of manufacturers surveyed said they used recycling and reuse policies, 58% used water-reduction programs, 50% practiced energy management, and 33% had established a corporate “green team.” Fifty-two percent said they noted cost reduction as a result of going greener.³⁶

Manufacturers have also involved consumers in their plans for waste reduction. Caterpillar, Glynn says, has a program in which it reconditions or remanufactures old engines and sells them at 60% of what a new one would cost, with a like-new warranty. “It’s a beautiful example of a sustainable product, and the marketplace loves it,” he says.³⁷

MICHAEL BIXENMAN

Doctor of Business Administration, University of Phoenix, 2007

Helping Clean the Planet, One Innovation at a Time

Although most manufacturing companies now strive to incorporate environmentalism into their businesses, Kyzen Corporation recognized the benefits of going green over 20 years ago. Winner of the 2009 Global Technology Award for one of its green precision cleaning products, the global company was established in 1990 by owner Michael Bixenman, now a graduate of the University of Phoenix Doctor of Business

Administration program. Kyzen's mission is to manufacture cleaning products for electronic circuitry that are free of environmentally harmful chlorofluorocarbons. The company has expanded its product line to include cleaning solutions for metal parts, silicon wafers, and optical lenses, and continues to study new soluble-material sets as more advanced electronics enter the marketplace.

"Kyzen is dedicated to developing greener technologies that serve a specific niche within the manufacturing industry while using fewer resources to make our products," Bixenman says.

Green manufacturing is not always easy, he admits, noting that Kyzen, like many other businesses today, faces strict federal environmental regulations that can often prove costly to implement. Bixenman says Kyzen must continuously innovate to stay ahead of its competitors and to address such complexities as making products to remove the different kinds of residues that occur in electronics as manufacturers use more lead-free alloys. "Just as any organization, we have to constantly rebuild ourselves and rethink our strategies in order to survive," he says.

Bixenman foresees a bright future ahead for green manufacturing. "It's astonishing how clean manufacturing is today compared to as little as 20 years ago," he notes. "I truly believe that if we bring business leaders and manufacturing companies together to discuss industry-wide goals for a cleaner industry, we can accomplish almost anything."

Conclusion

Far from the dying industry that many people believe it to be, manufacturing remains a large and vital part of the U.S. economy. It provides workers with well-paying, intellectually stimulating jobs, maintains a high level of productivity, and innovates products and practices that create wealth. Yet American manufacturing faces intense competition from abroad, placing these benefits in peril.



2

U.S. Manufacturing in a Global Context

EXECUTIVE SUMMARY

Manufacturing, aided by advances in technology and transportation, helped America become the world's most prosperous nation by the mid-20th century.

Starting in the 1970s, American manufacturing lost its dominance as other countries built up their productive capabilities and attracted manufacturers with low labor and regulatory costs.

From 2001 to 2008, America closed 40,000 manufacturing plants and lost 5 million manufacturing jobs.

China's economy has received a massive boost from economic reforms that allowed for greater private enterprise and foreign investment. China now has the second-largest economy in the world. America's trade deficit with China rose from \$83 billion in 2000 to \$266 billion in 2008.

American manufacturers operate at a disadvantage compared to many other nations: They pay higher wages and more taxes, give employees more benefits, and have higher health, safety, and environmental costs. Structural costs in the United States are 17.6% higher than those of its nine largest trading partners.

American manufacturers face heavy competition from overseas. Many corporations have moved their production facilities abroad, where costs are lower, leading to the loss of manufacturing jobs, facilities, and entire industries in the United States. The outsourcing of American jobs is often portrayed as a matter of companies' simply moving to where wages are lowest, but the reality is much more complex. Historical, economic, political, and technological forces have interacted over decades to bring American manufacturing to this juncture.

A Brief History of American Manufacturing

Manufacturing has been part of America's history almost from the beginning. The movement for American independence coincided with the start of the Industrial Revolution. The first cotton mill in the United States was built in 1787.¹



The War of 1812 spurred expansion of America's manufacturing sector. During the war, British blockades created shortages of certain goods, particularly cotton, leading the young nation to develop its own industries. Following the war, the American government decided to increase the country's self-sufficiency by investing in infrastructure such as canals, ports, and interstate turnpikes. To support fledgling industries, it also levied high tariffs on imports of such goods as cotton, iron, and textiles.²

These initiatives, coupled with technological developments, helped American manufacturing to thrive. Railroads and steam-powered boats created a national market and made economies of scale possible for the first time. The American system of manufacturing, in which semiskilled workers used machine tools and jigs to make standardized, interchangeable parts for complex products, marked the beginning of industrial mass production.³

In the early 20th century, the Ford Motor Company developed the assembly line, a technique that increased efficiency and reduced costs so greatly that members of the middle class could now afford automobiles. The assembly line system soon spread to multiple industries, helping America become the world's most prosperous nation by the end of World War II. Manufacturing was also boosted by government assistance to returning veterans, such as the G.I. Bill, which increased consumer spending by providing college education and loans to former servicepeople, and by increased R&D funding in the wake of the *Sputnik 1* launch. At its peak in 1960, U.S. manufacturing employed 26% of American workers and provided 27% of the country's total GDP.⁴

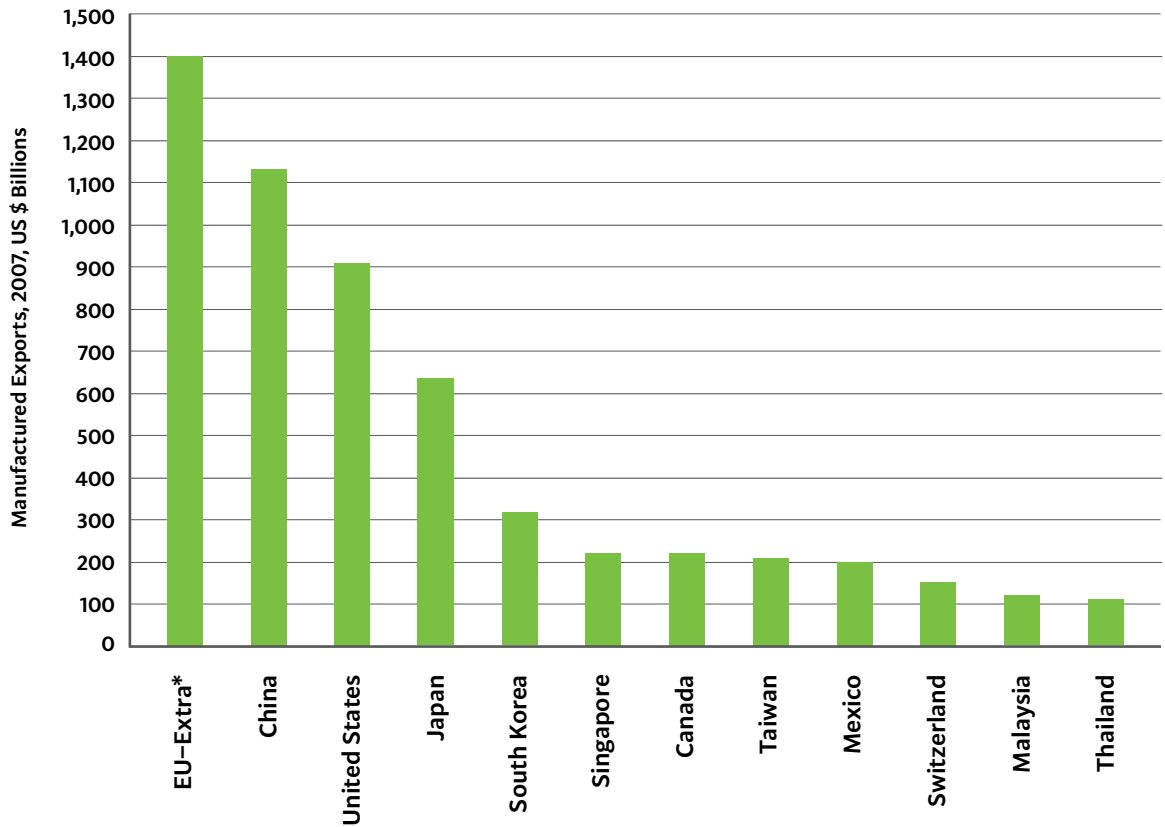
During the Cold War era, fears of Communist expansion led the United States to rebuild the productive capacities of its allies, notably Britain and Japan. Government and corporate leaders advocated free trade, believing it would encourage economic growth and worldwide democratization. The United States took part in international ventures to promote free trade, such as the International Monetary Fund, the World Bank, and the General Agreement on Tariffs and Trade (which later became the World Trade Organization).⁵

In the 1970s, America's dominance in world manufacturing began to decline as other nations increased their manufacturing capabilities—notably Japan, which led the world in consumer electronics in the 1980s; and the “Asian Tigers,” or Hong Kong, Taiwan, South Korea, and Singapore. High oil prices drove up production costs in the United States, leading some companies to move their production centers to low-wage countries. Developing nations wooed foreign investment by offering companies lower regulatory costs, tax abatements, and free production facilities.⁶

China Rising

Among these countries was China. After the death of Chairman Mao Zedong in 1976, the Chinese government restructured China's economy, opening the country to foreign trade and investment. It also invested heavily in manufacturing, creating special economic zones where foreign investors could receive tax concessions and protecting its domestic industries with high import duties. China also benefited economically by being able to offer investors lower operating costs, as its wages were low, its currency undervalued, and its environmental and safety standards less stringent than in most industrialized countries.⁷

The United States Is the World's Third Largest Manufacturing Exporter



Note: *Extra means exports to nonmembers. Total EU exports, including exports between member countries, were \$4,249 billion.

Source: The Manufacturing Institute. (2009). *The facts about modern manufacturing* (8th ed.). Retrieved from http://www.nist.gov/mep/upload/FINAL_NAM_REPORT_PAGES.pdf

Since the 1990s, China has witnessed extraordinary economic growth, surpassing the United States and Germany to become the world's largest exporter.⁸ The U.S. trade deficit with China rose from \$83 billion in 2000 to \$266 billion in 2008; in 2007, trade with China comprised almost one third of America's total global trade deficit, and 55% of its trade deficit when oil is excluded.⁹ China now has the second-largest economy in the world after the United States.¹⁰

Some scholars question whether China's explosive growth is sustainable, both environmentally and economically. China is one of the world's most polluted nations and produces more emissions of CO₂ and sulfur dioxide (a precursor to acid rain) than any other country.¹¹ Moreover, as China's standard of living has risen, so has the cost of doing business there.¹² "About 15 years ago, cost relative to skill set was one of the main reasons U.S. manufacturers outsourced," says SmartTrac president and University of Phoenix MBA graduate George Murray. "Now that China's economy has grown, the cost to employ a Chinese engineer is nearly the same as the cost to employ an American engineer."

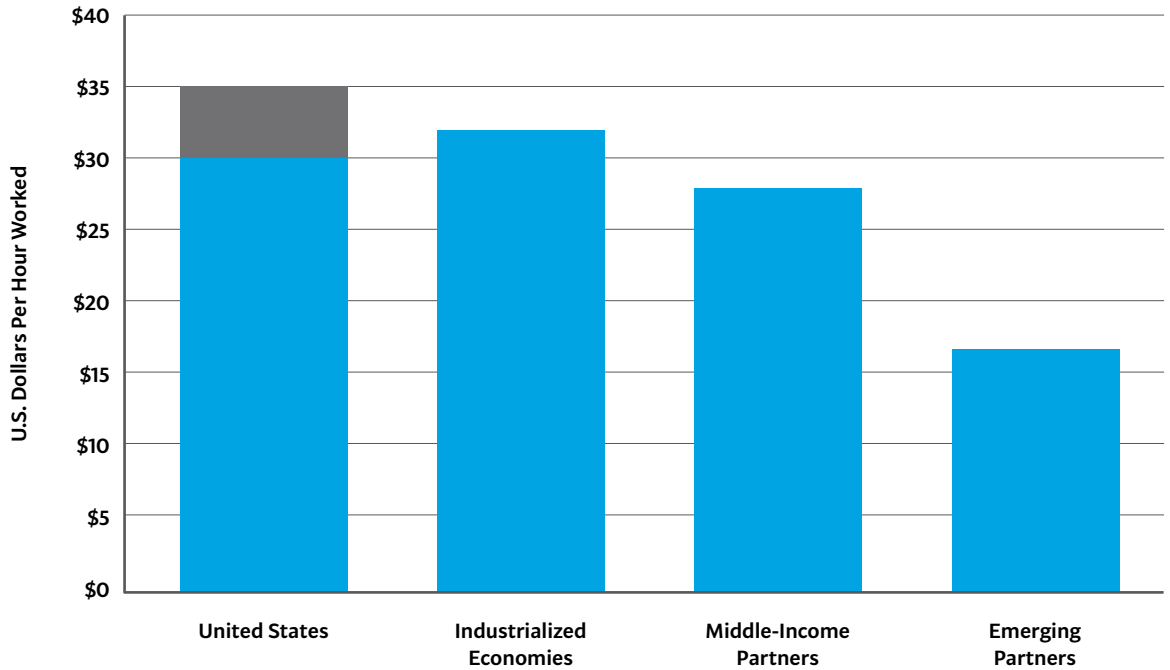
Globalization Has Hurt American Manufacturing

The rise of foreign manufacturing has been detrimental to American manufacturing. The United States lost about 40,000 manufacturing plants and 5 million manufacturing jobs during the years 2001–2008.¹³ Certain industries, such as textiles, luggage, ceramic tile, and glassware, have almost entirely moved overseas, while others struggle to survive on American soil. The U.S. furniture industry lost 60% of its production capacity between 2000 and 2008; during that same time period, the share of printed circuit boards made in the United States dropped from 26% to 8%.¹⁴

By 2008, almost 37% of all manufactured products in the United States were imported, compared to less than 10% in 1967.

