Community Colleges' Roles in Rebuilding America's Manufacturing

Report from the Trans-Atlantic Technology and Training Alliance Symposium on "The Future of Manufacturing," October 1-2, 2012

Regional Technology Strategies, Inc.
www.rtsinc.org
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The **Trans-Atlantic Technology and Training Alliance (TA^3)** is a network of leading post-secondary education and training institutions (e.g., community, technical, commercial, and further education colleges) in the United States, Europe, and South Africa. The alliance took root in 1994, with support from the German Marshall Fund of the United States, as an outgrowth of the southern state-based Consortium for Manufacturing Competitiveness.

The TA3 is managed by co-secretariats, Regional Technology Strategies in North Carolina for the U.S. and the Danish Agency for Universities and Internationalisation in Copenhagen for Europe.

This international alliance is dedicated to sharing practices that prepare workers to be creative and productive employees; improve access for non-traditional students; provide opportunities for multi-cultural faculty development and student exchange; build connections to economy and community; and strengthen and expand the roles of the colleges in providing business, social, cultural, and entrepreneurial services. The focus of the Alliance is on the intersection of education, economic development, and social cohesion.

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http://www.ta3online.org

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This paper summarizes the context, presentations, and discussions from a symposium on "The Future of Manufacturing: Implications for Community Colleges" that was held on Oct 1-2, 2012 in Covington, Kentucky. The event was sponsored by the Trans-Atlantic Technology & Training Alliance, an international