The United States faces a considerable trade deficit—one that has risen steadily until slowed by onset of the recession in 2008. In 2000, the U.S. deficit in manufactured goods stood at \$319 billion; by 2007, it had risen to \$500 billion,¹⁵ or about \$2,000 for every American citizen.¹⁶ Over the same time period, America's share of global exports of manufactured goods declined from 19% to 14%.¹⁷ By 2008, almost 37% of all manufactured products in the United States were imported, compared to about 33% in 2003 and less than 10% in 1967.¹⁸

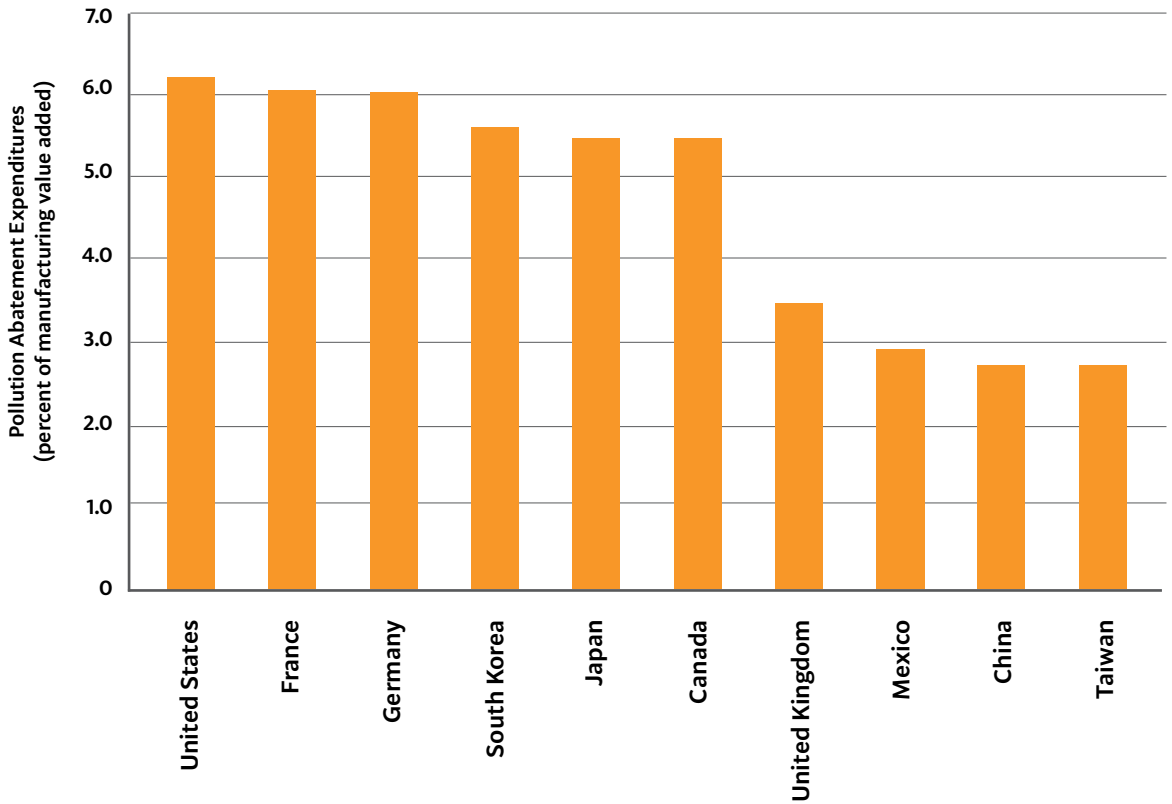
External Costs Hamper U.S. Manufacturing's Global Competitiveness



- Excess U.S. cost burden
- Production costs

Source: The Manufacturing Institute. (2009). *The facts about modern manufacturing* (8th ed.). Retrieved from http://www.nist.gov/mep/upload/FINAL_NAM_REPORT_PAGES.pdf

American Manufacturers Pay More in Pollution Abatement Costs than Other Nations



Source: The Manufacturing Institute. (2009). *The facts about modern manufacturing* (8th ed.). Retrieved from http://www.nist.gov/mep/upload/FINAL_NAM_REPORT_PAGES.pdf



Why U.S. Manufacturing Is Having Difficulty Competing Globally

Many factors place U.S. manufacturing at a competitive disadvantage compared to other nations. Operating costs in the United States are much higher than they are elsewhere in the world. American manufacturing employees receive high wages: an average of \$22.87 per hour, compared to the 72¢ per hour the average Chinese manufacturing employee makes.¹⁹ U.S. workers likewise typically receive benefits that employers in other countries do not provide, such as health insurance, worker's compensation, and 401(k)s. American companies also pay high environmental and health and safety costs. Pollution abatement costs in the United States are even higher than those of the "green economies" of Western Europe.²⁰ Altogether, structural costs in the United States are 17.6% higher than those of its nine largest trading partners.²¹

American companies also pay taxes at higher rates than do most of their foreign competitors. The United States has the second highest statutory corporate tax rate among major industrial countries in the Organisation for Economic Co-operation and Development, trailing only Japan.²² U.S. corporate tax rates have remained steady since the 1990s, whereas all of America's major competitors have lowered theirs.²³

Conclusion

Although American manufacturing remains a robust industry, it faces serious competition from abroad. To overcome its disadvantages in terms of cost, the sector must differentiate itself through what has historically been one of its defining features: its capacity for innovation. "America continues to be a world leader in innovation and the creation of new products, but we cannot afford to grow complacent," says Emily Stover DeRocco, president of The Manufacturing Institute. "Manufacturers must remain committed to research and development."²⁴

However, as the following chapter explains, the manufacturing field is facing a serious talent shortage that may hamper its ability to innovate. Policymakers, business leaders, and educators must work together to eliminate the growing manufacturing skills gap if the sector is to remain competitive on a global scale.



3

The Skills Gap

EXECUTIVE SUMMARY

American manufacturers report a shortage of skilled workers such as machinists, machine tool operators, technicians, scientists, and engineers.

A high school degree is no longer adequate preparation for many entry-level manufacturing jobs, which require employees to be proficient with sophisticated technology.

Many entry-level workers also lack the critical thinking and problem solving skills they will need to be successful working under new management techniques such as Total Quality Management and lean manufacturing, which emphasize independent thinking on the part of employees.

Manufacturing managers, many of whom are former front-line employees, have technical skills but may lack business and administrative skills.

This skills gap is weakening manufacturers' ability to meet production goals and productivity targets. Ultimately, it will hurt American manufacturing's ability to compete globally.

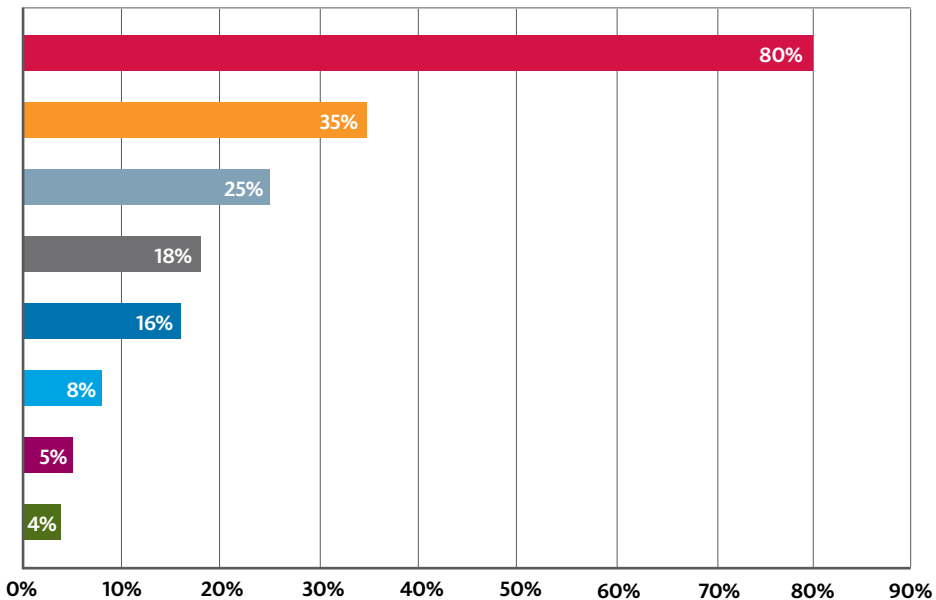
Demographics are contributing to the skills gap as many highly skilled workers are reaching retirement age.

Younger people today are less likely to choose manufacturing as a career because many view manufacturing as a dying industry and factories as dangerous and dull places to work.

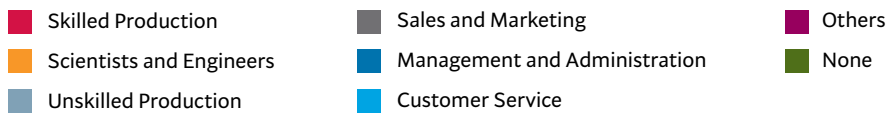
Recent growth in foreign manufacturing has hurt America's ability to compete overseas, but a homegrown problem may present an equally large threat to American manufacturing capabilities: the skills gap. Despite recent layoffs, American manufacturers are having difficulty hiring skilled employees. Even in states such as Michigan, where 300,000 manufacturing jobs were lost between 2000 and 2008, small- and medium-sized plants are still in need of skilled workers such as machinists, computer numerically controlled machine tool operators, craft workers, distributors, and technicians.¹ Manufacturers also report shortages of the scientists and engineers whose efforts drive new product innovation.

Extent of the Skills Gap

Types of Manufacturing Employees in Short Supply



Percent of Manufacturing Employers Who Indicated Each Type of Employee Would Be in Short Supply Over the Next Three Years



Source: Deloitte, The National Association of Manufacturers, & The Manufacturing Institute. (2005). *2005 skills gap report—A survey of the American manufacturing workforce*. Retrieved from http://www.doleta.gov/wired/files/us_mfg_talent_management.pdf

At first glance, the skills gap may seem counterintuitive, given that 78% of manufacturing employers report a recent or planned reduction in force.² However, manufacturing is facing not a worker shortage but a skills shortage: Only 17% of companies report shortages of *unskilled* workers, whereas 51% are in need of skilled production workers, and 36% lack scientists and engineers.³

The skills gap varies considerably by sector. Sixty-three percent of aerospace and defense employers, 63% of life science companies, and 45% of energy companies report shortages, but 98% of automotive companies say they have no shortage.⁴

Consequences of the Skills Gap

The skills gap has weakened manufacturers' production capabilities. Eighty-three percent of manufacturers surveyed by Deloitte said the skills gap negatively impacted their ability to serve customers, 53% said they had difficulty keeping production levels consistent with customer demand, 43% had trouble achieving productivity targets, and 33% struggled to maintain levels of customer service and satisfaction.⁵

The skills gap will ultimately hurt America's ability to compete in a demanding and

Eighty-three percent of manufacturers say the skills gap hurts their ability to serve customers.

rapidly changing global economy. Manufacturers say that, after new product innovation, having a high-performance workforce is a key driver of success.⁶ Forty percent of members of Fabricators and Manufacturing Association International state that finding skilled workers is their top concern—an even more pressing one than rising costs of materials, labor, and benefits or staying current with new technology.⁷

Causes of the Skills Gap

Both societal and technological forces have combined to bring about the skills gap. For example:

Manufacturing has become increasingly sophisticated, requiring workers to have



greater skill levels. Decades ago, the manufacturing field offered many opportunities for low-skilled workers with no experience or higher education. In 1973, half of all manufacturing workers had not completed high school, and only 8% had any postsecondary education. Entry-level assemblers or machine tenders were taught a single set of repetitive motions, whereas more-skilled workers learned their trade on the job through formal apprenticeship programs.⁸

During the 1980s and 1990s, U.S. manufacturers responded to the first large wave of imports by adopting such techniques as Total Quality Management (TQM)—a management philosophy that stresses continuous improvement in the quality of products and process—and lean manufacturing, a production system originating in Japan that emphasizes optimizing workflow, reducing inventory, and eliminating waste. A fundamental tenet of both TQM and lean manufacturing is employee empowerment: giving employees greater autonomy and ownership of the quality of what they produce; treating workers at all levels as part of the same interdependent system; listening to and implementing their ideas about how to improve processes; and sharing more information with them. To work successfully in plants that practiced TQM or lean manufacturing, employees had to

learn to think strategically, communicate clearly, and make informed decisions.

Computer-based manufacturing and automation also grew in prominence during the 1980s and 1990s. Low-skill jobs were replaced by machines, whereas skill requirements rose for the remaining jobs, as workers now needed more training to use, program, maintain, and repair the new technologies.⁹

“Today, most manufacturers use highly integrated systems, and skilled production workers are in many respects technologists: workers who can engage both with products and the systems that drive the evolution of those products,” says Emily Stover DeRocco, president of The Manufacturing Institute.¹⁰

“Once, machine operators just needed to be able to run machines and supervise their operation,” says University of Phoenix graduate and SmartTrac president George Murray. “Now, machine operators act as quality inspectors and technicians as well. They need to understand schematics, be able to conduct preventive maintenance, and have entry-level programming skills.”

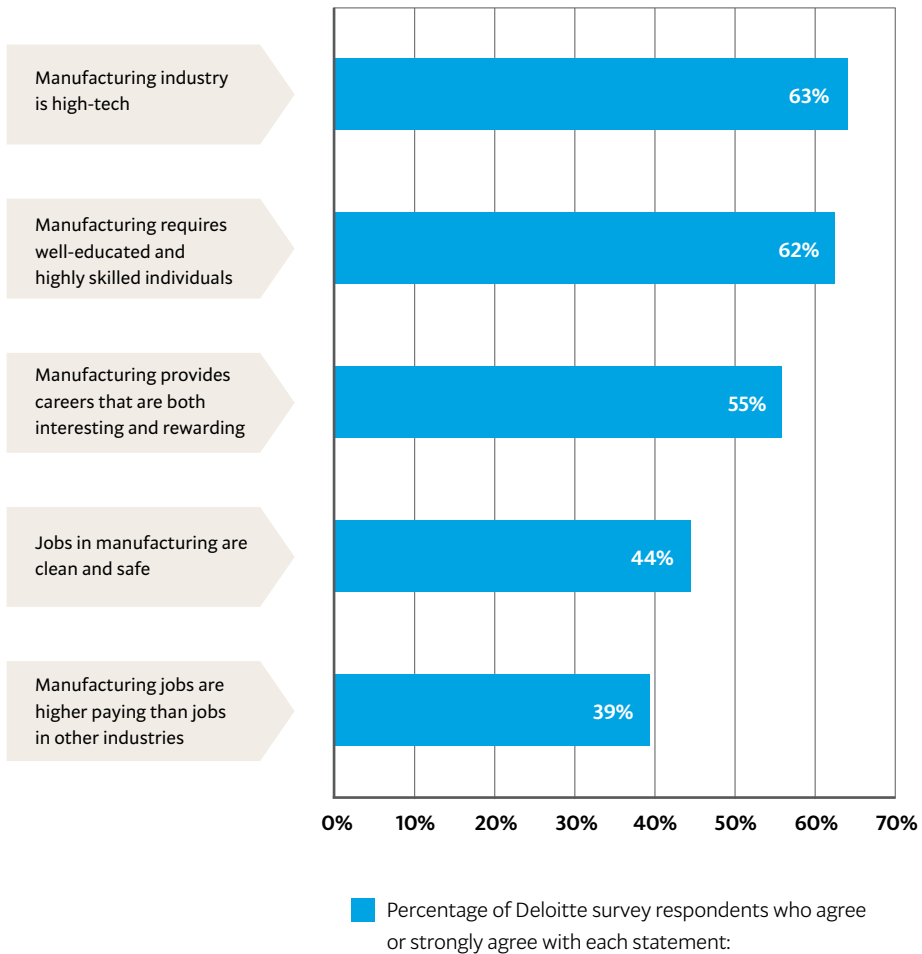
Due to these increased skill requirements, more manufacturers require entry-level employees to have at least some higher education. The United Motors plant in Dundee, Michigan, for example, specifies that all its hourly workers must hold 2-year degrees.¹¹ In some companies, higher education is a prerequisite for promotion—a shift from a longstanding tradition of promoting workers based on longevity, regardless of their level of education.

Many skilled manufacturing workers will soon retire. More than half of today’s machinists, machine assemblers, systems operators, and technicians are over age 40, and 26% are over 50.¹² The recession has kept many workers from retiring, but a wave of retirements is expected once the economy recovers, DeRocco says. “Two-thirds of my shop is ready to retire in the next five years,” says Tyco Electronics supervisor and University of Phoenix graduate Mike Davis, Sr.

The rapid changes in skills requirements have also created a skills gap *within* the manufacturing workforce, as older workers who were trained to use older technologies often oversee younger workers with very different skill sets. Older management professionals may need education to upgrade their knowledge of technologies, operational standards, and supply chain management.¹³

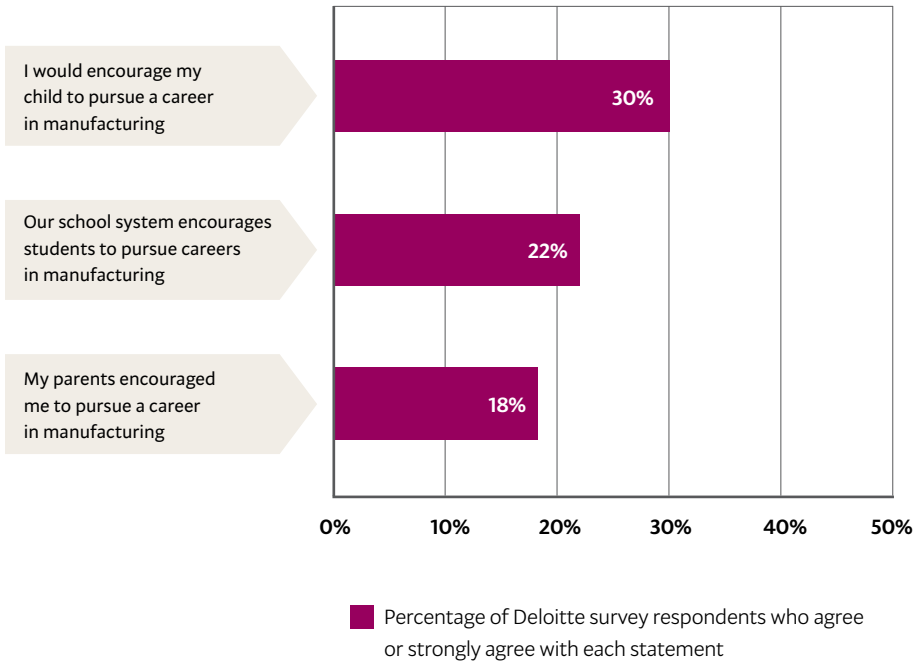
The general public views manufacturing as a declining industry and manufacturing

Americans' Perceptions of Manufacturing



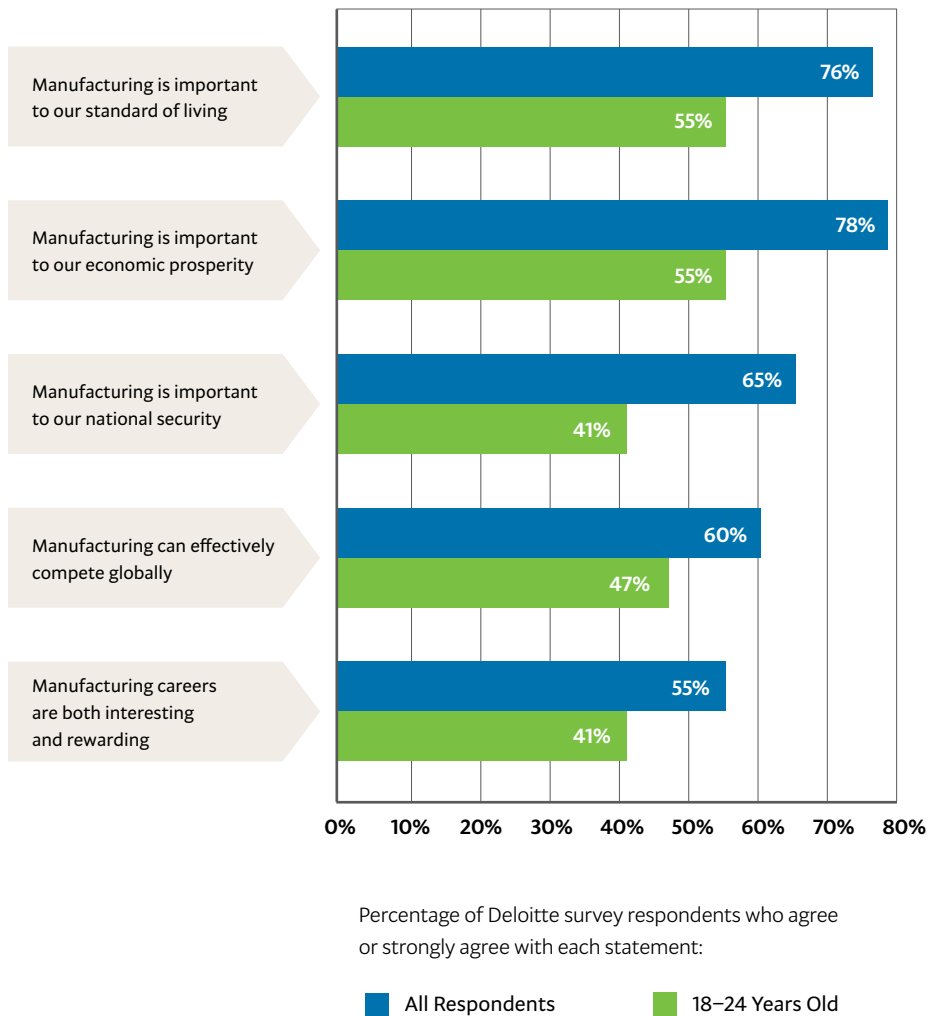
Source: Deloitte & The Manufacturing Institute. (2010). *Made in America? What the public thinks about manufacturing today*. Retrieved from <http://institute.nam.org/view/2001024535112650658>

Manufacturing Not Viewed as a Good Career Option



Source: Deloitte & The Manufacturing Institute. (2010). *Made in America? What the public thinks about manufacturing today*. Retrieved from <http://institute.nam.org/view/2001024535112650658>

Young Americans Less Likely to Value Manufacturing



Source: Deloitte & The Manufacturing Institute. (2010). *Made in America? What the public thinks about manufacturing today*. Retrieved from <http://institute.nam.org/view/2001024535112650658>

jobs as dull, low-tech, and dangerous. Manufacturing suffers from an image problem. People outside the industry often think that manufacturing has changed little since the days of Henry Ford; that factories are dark, dirty, and dangerous; and that manufacturing jobs are low-skill and monotonous. Swayed by media portrayals that focus on layoffs and factory closings instead of productivity, average consumers may believe American manufacturing is an industry without a future. As a result, they are less likely to consider manufacturing as a viable career. Although 78% of Americans say manufacturing is important to economic prosperity, only 30% would encourage their children to pursue careers in manufacturing.¹⁴

Evidence does suggest that these perceptions may be changing. In 2009, for example, only 33% of Americans surveyed by Deloitte said they thought that manufacturing was clean and safe, and 59% said that manufacturing workers were highly skilled.¹⁵ In 2010, those numbers rose to 44% and 63%, respectively.¹⁶ Significantly, young Americans (ages 18-24) were the age group least likely to think manufacturing is clean, safe, and high-tech; that its workers are highly skilled; that the industry is essential to economic prosperity; or that the government should invest more in manufacturing.¹⁷

American schools do not promote manufacturing as a career. Today, few high schools point students towards careers in manufacturing: 61% of Americans say their local schools do not promote manufacturing careers.¹⁸ Guidance counselors, who may not know what modern manufacturing entails, tend to direct students toward other careers instead. Fewer schools now offer the shop classes and vocational programs that teach students usable manufacturing skills.

Stemming the Skills Gap

Manufacturers are taking steps to decrease the skills gap. Many companies attempt to attract young people to the manufacturing field through such initiatives as apprenticeships and paid training programs for high school and college students, alliances with nearby universities and community colleges, and participation in job fairs and career days. Others work to improve employee retention by increasing benefits, making changes to their organizational culture, and improving their supervisors' management skills through training. Higher education, too, has a role to play in stemming the skills gap. That role will be explored in the following chapter.



4 Closing the Skills Gap Through Higher Education

EXECUTIVE SUMMARY

Many workers lack basic skills such as writing, communication, mathematics, and problem solving, manufacturing employers say.

Higher education can give manufacturing employees both the basic and higher-order skills they need to thrive in today's sophisticated, fast-paced, global manufacturing field.

The Manufacturing Institute has created a Skills Certification System that identifies and benchmarks skills workers need to perform various manufacturing jobs.

Employers who use skills certification systems report such benefits as lower recruitment and training costs and higher retention rates.

University of Phoenix has partnered with The Manufacturing Institute to develop curricula that teach the competencies specified by the Advanced Manufacturing Competency Model created by the U.S. Department of Labor Employment and Training Administration.

To successfully educate manufacturing workers, higher education institutions should offer flexible class schedules, hire faculty with experience in the manufacturing field, train support staff to meet the needs of working learners, and provide students with the opportunity to work collaboratively.

Manufacturers, policymakers, and K-12 educators must work together to ensure that American manufacturing remains competitive on a global scale, but instructors in higher education can also be part of the solution. Colleges and universities can help mitigate the skills gap in a variety of ways. For example, higher education can

- provide programs to improve entry-level workers' math, reading, and communications skills;
- promote bachelor's- and master's-level courses in supply chain management, finance, economics, and other topics that will enable graduates to contribute more to their companies; and

- provide lifelong learning opportunities for workers who want to stay current with new technologies and management theories.

Institutions of higher education can also help manufacturers by meeting the needs of working learners and by aligning their course offerings with industry-identified and -recognized competencies and skills certification standards, such as those endorsed by the National Association of Manufacturers.

The Basic-Skills Gap

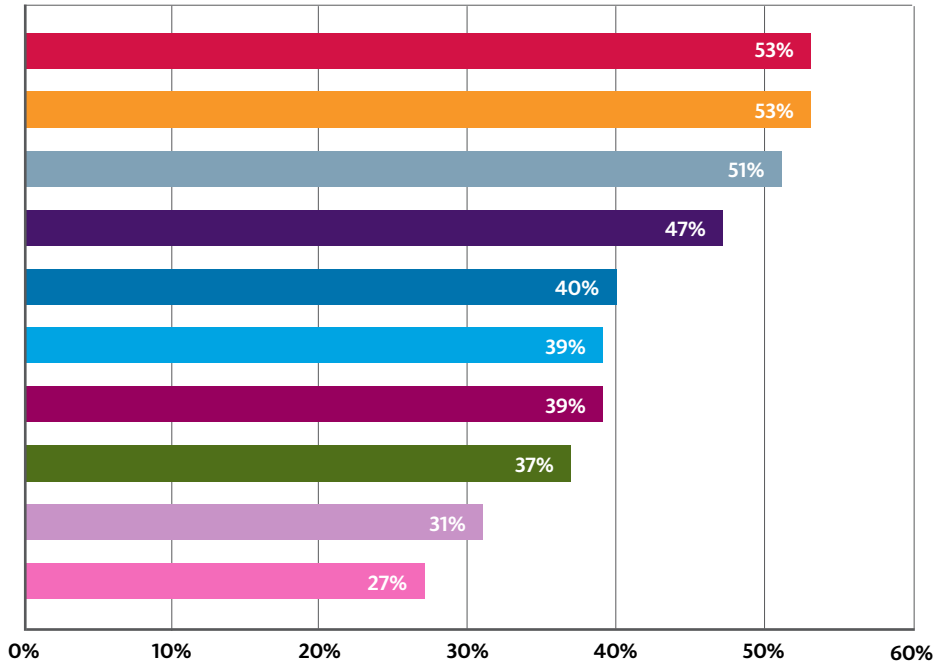
The lack of technically skilled employees is a serious problem for manufacturers, but companies also report that entry-level workers often do not even have sufficient *basic* skills. Forty-six percent of manufacturers indicate that employees have inadequate problem-solving skills, whereas 36% say workers lack sufficient reading, writing, and communication skills.¹ Eighty-one percent say that the K-12 school system does not properly prepare graduates for floor-level careers in manufacturing. Companies find that even basic employability skills, including attendance, timeliness, and work ethic, are lacking.²

Eighty-one percent of manufacturers say the K-12 school system does not prepare graduates for entry-level careers in manufacturing.

Manufacturers lose time and money on employees who are unprepared to enter the workforce. Companies' training budgets increase when they must train employees in basic manufacturing processes, computer proficiency, or even in such skills as math and writing before they receive job-specific training. Many companies also report issues with "revolving door" hires: candidates who, attracted to the high wages manufacturing provides, accept jobs only to quit shortly after hire due to lack of interest, unmet expectations, or weak workplace competencies. These short-lived employees cost companies money on recruitment, retention, and wasted training costs.

Sixty percent of manufacturers say a GED or high school diploma does not provide adequate preparation for success in the manufacturing field,³ and many of them now require workers to hold at least a 2-year college degree. As SmartTrac president George Murray puts it, "Thirty years ago in the manufacturing field, education was a nice thing to have. Now it's a minimal requirement."

Types of Skills Desired by Manufacturing Employers

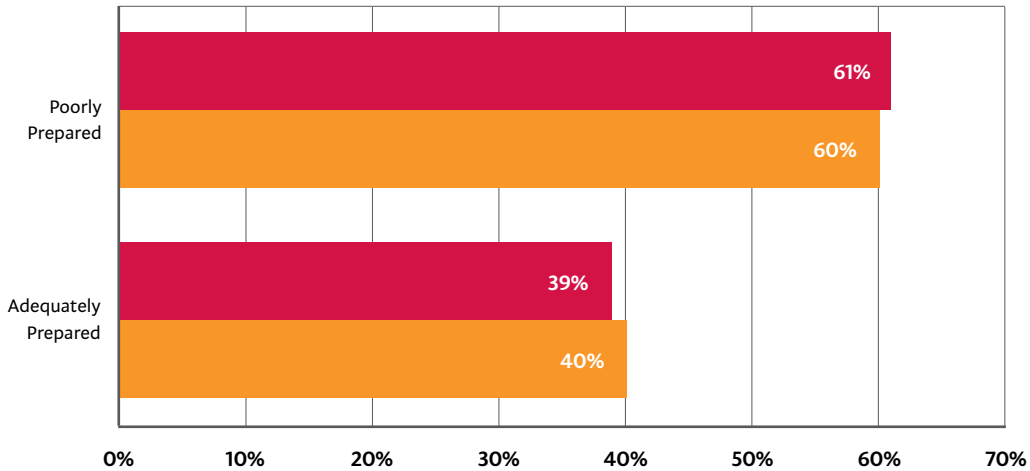


Percentage of Manufacturing Employers Who Indicate Employees Will Need More of Each Skill Over the Next Three Years

- Strong Basic Employability Skills
- Technical Skills
- Reading/Writing/Communication Skills
- Ability to Work in a Team
- Strong Computer Skills
- Ability to Read and Translate Drawings/Diagrams/Flow Charts
- Math Skills
- Strong Supervisory/Managerial Skills
- Innovative/Creative
- English Language Fluency

Source: Deloitte, the National Association of Manufacturers, & the Manufacturing Institute. (2005). *2005 skills gap report—A survey of the American manufacturing workforce*. Retrieved from [http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_mfg_talent_management_042007%20\(exp%20041510\)\(1\).pdf](http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_mfg_talent_management_042007%20(exp%20041510)(1).pdf)

High School Degrees Not Enough to Succeed in Manufacturing, Employers Say



Respondents were asked the question, “How prepared for a typical entry-level job in your company are applicants with high school/GED qualifications?”

- Executives at companies with over 500 employees
- Executives at companies with fewer than 500 employees

Source: Deloitte, National Association of Manufacturers, & The Manufacturing Institute. (2005). *2005 skills gap report—A survey of the American manufacturing workforce*. Retrieved from [http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_mfg_talent_management_042007%20\(exp%20041510\)\(1\).pdf](http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_mfg_talent_management_042007%20(exp%20041510)(1).pdf)

Education Gives Employees Higher-Order Skills

In today's complex, high-tech, global manufacturing field, intellect has become as important as manual labor. Employees are often expected to understand the business they work for and how their role contributes to customer satisfaction, the operation of the supply chain, and the company's bottom line. "It's no longer enough for manufacturing employees to understand one small corner of the business," says Kenneth Kernen, director of corporate purchasing at Quad/Graphics and a University of Phoenix MBA graduate. "They need to understand the manufacturing process from start to finish, and be knowledgeable about such topics as supply chain management, inventory methods, and capacity utilization."

Terri Pomfret, training director for Fortune 100 company Johnson Controls and a doctor of management graduate from the University of Phoenix, agrees that manufacturing workers need a broad skill set. "Employees in the manufacturing field have technical expertise, but don't always know how to work on a team—a crucial skill, as in manufacturing nothing is done alone," she says. "Cultural competence, creative thinking, and strategic thinking are also skills manufacturing employees need to develop. Employees need to know how to manage projects, make plans, cope with change, make decisions, and think creatively, strategically, and analytically."

"Higher education prepares workers to better organize their thoughts and communicate their ideas both verbally and in written form," says Thombert, Inc. senior manager and University of Phoenix doctor of management graduate Maureen Lockwood. "I hire people with college degrees because they have the ability to approach projects systematically: to define the underlying issues and outline the steps they need to take to reach an outcome."

Today, manufacturing employees at all levels are expected to think systemically and contribute ideas for organizational improvement. "All of our associates throughout the plant have some kind of technical certification," says Fred Bentley, chief operating officer at Hayes Lemmerz and a University of Phoenix MBA graduate. "We expect our employees to take ownership and look for ways to improve processes, increase machine uptime, and communicate effectively with employees in other departments."

"I appreciate employees who provide constructive criticism on my company's processes and the strategic direction it's taking," Murray says. "Their ideas help our executive

team make better, more-informed decisions.” Education, he adds, gives employees the confidence and communication skills they need to be able to offer constructive suggestions. It also makes them more flexible, “so that when the business changes, they are able to adapt.”

The rise of global commerce has made the manufacturing industry more complex, requiring employees, especially those involved in logistics, to have a varied and flexible skill set. “People working in today’s manufacturing field need to have strong leadership skills, be adaptable, understand different cultures, and be very good with numbers,” says University of Phoenix faculty member Elena Asher. In her position as logistics manager for Gear for Sports, Asher has to cope with such contingencies as foreign suppliers going out of business, steamship lines cutting or changing their routes, fluctuations in the price of cotton, natural disasters that disrupt shipping, rising fuel costs, and security issues, all of which can affect whether her company gets its products to buyers on schedule. She draws upon such experiences in the classroom, where she builds students’ capacity for flexibility, organization, and problem solving by having them analyze situations similar to those she faces on the job.

The Manufacturing Institute Skills Certification System

Manufacturers recognize the need for greater workforce development, and many companies have implemented training strategies that involve identifying which skills workers require to be successful in each position, setting benchmarks for those skills, and developing competencies. As Pomfret observes of Johnson Controls’s training program, “Until last year, if you asked 10 people what their skills expectations were for a quality engineer, you’d get 10 different answers. Now, we’ve identified 14 competencies and 33 basic skills that quality engineers need to have.”

Caterpillar, Inc., likewise runs Caterpillar University, which holds classes in such diverse subjects as reading blueprints, using software, understanding financial statements, and preventing compliance problems. “Caterpillar University was put in place to help provide more systematic learning,” says Christopher Glynn, director of talent development at Caterpillar, who notes that the program also provides tuition assistance and allows workers to create individual learning plans for their current jobs or those to which they aspire.⁴

Smaller companies may not have the training resources of corporations like Johnson Controls and Caterpillar. In addition, different companies may define competencies in various ways, making it hard for employers to know exactly what new hires are able to do.

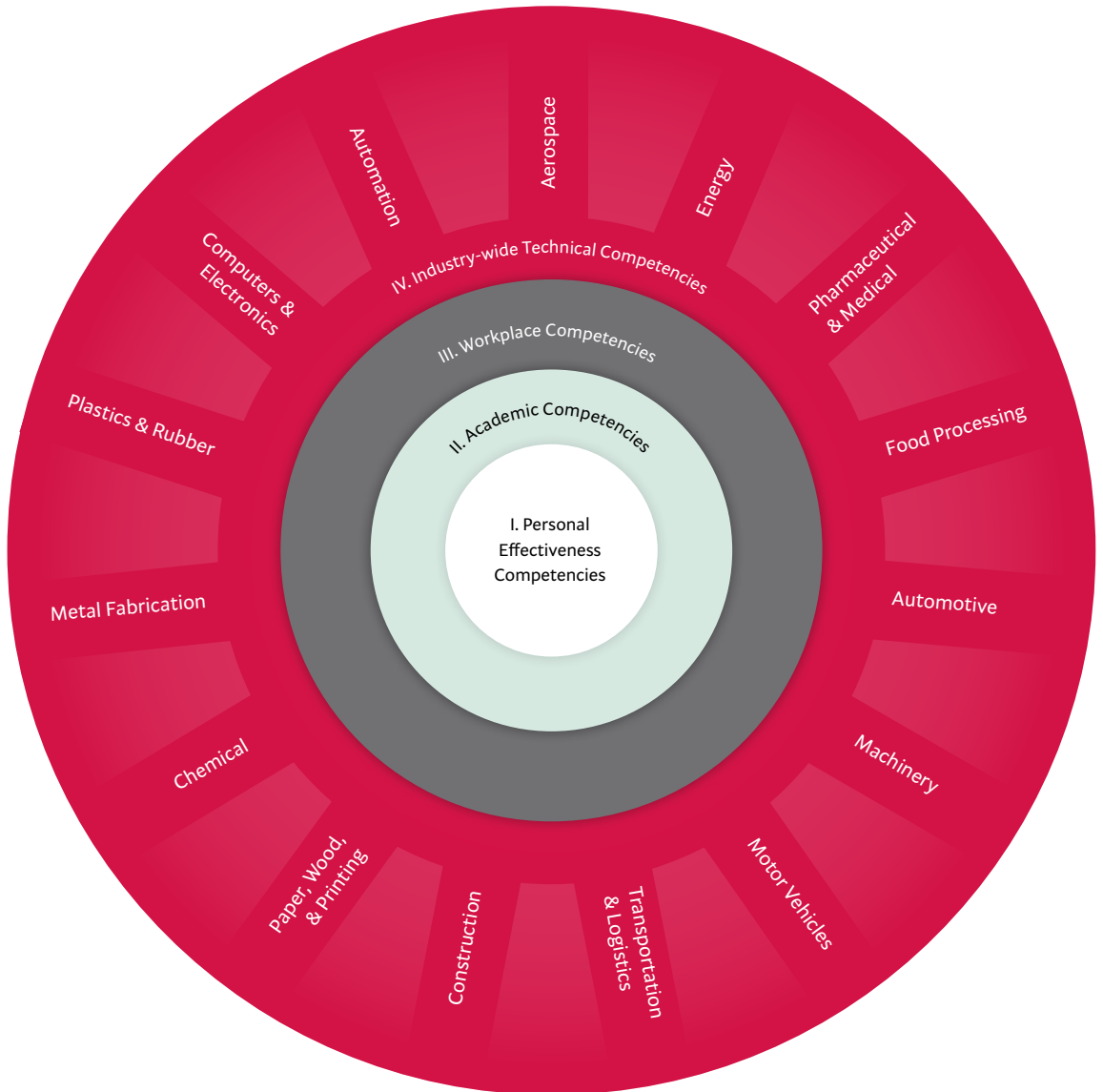
To help solve such problems, the U.S. Department of Labor Employment and Training Administration created the Advancement Manufacturing Competency Model, a framework outlining the competencies workers need to succeed in the manufacturing industry. Developed with the assistance of the National Association of Manufacturers (NAM), the National Council for Advanced Manufacturing, and the Society of Manufacturing Engineers, the model identifies competencies in nine areas ranging from personal effectiveness to academics to industry-specific technical skills to management. Launched in 2006, the model was revised in 2010 to keep current with changes in the industry such as an increased emphasis on sustainability.⁵

The Manufacturing Institute, the nonprofit, nonpartisan education and research affiliate of the NAM, likewise developed a skills certification system. This system identifies the skills needed to perform various manufacturing jobs, and provides certification to workers who demonstrate these skills. The system covers competencies ranging from basic work readiness and employability skills to occupation-specific technical skills and postsecondary education. Credentials workers receive are portable across all sectors, are third-party validated, and are accredited by industry-trusted organizations like the American National Standards Institute and the National Organization for Competency Assurance.

The NAM-Endorsed Manufacturing Skills Certification System is currently being tested in community colleges in four states. As of September 2010, 25 states have plans for deployment.

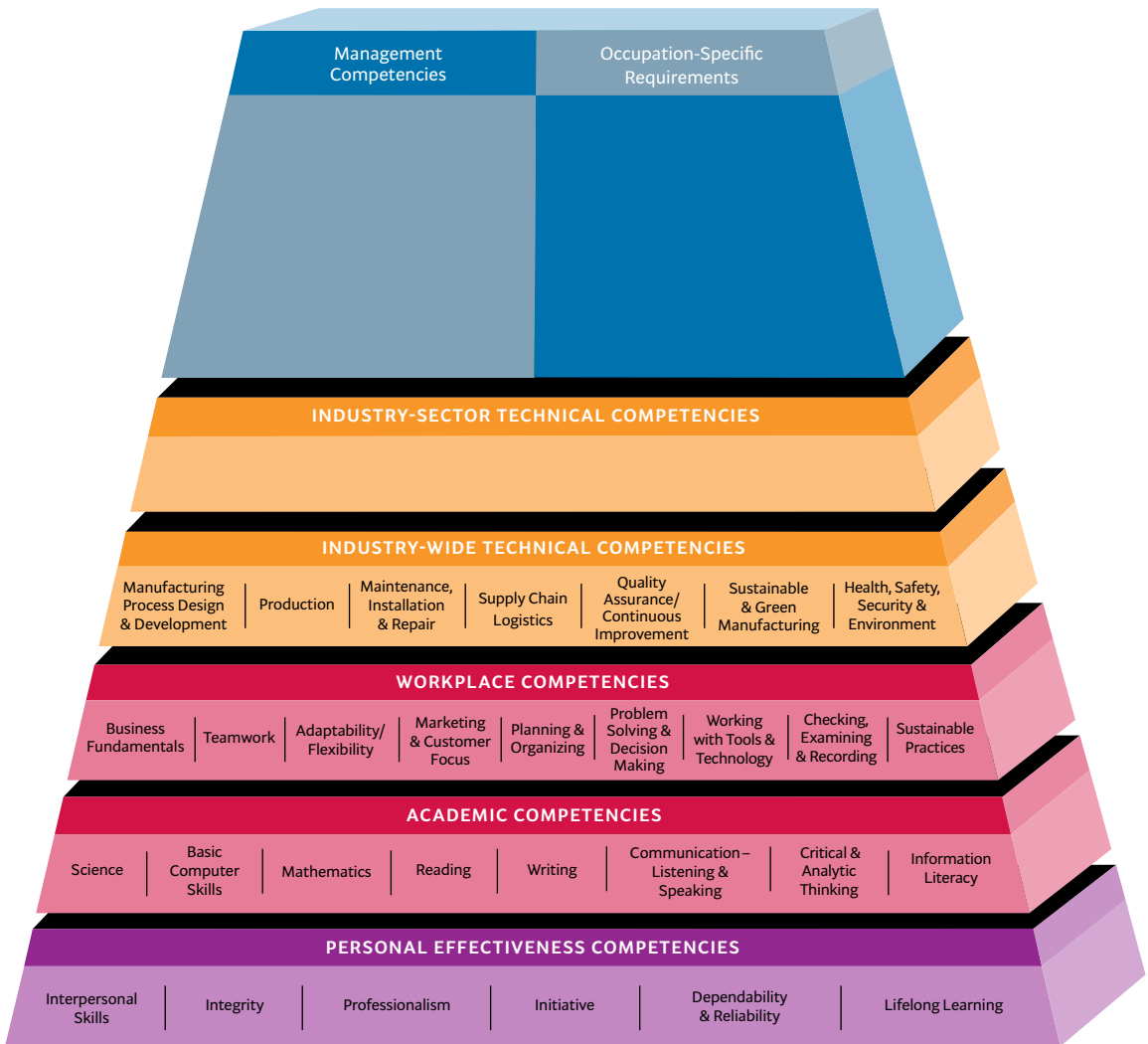
Skills certification offers many advantages to manufacturers. For example, most manufacturers use interviews, background checks, and reference checks when hiring employees, but these methods alone may not identify the best candidates. Applicants with skills credentials have already demonstrated interest in manufacturing and have shown that they can work safely, follow directions, work well in teams, be flexible and adaptable, solve problems, and see value in remaining with a company. Skills certification can also lower training costs by enabling employers to target more precisely the competencies each worker needs to develop.⁶

Skills for Manufacturing



Source: University of Phoenix & the Manufacturing Institute. (2011). *Manufacturing skills certification: Employer perspectives*. Phoenix, AZ: University of Phoenix.

Advanced Manufacturing Competency Model



Source: United States Department of Labor Employment and Training Administration. (2010). *Advanced manufacturing competency model*. Retrieved from <http://www.careeronestop.org/competencymodel/pyramid.aspx?hg=Y>

Manufacturing executives surveyed by the University of Phoenix Research Institute report many benefits to using a credentialing system, including lower recruitment costs, lower training costs for entry-level employees, higher employee retention rates, stronger advancement opportunities for incumbent employees, and improved employee input and engagement. Hiring managers state that the credentialing system enables them to compare candidates more fairly, and that the system increases new hires' ability to learn faster and contribute in the workplace. In addition, the credentialing system helps to lower turnover, improve safety, and increase employee enthusiasm and commitment. Some managers also say the system allows them to highlight employee competencies to prospective customers, and to determine which employees are potential leaders.⁷

The main drawback to the NAM-Endorsed Manufacturing Skills Certification System is that it has yet to achieve critical mass. Community and technical colleges are reluctant to offer credentialed courses until they know employers value credentials, and employers do not want to change their policies and require credentials unless they have enough credentialed workers to hire. Moreover, some HR managers are still unaware of changing technology and workplace needs, and so may not implement credential requirements.⁸

University of Phoenix Partners With The Manufacturing Institute to Improve Students' Skill Base

Some manufacturers have partnered with colleges and universities to help ensure that graduates have the skills and competencies they need to be successful in the manufacturing workplace. In March 2010, University of Phoenix and The Manufacturing Institute chartered such an alliance. University of Phoenix, working in tandem with The Manufacturing Institute, developed curriculum relevant to the manufacturing workforce that teaches the competencies outlined in the Advanced Manufacturing Competency Model. The University will grant students some academic credit for prior educational work and NAM-endorsed industry certifications.

“This unique alliance will provide students with an education with real-world relevance that meets the needs of high-tech manufacturing,” says Brian Lindquist, Ph.D., dean of the University of Phoenix School of Business. “Graduates will gain the knowledge and skills that are most needed in the manufacturing industry, both today and tomorrow.”

“We are excited to partner with University of Phoenix to better prepare the manufacturing workforce for the challenges of the 21st century,” says The Manufacturing Institute’s president, Emily Stover DeRocco. “This partnership represents a bold approach of marrying the needs of industry to the assets of a university.”⁹

University of Phoenix Offers Bachelor’s Degree in Management With a Concentration in Manufacturing

University of Phoenix offers one manufacturing-specific baccalaureate degree: the bachelor in management with a concentration in manufacturing (BSM/MAN). This concentration prepares students to oversee the business planning, global sourcing, procurement, production, and logistical activities that make up an organization’s operations and supply chain. Its curriculum is aligned to the Advanced Manufacturing Competency Model, was developed with the assistance of The Manufacturing Institute, and was approved by select manufacturing executives who sit on The Manufacturing Institute’s Board of Trustees.

The BSM/MAN degree is appropriate for floor-level manufacturing employees who plan to move into management positions, or manufacturing managers who want to develop the critical thinking skills and knowledge of business theory and practice that a bachelor’s degree provides. BSM/MAN students receive a solid background in such areas of business as communications, business law, consumer psychology, microeconomics, accounting, finance, and information systems. They also complete coursework in such manufacturing-specific subjects as innovating for competitive advantage, managing quality in the supply chain, logistics management, operations management, lean enterprise, and global sourcing and procurement.

Best Practices for Educating Students in the Manufacturing Field

Many of the people who enroll in manufacturing courses at colleges and universities are nontraditional students: adult learners who work part- or full-time while attending school and who often have family responsibilities. For more than three decades, University of Phoenix has been a leader in educating working adults. It has developed the following innovations as educational best practices for students who work in manufacturing:

Flexible class scheduling and online classes. Manufacturing employees often work 40 or more hours a week, and some work on the second and third shifts, making it difficult

for them to attend daytime classes. Others live in rural areas far from major educational institutions. To best serve these students, colleges and universities need to employ flexible scheduling, schedule night and weekend classes, and make classes available online.

Support systems. Some manufacturing workers have never taken college courses, whereas others, especially veteran employees looking to refresh their skills, have been out of school for years. Such students appreciate guidance with procedures like enrolling, applying for financial aid, and selecting classes. University of Phoenix provides students with three advisors who serve this purpose: an enrollment advisor, an academic advisor, and a financial advisor. Its faculty members, who are required to be available to students on a regular basis, often serve as sources of social support as well. “Through teaching online, I’ve formed relationships with students I’ve never met face-to-face,” University of Phoenix faculty member Lisa Holmes says. “Teaching has helped me grow as a professional as well: I stay current with trends in the industry and learn what people in other companies and industries are doing.”

Practitioner faculty. University of Phoenix faculty members are required to have work experience in the fields in which they teach, which enables them to help students see the connection between theory and practice. As Kerns observes, “There’s no better way to gain knowledge about an industry than to learn from someone who has first-hand experience. They bring a certain authority to the classroom that you can’t find within the pages of a book; they help us relate textbook learning to what we do on the job.”

Teamwork. In most classes, University of Phoenix students are asked to complete group assignments that promote communication and collaborative skills. Students often befriend their classmates, who become sources of social support as they complete degree programs together. The virtual classrooms used in online classes at the University of Phoenix also foster teamwork. “The discussion forums we use allow students to interact and discuss their experiences,” Holmes says, “as well as letting instructors make comments and ask probing questions to help students better understand the topics.”

MIKE DAVIS, SR.

Current bachelor’s degree student

Keeping Current in a Changing Industry

Many manufacturing employees who have been in the industry for decades are returning to school to refresh their skills and learn new techniques and theories. Tyco Electronics supervisor Mike Davis, Sr., is one of them.

Davis says he entered the manufacturing field because it was the expected career choice for young people growing up in his town in the 1970s. He enjoyed working as a machinist: “I liked how you could take a piece of metal or some plastic pellets and turn them into something useful,” he says.

Davis chose to pursue a bachelor’s degree because he wanted to update his skill set to be more successful in a changing industry. “I needed to be competitive with the younger workers who just graduated from college,” he notes. “Even if you’ve been in the trade for 35 years, like I have, your employers still want you to keep current with the technology.”

The education he has received, Davis says, has helped him weather such paradigm shifts as lean manufacturing and globalization. “Our company has introduced a new lean manufacturing style over the past couple of years, and the information I learn in class is germane to that,” he says. “My classes have also helped me negotiate cultural differences with our partners in China and Germany.”

Davis believes that fewer young people are entering manufacturing because they do not realize how high-tech the industry has become. “People think manufacturing is a dark, dingy industry, and we need to get the word out that it’s sophisticated and clean,” he says. “Nowadays I come to work in a dress shirt and slacks. Companies need to start engaging with high schools and show students how appealing manufacturing jobs can be.”

As a manager, Davis still remains “hands-on” by mentoring employees in the company’s apprentice program. “My advice to all my apprentices is to go back to school,” he says.

Conclusion

Manufacturers are aware of the nation’s skills gap, and are taking important steps to solve it, but institutions of higher education must do their part as well. By employing best practices for educating working adults, and using programs such as the NAM-Endorsed Manufacturing Skills Certification System and frameworks like the Advanced Manufacturing Competency Model to ensure that graduates have the skills and competencies most needed in today’s workplace, educators can help American manufacturing to thrive.

PART II **ON THE FRONT LINES:
MANUFACTURING SUCCESS STORIES**



5

Building Skills, Strengthening Companies: Manufacturing Professionals Pursuing Higher Education

EXECUTIVE SUMMARY

Manufacturing employees seek degrees for various reasons: to update their skills and knowledge after years on the job, to prepare themselves to move into management, or to perform research that will help their companies prosper.

The reasons manufacturing employees seek higher education are as varied as the employees themselves. Some are industry veterans who want to stay current with a sector that has changed rapidly since they first entered it decades ago. Others pursue master's degrees to prepare them for management or executive positions. Some want to increase their cultural competence and knowledge of global affairs to help their companies be more competitive internationally, whereas others are seasoned executives looking to bring scholarly attention to the manufacturing process through the medium of a doctoral dissertation. "Manufacturing students are a very diverse population," says University of Phoenix faculty member Lisa Holmes. "They range from experienced professionals to those who are just beginning their careers, and they represent a wide range of industries. These students bring a rich variety of experience to the classroom."

The following stories of University of Phoenix students and graduates are suggestive of the diversity of manufacturing professionals who return to school, shedding light on their career paths, their reasons for pursuing degrees, and the ways education has built their skills and helped them and their companies to thrive.

GEORGE MURRAY

Bachelor of Science in Management, 1998

Master of Business Administration, 2000

Education Drives International Success

Skills learned during his bachelor's and MBA studies have helped SmartTrac Technology USA president George Murray lead and grow his company, even in tough economic times. Murray, who has held the positions of plant manager, director of manufacturing, senior global strategic program manager, vice president of operations, and president of U.S. operations, began his career in the manufacturing industry after leaving the military. He was hired by TRW Automotive in Queen Creek, Arizona, where his experience with military explosives proved valuable in the manufacture of air bags, which uses vola-

tile chemicals. In his seven years with the company, Murray was promoted from technician to supervisor to senior supervisor, and began studying for his bachelor's degree. He chose University of Phoenix because its flexible scheduling allowed him to go to school while working full time and supporting a family.

Murray opted to earn an MBA to make himself more competitive. "It takes that level of education to be successful in a global market," he observes. His classes, he says, gave him a better understanding of how businesses interact on an international level, and taught him to collaborate with people from different cultures.

A proponent of higher education for all manufacturing workers, Murray says that education gives workers' a clearer picture of how businesses work and how they can contribute. It also increases workers' critical thinking capabilities, he adds, so that they can get to the root causes of problems and not just deal with the surface symptoms. For example, machine operators must not just correct errors that their machines make, but also understand why certain errors keep being made.

"The best leaders know what it takes to be profitable, but are also creative and innovative."

Education, Murray believes, is key to the entrepreneurial spirit that makes the best leaders successful: "They know what it takes to be profitable, but they also are creative and innovative—able to think up the next new product or the best means to track inventory." That spirit, he says, helps drive SmartTrac's success: "We say that good is not enough—we have to be great, and we have to be better than our competition."

ROBERT GRAUER

Doctor of Management, 2009

Examining Links in the Supply Chain

The relationship between manufacturers, the retailers they serve, and the customers who buy their products can be complex. Today more than ever, manufacturers need dense and accurate data when making production decisions. Robert Grauer chose to study the availability and accuracy of such data when writing his doctoral dissertation for University of Phoenix.

Grauer, an entrepreneur and business owner who lives in Oakland, California, has 30 years of experience in food marketing and manufacturing. He worked as a regional manager at ConAgra Foods and as chief financial officer of Select Trade Sales and Marketing, Inc., and now is president and chief executive office of Blue Coupe Partners, Inc., which does business as the bakery distribution company In a Nutshell. In 2006, he founded RWG Resources, Inc., a consulting company specializing in business modeling, marketing and sales strategy, customer service performance metrics, and other industry analyses.

For his doctoral dissertation, Grauer studied the marketing of store brands of perishable food products. Such private-label brands have become popular in recent years, accounting for \$87 billion in national sales in 2010. However, Grauer found while performing his doctoral research that the marketing of such brands can limit consumers' choices. He discovered that food manufacturers lacked raw data about consumer brand preference and thus relied largely on studies published by organizations like the Private Label Manufacturers Association and the Nielsen Company when making production decisions. These studies suggested that more consumers were buying store brands due to the recession, and that they would continue to buy them once the economy rebounded.

Grauer's research suggests that brand preferences are more nuanced phenomena. When surveying consumers, he found that many would often bypass store brands in favor of national brands because they thought the national brands were of better quality. Consumers told him they were more loyal to retailers who carried their favorite brands and would delay purchases when their preferred brands were out of stock. "People are extremely knowledgeable about the brands retailers are stocking," Grauer says. "Some felt so strongly about certain brands that they were writing notes about them in the margins of the survey, especially when they could no longer buy the national brands they had once purchased."

"One key value I learned in business and through my doctoral studies is to be an honest and trustworthy partner with my customers."

Grauer's study suggests that more research about consumer preferences is needed to help manufacturers make the best decisions about production and vendor partnerships. "One key value I learned in business and through my doctoral studies is to be an honest and trustworthy partner with my customers," Grauer says, adding that he hopes research like his will help manufacturers uphold those values.

KENNETH L. KERNEN

Bachelor of Science in Business Management and Administration (dual major), 2007

Master of Business Administration, 2009

Experience Plus Education Leads to Success

Over the course of his almost 40 years in manufacturing, Kenneth Kernen has held nearly every position, from floor sweeper to senior executive. His extensive experience, coupled with the skills he learned in his bachelor's and master's degree programs, has enabled him to earn a position as a procurement and operations professional for a \$5 billion international company.

After graduating from high school, Kernen followed his father and grandfather into the manufacturing industry by taking a job as a laborer at Rexnord, Inc. ("In the 1960s and 70s, if you lived in the Midwest it was a foregone conclusion that you would go into manufacturing," he says.) He later worked for a bearings manufacturer and a company that made recycling balers, starting as a floor sweeper and being promoted to computer numerically controlled lathe operator, shift foreman, machinist, purchasing agent, safety director, director of purchasing, and trustee.

Kernen became interested in University of Phoenix when a friend told him about classes he was taking. "I did some research into the University, and discovered the faculty all had industry experience, which intrigued me, because there's no better way to gain knowledge about an industry than to learn from someone who has first-hand experience," he says. After earning a bachelor's degree—and being named Outstanding Student at the Milwaukee campus—he continued on for an MBA. "I chose to pursue the MBA because today MBAs are the standard of excellence," he says. "When people earn MBAs, it's proof that they've put in the effort to increase their skills and pursue their goals at a higher level." The master's degree also qualifies Kernen to pursue a secondary career: teaching at the college level. "Teaching has become a passion for me, and I can't wait to begin," he says.

Kernen is now a senior executive at Quad/Graphics, a printing company headquartered in Wisconsin. Currently, he is spearheading the replacement of parts for the company's machinery. "One reason I was hired was that I had experience both on the shop floor and in purchasing," he says. "Not too many people have that skill set any more." Quad/Graphics had so much confidence in Kernen's abilities that, just five weeks after he was hired, he was asked to evaluate and recommend a 5-year plan for global sourcing, even



though he had no international experience. “In one week’s time, I was able to present a plan that is now being used as the basis for our company’s sourcing future,” he says.

Kernen believes that education can provide the answer to the skills gap. “We’re missing a whole generation of people who can help the U.S. become a manufacturing power again,” he observes. “We need to educate the upcoming generation about the fact that America used to be a manufacturing nation and that we can be one again if we recapture our innovative spirit.”

FRED BENTLEY

Master of Business Administration, 2004

Steering a Company Through Difficult Economic Times

Many manufacturing firms have struggled due to economic fluctuations and competition from foreign producers. It takes vision and determination to get a company through difficult times, as Fred Bentley, chief operating officer of wheel manufacturer Hayes Lemmerz International, Inc., can attest. Bentley helped the Northville, Michigan-based company emerge from voluntary bankruptcy protection in late 2010 after drastically reducing its debt and cutting costs.

Bentley grew up in Vandalia, Ohio, where both his parents worked in the automotive industry. He joined the industry at an early age, working as a plant manager for the automotive and aerospace company AlliedSignal and managing director of Honeywell International Inc.'s European and South African aftermarket operations. Along the way, he earned a bachelor's degree in industrial engineering from the University of Cincinnati and an MBA from University of Phoenix, and completed the Advanced Management Program at Harvard Business School. In 2001, he joined Hayes Lemmerz as president of the company's Commercial Highway and Aftermarket division, eventually taking on positions as the president of the company's International Wheel Group and the Global Wheel Group before being named chief operating officer in July 2007.

“America used to be a manufacturing nation and we can be one again if we recapture our innovative spirit.”

During Bentley's tenure at Hayes Lemmerz, the company has faced numerous challenges. In 2001, it closed its Petersburg, Michigan, power train components facility and its Bowling Green, Kentucky, steel wheel facility, and filed for voluntary Chapter 11 restructuring. Over the next several years, it sold certain assets, closed other facilities, and made smaller acquisitions as necessary. In May 2009, in debt and facing a tough economic climate, Hayes Lemmerz was delisted from the NASDAQ and filed voluntary petitions for Chapter 11 in order to restructure; in September of that year, it underwent a major realignment of its global operational sites.

Bentley and the company's management team have worked hard to improve the company's economic prospects, reducing its debt load from \$2.3 billion in 2001 to \$240 million, and implementing a new strategy that focuses on narrowing product lines while expanding the global customer base and growing through innovation.

One of the biggest challenges Hayes Lemmerz faces, Bentley says, is finding talent at all levels, from the shop floor to the boardroom. Manufacturers need employees with sophisticated technical skills who are also problem solvers and thoughtful decision makers, he says.

When asked if he recommends manufacturing as a career, Bentley answers in the affirmative. "Manufacturing gives people who have a passion for making things long-term career opportunities and the ability to make a difference," he says.



6

Diversity in Manufacturing



EXECUTIVE SUMMARY

To reduce the skills gap, manufacturers will need to reach out to diverse segments of the population.

Latinos, who comprise a large and growing part of the U.S. workforce, are an important group for manufacturers to recruit. Some Latinos lack English proficiency and key job skills, so employers will need to provide them with training.

Manufacturers are taking steps to attract women to the industry and to retain female employees, including mentoring programs and women's affinity groups.

Manufacturing has become a diverse industry. To bridge the skills gap, manufacturers are reaching out to minorities—particularly Latinos, who form a growing percentage of the American workforce—and to women, who hold the education and managerial experience manufacturers need. Many female, minority, and international graduates of University of Phoenix have found success in the manufacturing field; their stories illustrate their varied contributions to the industry.

Latinos in Manufacturing

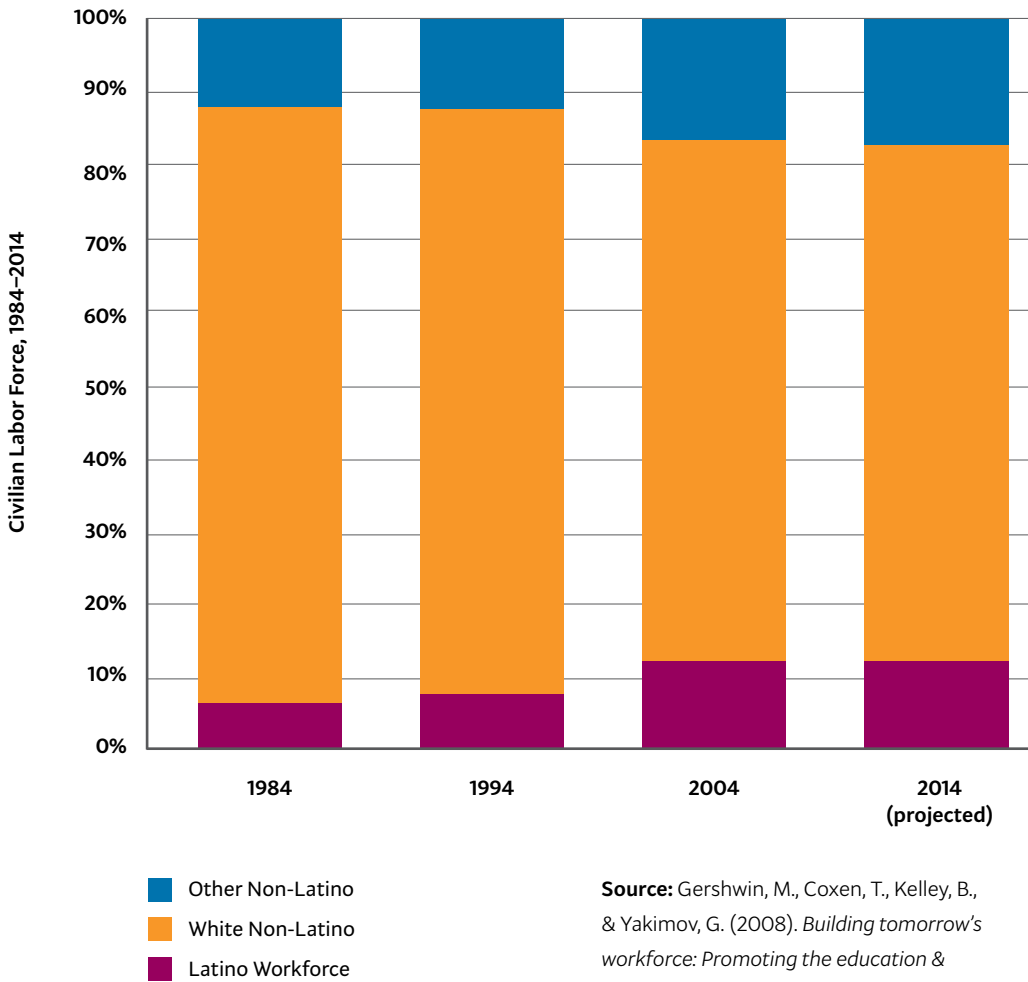
Over the last four decades, Latino employees have comprised a growing segment of the U.S. manufacturing workforce. They hold 15% of manufacturing jobs, and will likely make even larger contributions to the industry as the demographics of the working U.S. population change.¹

Within the next decade, one out of four workers will be a Latin American immigrant.

The Bureau of Labor Statistics predicts that, by 2016, the Hispanic-American workforce will grow to 27 million, a 30% increase from 2006. Within the next decade, one out of four workers will be a Latin American immigrant.²

This changing workforce will challenge employers, who will likely need to increase training and education opportunities for this new group of workers. Many Latino workers

The Latino Workforce is Growing



Source: Gershwin, M., Coxen, T., Kelley, B., & Yakimov, G. (2008). *Building tomorrow's workforce: Promoting the education & advancement of Hispanic immigrant workers in America*. Retrieved from <http://institute.nam.org/view/2001005205313822935/info>

lack the skills and academic credentials needed for success in manufacturing. Over half have less than a high school education, and many have limited proficiency in English, which can restrict their employability and opportunities for advancement. Only 25% of Latino youth of college-going age pursue higher education.³

“It’s important that we give Hispanics in entry-level jobs the opportunity to advance their education, skills, and English proficiency,” says Emily Stover De Rocco, president of The Manufacturing Institute.⁴ More programs and partnerships, she says, are needed to connect immigrants to college opportunities and increase their English language and workplace skills. One example of such a partnership is The Manufacturing Institute’s collaboration with Retention Education, Inc. to design and implement English proficiency programs that will boost literacy, educational attainment, and career advancement among the Latino manufacturing workforce in Texas. Likewise, the Hispanic Scholarship Fund has partnered with BMW Manufacturing Co. to award scholarships to 20 exemplary Latino scholars from South Carolina over the next five years.⁵

Women in Manufacturing

Women, who comprise more than 50% of the labor pool and now outpace men in earning bachelor’s and doctoral degrees, represent an important segment of the population for bridging the manufacturing skills gap. Women hold more than half of all managerial and professional positions across all sectors, and have recently made gains in manufacturing. Over the past decade, the number of woman-owned manufacturing firms nearly doubled. Nineteen percent of manufacturing companies are now owned by women, and 21% are owned jointly by women and men. Sixteen percent of all manufacturing employees work in woman-owned firms.⁶

University of Phoenix doctoral graduate Terri Pomfret believes that manufacturing companies should increase their efforts to hire qualified women and minorities. “People tend to hire others who look, think, and behave like they do,” she says. “That’s human nature, but companies need to break out of that paradigm and understand that diversity makes them stronger.”

Some manufacturers are already taking steps to increase their gender diversity by recruiting, training, and retaining female employees. They sponsor internships and scholarships for women, send recruiters to women’s groups on campus, implement management training programs for women, and hold women’s affinity groups in which



female senior executives meet to network and discuss women’s issues. Others become involved in programs such as Deloitte’s 100 Wise Women, which matches 100 trained mentors with junior employees, and the Deloitte Women’s Initiative, which holds professional development, networking, and mentoring activities.⁷

University of Phoenix Graduates in Manufacturing

MAUREEN LOCKWOOD

Doctor of Management, 2008

Performing Research, Promoting Manufacturing

Manufacturing manager Maureen “Mo” Lockwood brings experience earned during her doctoral studies to work with her every day. A senior manager for Thombert, Inc., a small Iowa company that makes industrial wheels, Lockwood has been interested in engineering since high school, when her guidance counselors noted her enthusiasm for math and science and encouraged her to major in the subject.

After graduating from college with an engineering degree, she worked for Rubbermaid, first as an engineer and then as a continuous value improvement coordinator. “This position allowed me to help others be better engineers and to bring out their creative ideas for solving problems,” she says. She was then promoted to quality manager, materials and management information system manager, distribution manager, production manager, and divisional project manager. Lockwood now oversees all of Thombert’s factory and engineering jobs at two facilities, “supervising everything from production to warehousing, shipping, engineering, and quality control.”

While researching ways to improve her company, Lockwood read several books on management and discovered that most focused on white-collar employees. She wondered whether recent research about employee engagement would apply to blue-collar workers as well, and chose this subject as the topic for her doctoral dissertation. She opted to attend University of Phoenix, partly because she lived in a small Iowa town an hour away from the nearest colleges. “Going to a traditional university wasn’t an option for me,” she says.

During her doctoral research, Lockwood found that employees view their supervisors as symbols of the company they work for. “The more a manager strengthens and clarifies her relationship with an employee, the more strongly the employee will be connected to the company,” she says.

“The experience of earning my doctorate has helped me learn how to be a better researcher, to be less opinionated and more fact-driven,” Lockwood adds. “It opened my eyes to the amount of information that is available and strengthened my ability to evaluate creative ideas and put together experimental designs to test them.”

Lockwood believes that gender does not necessarily put women at a disadvantage in manufacturing. “Being female is irrelevant if you make it that way—it’s all in your attitude,” she says. “Once I did have a male employee quit because he didn’t want to work for a woman. We never had the chance to see if we could work things out, as he left first. But that was his decision, and I respect him for making the choice that felt right for him.”

Lockwood, a member of the Advanced Manufacturing Council and the Iowa Innovation Council, works with high school students to help change the perception that manufacturing is a dying industry. “I strongly believe that American manufacturing will continue to prosper and differentiate itself in the future,” she says. “We need to change its reputation—to make people see that manufacturing is an industry where we make things happen.”

MICHAEL JAMES

Doctor of Business Administration, 2008

Strengthening Jamaican Manufacturing

A native of Moreland, Jamaica, contracting officer Michael James hopes to see a “quality revolution” take place in Jamaican manufacturing. James, an industry veteran, has held managerial positions in production and quality control in both Jamaica and the United States since 1977, and now works for the U.S. Department of Veterans Affairs.

James brought his experience in Jamaican manufacturing to bear on his 2008 doctoral dissertation for University of Phoenix, in which he studied the relationship between Jamaican manufacturing companies’ organizational performance and their use of Total Quality Management (TQM). Developed in the 1950s by American statistician William Edwards Deming, TQM is a widely-used business management style that stresses companies’ use of strategy, data, and communications to continuously improve products and customer satisfaction levels. During the 1980s and 90s, techniques like TQM and lean manufacturing brought about a “quality revolution” in American manufacturing, but such techniques are not as widely employed in Jamaica.

For his doctoral research, James interviewed high-level manufacturing executives and performed analysis of the productivity of firms that were and were not TQM classified. He found that some Jamaican companies—especially those that used TQM—were producing at nearly an internationally competitive level. To be more competitive, James writes, Jamaican firms need to employ a combination of TQM and traditional economic models. *The Business Review* published part of James’s dissertation as a December 2009 article.

James used his research and the skills he developed during the doctoral program to launch a consulting firm, 101 Management Consulting Network (101MCN), which provides TQM implementation services to small and midsize companies in Jamaica and the Caribbean. He provides clients with the assessment tools he created for his dissertation, including assessment of their level of quality management implementation and international competitiveness.

“101MCN’s philosophy is that manufacturing in the Caribbean will be better served when quality is built into every aspect of work processes,” he says, adding that the company “was a product of each and every research paper I completed during my time as a University of Phoenix learner.”

101MCN draws upon the talents of independent management consultants from each member country of the Caribbean Community Single Market and Economy. “Instead of operating in isolation, we’re now bringing our skills and experience together so we can compete successfully with the industry giants,” James says.

TERRI POMFRET

Doctor of Management, 2008

Improving Training through Systematic Thinking

As training director for Fortune 100 company Johnson Controls, Dorothea “Terri” Pomfret is working to reduce the skills gap. Pomfret was chosen as training director due to her extensive business, technical, and engineering experience. She and her colleagues, who represent all three of Johnson Controls’s major divisions, are developing a curriculum strategy for the company’s technical academies. Employees do not always have the skill set they need when joining the company, she explains; they are often technically adept but need to improve their soft skills, such as working in teams, acting as leaders, writing and speaking clearly, making decisions, thinking strategically, and communicating across regional and national boundaries. She and her colleagues identify the skills needed for various positions, create and administer assessments to test employees’ skill levels, and craft a curriculum that enhances those skills. Some courses are held online and some in workshop settings. Johnson Controls also partners with universities to develop academic programs in manufacturing.

Earning a doctoral degree, Pomfret says, improved her leadership, research, and communications skills. “The program emphasized writing succinctly,” she says, “which proved very helpful when I needed to formulate the objectives of the Johnson Controls academies.” She also found that her doctoral studies were useful when working with older employees who were skeptical of Internet-based classes. “I drew upon my doctoral experience to give credibility to the idea of online learning,” she says.

A lifelong working learner, Pomfret worked full time while earning her undergraduate, master’s, and doctoral degrees. “I missed out on some of the fun things that undergraduates do, but working made me take my education more seriously,” she says.

ENRIQUE SAMPSON, JR.

Doctor of Management, 2008

Keeping American Manufacturing at Home

“Knowledge is essential in the aerospace sector,” says Enrique “Rick” Sampson, Jr., a senior manager at Boeing’s Defense, Space, and Security unit. A 25-year veteran of the commercial and defense aerospace industry, Sampson works with countries such as India and Saudi Arabia to develop outsourcing programs dealing with defense and aerospace products.

Sampson studied outsourcing for his doctoral dissertation, and developed a framework that aerospace industry leaders could use when deciding whether to outsource parts of their manufacturing processes. During his research, he made a discovery that surprised him: Small- and medium-sized aerospace companies tend not to outsource if their American employees have the complex technical skills needed for manufacturing their products. His study also showed, however, that U.S. employees’ skill sets are decreasing while other countries are emphasizing key skills such as engineering and machining. If not reversed, he says, this trend will hurt America’s international competitiveness.

Aerospace managers, Sampson says, need to build a strong knowledge base to meet the demands of their technically proficient workforce, and all manufacturing employees must possess knowledge and technical skills for America to remain globally competitive. “We need to impart the knowledge our workers need to move from low-level manufacturing jobs to more complex and highly technical positions like those in the aerospace industry,” he says.

Sampson says his doctoral education expanded his knowledge and skills. “It allowed me to become a mentor both to my colleagues and to professionals outside my company,” he says.

He also notes his research opens the door for a follow-up study to examine what educational avenues employees should follow, such as attending trade schools or community colleges, to make themselves most valuable to employers. “Education is really the key to growth,” he adds.

CONCLUSION: PREPARING THE MANUFACTURING EMPLOYEES OF TOMORROW

In manufacturing today, employees have become knowledge workers. Technology and globalization have impacted manufacturing as they have all industries, and, in response, the sector has become more technically and conceptually sophisticated. Manufacturing employees no longer perform one set of functions day in, day out, at an assembly line. Even at entry level, they operate computers, maintain complex machinery, and use mathematical and analytical skills. They also need “soft skills” such as writing, critical thinking, teamwork, and decision making. Under the new paradigm of lean manufacturing, employees at all levels take more responsibility for their work, and are expected to solve problems, think creatively, and understand their place in the company and the supply chain. For American manufacturing to remain innovative and to succeed abroad, most manufacturing employees need to possess a broad skill set.

Higher education can help manufacturing employees develop these sorely needed skills at all stages in their careers: whether they are job candidates or entry-level workers who need basic writing, mathematics, and technical skills; more experienced workers seeking business or supply chain management degrees to prepare them for managerial positions; veteran employees who want to keep current with new technologies and business practices; or executives pursuing MBAs and doctorates to bring advanced skill sets to their companies.

This seemingly broad range of students has one characteristic in common: All are adult working learners. To best serve their needs—at any educational or skill level—educators should keep the following points in mind:

Industry relevance. One problem with educating manufacturing students has been a lack of curricular alignment with industry standards. Without such standards, employers can only have a rough estimate of which skills new hires possess, and educational programs might produce graduates very skilled in some areas (technical expertise) but lacking in others (teamwork and communications). Educators can

assure students are gaining the skills and competencies employers need by aligning their programs with standards such as the Advanced Manufacturing Competency Model and the Manufacturing Skills Certification System endorsed by the National Association of Manufacturers.

Higher education institutions can also make their programs more industry-relevant by selecting faculty who have worked in the manufacturing field. These practitioner faculty can bring their experience with them to the classroom and show students how their textbook learning relates to the workplace. Working adult students particularly appreciate faculty with industry experience, whom they often view as colleagues and mentors.

Flexibility. Most manufacturing employees cannot afford to take time off from work to attend classes. Many also have family and personal commitments that make heavy demands on their time. Flexible class scheduling—especially classes held in the evenings or on weekends—can make it possible for them to earn degrees. Online learning is also a good alternative for many time-strapped employees who need to fit coursework around work and family obligations.

Support. Some manufacturing workers have no higher education experience, whereas many others have been out of school for years. Attending college can be a daunting prospect for many, and they may find the process of enrolling in school, selecting classes, and applying for financial aid confusing. Faculty and staff should be trained to recognize the needs of adult learners and be prepared to provide this population with logistical and emotional support. Team-based learning can also serve as a source of support for working learners, who often build lasting collegial relationships and friendships with their classmates.

When these factors are taken into account, educators will be in a better position to support manufacturing students and help them gain the skills and competencies needed to close the talent gap.

ENDNOTES

PREFACE

1. Barack Obama, State of the Union address (January 25, 2011), accessed May 16, 2011, <http://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state-union-address>.
2. Ibid.
3. The Manufacturing Institute, *The Facts About Modern Manufacturing*, 8th ed. (Washington, D.C.: The Manufacturing Institute, 2009), accessed May 8, 2011, http://www.nist.gov/mep/upload/FINAL_NAM_REPORT_PAGES.pdf.
4. Ibid.
5. Ibid.
6. Ibid.
7. Ibid.
8. Joel Popkin, Kathryn Kobe, and National Association of Manufacturers and Council of Manufacturing Associations, *Manufacturing Resurgence: A Must for U.S. Prosperity* (Washington, D.C.: National Association of Manufacturers, 2010), accessed May 8, 2011, <http://documents.nam.org/CMA/PopkinReport.pdf>.
9. Executive Office of the President, *A Framework for Revitalizing American Manufacturing* (2009), accessed May 8, 2011, <http://www.whitehouse.gov/sites/default/files/microsites/20091216-manufacturing-framework.pdf>.
10. Deloitte, National Association of Manufacturers, and The Manufacturing Institute, *2005 Skills Gap Report—A Survey of the American Manufacturing Workforce* (Washington, D.C.: The National Association of Manufacturers, 2005), accessed May 8, 2011, [http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_mfg_talent_management_042007%20\(exp%20041510\)\(1\).pdf](http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_mfg_talent_management_042007%20(exp%20041510)(1).pdf).
11. "U.S. Department of Labor Announces Release of Updated Advanced Manufacturing Competency Model," United States Department of Labor, accessed July 11, 2011, <http://www.dol.gov/opa/media/press/eta/eta20100611.htm>.

INTRODUCTION

1. Deloitte and The Manufacturing Institute, *Made in America? What the Public Thinks About Manufacturing Today* (2010), accessed May 8, 2011, http://www.deloitte.com/view/en_US/us/Industries/Process-Industrial-Products-Public-Sector/c0175336134ba210VgnVCM3000001c56f00aRCRD.htm.
2. Richard McCormack et al., *Manufacturing a Better Future for America* (Washington, D.C.: Alliance for American Manufacturing, 2009).
3. The Manufacturing Institute, *The Facts About Modern Manufacturing*, 8th ed. (Washington, D.C.: The Manufacturing Institute, 2009), accessed May 8, 2011, http://www.nist.gov/mep/upload/FINAL_NAM_REPORT_PAGES.pdf.
4. Ibid.
5. Ibid.
6. Ibid.
7. Ibid.
8. Ibid.
9. Ibid.
10. Ibid.
11. Ibid.
12. Ibid.
13. Ibid.
14. Ibid.
15. Ibid.
16. Ibid.
17. Ibid.
18. Ibid.
19. Ibid.
20. Ibid.
21. Ibid.
22. Ibid.
23. Ibid.
24. Ibid.
25. Ibid.
26. Ibid.
27. Ibid.
28. Ibid.
29. Ibid.
30. Ibid.
31. Ibid.
32. Ibid.
33. Ibid.
34. Ibid.
35. Ibid.
36. Ibid.
37. Ibid.
38. Ibid.
39. Ibid.
40. Ibid.
41. Ibid.
42. Ibid.
43. Ibid.
44. Ibid.
45. Ibid.
46. Ibid.
47. Ibid.
48. Ibid.
49. Ibid.
50. Ibid.
51. Ibid.
52. Ibid.
53. Ibid.
54. Ibid.
55. Ibid.
56. Ibid.
57. Ibid.
58. Ibid.
59. Ibid.
60. Ibid.
61. Ibid.
62. Ibid.
63. Ibid.
64. Ibid.
65. Ibid.
66. Ibid.
67. Ibid.
68. Ibid.
69. Ibid.
70. Ibid.
71. Ibid.
72. Ibid.
73. Ibid.
74. Ibid.
75. Ibid.
76. Ibid.
77. Ibid.
78. Ibid.
79. Ibid.
80. Ibid.
81. Ibid.
82. Ibid.
83. Ibid.
84. Ibid.
85. Ibid.
86. Ibid.
87. Ibid.
88. Ibid.
89. Ibid.
90. Ibid.
91. Ibid.
92. Ibid.
93. Ibid.
94. Ibid.
95. Ibid.
96. Ibid.
97. Ibid.
98. Ibid.
99. Ibid.
100. Ibid.

CHAPTER 1

1. Deloitte and The Manufacturing Institute, *Made in America? What the Public Thinks About Manufacturing Today* (2010), accessed May 8, 2011, http://www.deloitte.com/view/en_US/us/Industries/Process-Industrial-Products-Public-Sector/c0175336134ba210VgnVCM3000001c56f00aRCRD.htm.
2. Ibid.

3. The Manufacturing Institute, *The Facts About Modern Manufacturing*, 8th ed. (Washington, D.C.: The Manufacturing Institute, 2009), accessed May 8, 2011, http://www.nist.gov/mep/upload/FINAL_NAM_REPORT_PAGES.pdf.
4. Ibid.
5. Ibid.
6. Ibid.
7. Ibid.
8. Ibid.
9. Ibid.
10. National Association of Manufacturers, *Manufacturing Strategy for Jobs and a Competitive America* (Washington, D.C.: National Association of Manufacturers, 2011), accessed May 8, 2011, <http://www.nam.org/~media/99977BFAD78B4DA1B812C4DD3F3CC94F.ashx>.
11. Ibid.
12. Ibid.
13. National Association of Manufacturers, *Manufacturing Strategy*.
14. Richard McCormack et al., *Manufacturing a Better Future for America* (Washington, D.C.: Alliance for American Manufacturing, 2009).
15. The Manufacturing Institute, *Facts About Modern Manufacturing*.
16. National Association of Manufacturers, *Manufacturing Strategy*.
17. U.S. Department of Labor, Bureau of Labor Statistics, *Machinists. Occupational Outlook Handbook, 2010–11* (2010), accessed May 8, 2011, <http://www.bls.gov/oco/pdf/ocos223.pdf>.
18. U.S. Department of Labor, Bureau of Labor Statistics, *Tool and Die Makers. Occupational Outlook Handbook, 2010–11* (2010), accessed May 8, 2011, <http://www.bls.gov/oco/pdf/ocos225.htm>.
19. DeRocco, E. S. (2009, December.) Interview by C. Meyer.
20. Glynn, C. (2010, June). Interview by C. Meyer.
21. Joel Popkin, Kathryn Kobe, and National Association of Manufacturers and Council of Manufacturing Associations, *Manufacturing Resurgence: A Must for U.S. Prosperity* (Washington, D.C.: The National Association of Manufacturers, 2010), accessed May 8, 2011, <http://documents.nam.org/CMA/PopkinReport.pdf>.
22. Ibid.
23. The Manufacturing Institute, *Facts About Modern Manufacturing*.
24. Ibid.
25. James P. Andrew, Emily Stover DeRocco, and Andrew Taylor, *The Innovation Imperative in Manufacturing: How the United States Can Restore Its Edge* (Boston, MA: The Boston Consulting Group, 2009), accessed May 8, 2011, <http://www.bcg.com/documents/file15445.pdf>.
26. McCormack et al., *Manufacturing a Better Future for America*.
27. Andrew et al., *Innovation Imperative*.
28. The Manufacturing Institute, *Facts About Modern Manufacturing*.
29. Popkin et al., *Manufacturing Resurgence*.
30. Andrew et al., *Innovation Imperative*.
31. Ibid.
32. Emily DeRocco interview.
33. The Manufacturing Institute, *Facts About Modern Manufacturing*.
34. Ibid.
35. Ibid.
36. EFT Research, *Green Manufacturing: Adoption & Implementation 2008 report* (2008), accessed May 8, 2011, http://events.eyefortransport.com/manufacturing/free_report.shtml.
37. Christopher Glynn interview.

CHAPTER 2

1. Ruth Schwartz Cowan, *A Social History of American Technology* (New York: Oxford University Press, 1997).
2. Richard McCormack et al., *Manufacturing a Better Future for America* (Washington, D.C.: Alliance for American Manufacturing, 2009).
3. Cowan, *Social History*.
4. McCormack et al., *Manufacturing a Better Future for America*.
5. Ibid.
6. Ibid.
7. Ibid.
8. Ibid.
9. Ibid.
10. Loren Brandt and Thomas G. Rawski, *China's Great Economic Transformation*. (New York: Cambridge University Press, 2008).
11. McCormack et al., *Manufacturing a Better Future for America*.
12. David Barboza, "As China's Wages Rise, Export Prices Could Follow," *New York Times*, June 7, 2010, <http://www.nytimes.com/2010/06/08/business/global/08wages.html>.
13. McCormack et al., *Manufacturing a Better Future for America*.
14. Ibid.
15. James P. Andrew, Emily Stover DeRocco, and Andrew Taylor, *The Innovation Imperative in Manufacturing: How the United States Can Restore Its Edge* (Boston, MA: The Boston Consulting Group, 2009), accessed May 8, 2011, <http://www.bcg.com/documents/file15445.pdf>.
16. McCormack et al., *Manufacturing a Better Future for America*.
17. The Manufacturing Institute, *The Facts About Modern Manufacturing*, 8th ed. (Washington, D.C.: The Manufacturing Institute, 2009), accessed May 8, 2011, http://www.nist.gov/mep/upload/FINAL_NAM_REPORT_PAGES.pdf.
18. Ibid.
19. McCormack et al., *Manufacturing a Better Future for America*.
20. Andrew, DeRocco, and Taylor, *Innovation Imperative*.
21. Ibid.
22. National Association of Manufacturers, *Manufacturing Strategy for Jobs and a Competitive America* (Washington, D.C.: National Association of Manufacturers, 2011), accessed May 8, 2011, <http://www.nam.org/~media/99977BFAD78B4DA1B812C4DD3F3CC94F.ashx>.
23. Andrew, DeRocco, and Taylor, *Innovation Imperative*.
24. DeRocco, E. S. (2010, December.) Interview by C. Meyer.

CHAPTER 3

1. Richard McCormack et al., *Manufacturing a Better Future for America* (Washington, D.C.: Alliance for American Manufacturing, 2009).
2. Deloitte, Oracle, and The Manufacturing Institute, *People and Profitability: A Time for Change. A 2009 People Management Practices Survey of the Manufacturing Industry* (Washington, D.C.: The Manufacturing Institute, 2009), accessed May 10, 2011, http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_pip_peoplemanagementreport_100509.pdf
3. Deloitte, Oracle, and The Manufacturing Institute, *People and Profitability*.
4. Ibid.
5. Deloitte, The National Association of Manufacturers, and The Manufacturing Institute, *2005 Skills Gap Report—A Survey of the American Manufacturing Workforce* (Washington, D.C.: The National Association of Manufacturers, 2005), accessed May 8, 2011, [http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_mfg_talent_management_042007%20\(exp%20041510\)\(1\).pdf](http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_mfg_talent_management_042007%20(exp%20041510)(1).pdf).
6. Deloitte, Oracle, and The Manufacturing Institute, *People and Profitability*.
7. Deloitte, The National Association of Manufacturers, and The Manufacturing Institute, *2005 Skills Gap Report*.
8. McCormack et al., *Manufacturing a Better Future for America*.

9. Ibid.
10. DeRocco, E.S. (2010, December.) Interview by C. Meyer.
11. Ibid.
12. Deloitte, The National Association of Manufacturers, and The Manufacturing Institute, *2005 Skills Gap Report*; McCormack et al., *Manufacturing a Better Future for America*.
13. Brian Lindquist, *Innovation in Manufacturing: More Than Just New Technology*, accessed May 10, 2011, <http://www.eschoolnews.com/2010/07/14/innovation-in-manufacturing-more-than-just-new-technology>.
14. Deloitte and The Manufacturing Institute, *Made in America? What the Public Thinks About Manufacturing Today* (2010), accessed May 8, 2011, http://www.deloitte.com/view/en_US/us/Industries/Process-Industrial-Products-Public-Sector/c0175336134ba210VgnVCM3000001c56f00aRCRD.htm.
15. Ibid.
16. Deloitte and The Manufacturing Institute, *Public Viewpoint on Manufacturing. 2009 Annual Index* (2009), accessed May 10, 2011, http://www.areadevelopment.com/article_pdf/id39383_us_mfg_manufacturingviewpoint060809.pdf.
17. Ibid.
18. Deloitte, The National Association of Manufacturers, and The Manufacturing Institute, *2005 Skills Gap Report*.

CHAPTER 4

1. Deloitte, National Association of Manufacturers, and The Manufacturing Institute, *2005 Skills Gap Report—A Survey of the American Manufacturing Workforce* (Washington, D.C.: National Association of Manufacturers, 2005), accessed May 8, 2011, [http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_mfg_talent_management_042007%20\(exp%20041510\)\(1\).pdf](http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_mfg_talent_management_042007%20(exp%20041510)(1).pdf).
2. Ibid.

3. Ibid.
4. Glynn, C. (2010, June.) Interview by C. Meyer.
5. "U.S. Department of Labor Updates Advanced Manufacturing Competency Model," *IndustryWeek*, accessed July 11, 2001, http://www.industryweek.com/articles/u-s-department_of_labor_updates_advanced_manufacturing_competency_model_21751.aspx.
6. University of Phoenix and The Manufacturing Institute, *Manufacturing Skills Certification: Employer Perspectives* (Phoenix, AZ: University of Phoenix, 2011).
7. Ibid.
8. Ibid.
9. DeRocco, E. S. [Video file]. Retrieved from <http://www.phoenix.edu/alliance/mi/manufacture.html>.

CHAPTER 6

1. Executive Office of the President, *A Framework for Revitalizing American Manufacturing* (2009), accessed May 8, 2011, <http://www.whitehouse.gov/sites/default/files/microsites/20091216-manufacturing-framework.pdf>.
2. Mary Gershwin, Tammy Coxen, Brian Kelley, and Gary Yakimov, *Building Tomorrow's Workforce: Promoting the Education & Advancement of Hispanic Immigrant Workers in America*, accessed May 13, 2011, <http://institute.nam.org/view/2001005205313822935/info>.
3. Ibid.
4. Emily Stover DeRocco, interview by C. Meyer, December 2009.
5. Gershwin et al., *Building Tomorrow's Workforce*.
6. National Association of Manufacturers, *Women in Manufacturing. A Booklet of Best Practices* (Washington, D.C.: National Association of Manufacturers, 2010), accessed May 13, 2011, <http://institute.nam.org/view/2001005206943600746/info>.
7. Ibid.

REFERENCES

- Andrew, James P., Emily Stover DeRocco, and Andrew Taylor. *The Innovation Imperative in Manufacturing: How the United States Can Restore Its Edge*. Boston, MA: The Boston Consulting Group, 2009. <http://www.bcg.com/documents/file15445.pdf>.
- Barboza, David. "As China's Wages Rise, Export Prices Could Follow," *New York Times*, June 7, 2010. <http://www.nytimes.com/2010/06/08/business/global/08wages.html>.
- Brandt, Loren, and Thomas G. Rawski, *China's Great Economic Transformation*. New York: Cambridge University Press, 2008.
- Deloitte, and The Manufacturing Institute. *Made in America? What the Public Thinks About Manufacturing Today* (2010). http://www.deloitte.com/view/en_US/us/Industries/Process-Industrial-Products-Public-Sector/c0175336134ba210VgnVCM3000001c56f00aRCRD.htm.
- Deloitte, and The Manufacturing Institute, *Public Viewpoint on Manufacturing. 2009 Annual Index* (2009). http://www.areadevelopment.com/article_pdf/id39383_us_mfg_manufacturingviewpoint060809.pdf.
- Deloitte, National Association of Manufacturers, and The Manufacturing Institute, *2005 Skills Gap Report—A Survey of the American Manufacturing Workforce*. Washington, D.C.: National Association of Manufacturers, 2005. [http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_mfg_talent_management_042007%20\(exp%20041510\)\(1\).pdf](http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_mfg_talent_management_042007%20(exp%20041510)(1).pdf).
- Deloitte, Oracle, and The Manufacturing Institute, *People and Profitability: A Time for Change. A 2009 People Management Practices Survey of the Manufacturing Industry*. Washington, D.C.: The Manufacturing Institute, 2009. http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_pip_peoplemanagementreport_100509.pdf
- DeRocco, Emily Stover. University of Phoenix video interview. 3:08. Accessed May 17, 2011. <http://www.phoenix.edu/alliance/mi/manufacturer.html>.
- EFT Research. *Green Manufacturing: Adoption & Implementation 2008 report* (2008). http://events.eyefortransport.com/manufacturing/free_report.shtml.

- Executive Office of the President. *A Framework for Revitalizing American Manufacturing* (2009). <http://www.whitehouse.gov/sites/default/files/microsites/20091216-manufacturing-framework.pdf>.
- Gershwin, Mary, Tammy Coxen, Brian Kelley, and Gary Yakimov. *Building Tomorrow's Workforce: Promoting the Education & Advancement of Hispanic Immigrant Workers in America*. Accessed May 13, 2011. <http://institute.nam.org/view/2001005205313822935/info>.
- IndustryWeek. "U.S. Department of Labor Updates Advanced Manufacturing Competency Model." Accessed July 11, 2001. http://www.industryweek.com/articles/u-s-department-of-labor-updates-advanced-manufacturing-competency-model_21751.aspx.
- Lindquist, Brian. *Innovation in Manufacturing: More Than Just New Technology*. Accessed May 10, 2011. <http://www.eschoolnews.com/2010/07/14/innovation-in-manufacturing-more-than-just-new-technology>.
- The Manufacturing Institute. *The Facts About Modern Manufacturing*. 8th ed. Washington, D.C.: The Manufacturing Institute, 2009. http://www.nist.gov/mep/upload/FINAL_NAM_REPORT_PAGES.pdf.
- McCormack, Richard, Clyde Prestowitz, Kate Heidinger, John Russo, Sherry Lee Linkton, Ron Hira, Irene Petric, et al. *Manufacturing a Better Future for America*. Washington, D.C.: Alliance for American Manufacturing, 2009.
- National Association of Manufacturers. *Manufacturing Strategy for Jobs and a Competitive America* (Washington, D.C.: National Association of Manufacturers, 2011). Accessed May 8, 2011. <http://www.nam.org/-/media/99977BFAD78B4DA1B812C4DD3F3CC94F.ashx>.
- National Association of Manufacturers. *Women in Manufacturing. A Booklet of Best Practices* (Washington, D.C.: National Association of Manufacturers, 2010). Accessed May 13, 2011. <http://institute.nam.org/view/2001005206943600746/info>.

- Obama, Barack. State of the Union address (January 25, 2011). Accessed May 16, 2011. <http://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state-union-address>.
- Joel Popkin, Kathryn Kobe, and National Association of Manufacturers and Council of Manufacturing Associations. *Manufacturing Resurgence: A Must for U.S. Prosperity*. Washington, D.C.: The National Association of Manufacturers, 2010. Accessed May 8, 2011. <http://documents.nam.org/CMA/PopkinReport.pdf>.
- Schwartz Cowan, Ruth. *A Social History of American Technology*. New York: Oxford University Press, 1997.
- University of Phoenix, and The Manufacturing Institute. *Manufacturing Skills Certification: Employer Perspectives*. Phoenix, AZ: University of Phoenix, 2011.
- U.S. Department of Labor, Bureau of Labor Statistics. *Machinists. Occupational Outlook Handbook, 2010-11* (2010). Accessed May 8, 2011, <http://www.bls.gov/oco/pdf/ocos223.pdf>.
- U.S. Department of Labor, Bureau of Labor Statistics. *Tool and Die Makers. Occupational Outlook Handbook, 2010-11* (2010). Accessed May 8, 2011, <http://www.bls.gov/oco/ocos225.htm>.
- U.S. Department of Labor. "U.S. Department of Labor Announces Release of Updated Advanced Manufacturing Competency Model." Accessed July 11, 2001, <http://www.dol.gov/opa/media/press/eta/eta20100611.htm>.

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Manufacturing is an industry in transition. New technologies and processes have made American manufacturing more sophisticated and productive than ever before. Yet manufacturers face serious competition from abroad and a talent shortage at home that threatens their ability to innovate and meet consumer demands.

Manufacturing workers no longer perform one set of functions on an assembly line. Today's manufacturing employees are knowledge workers, thinking critically, making decisions, and generating ideas to improve products and processes. To thrive in this rapidly changing industry, employees need higher education. Entry-level workers need to improve their communication, mathematics, teamwork, and computer skills, while more advanced workers need analytical, theoretical, managerial, and cultural skills to help their companies compete on a global level. This book details the ways manufacturers and educators can work together to invest employees with the skills they need to keep American manufacturing strong, efficient, and innovative.

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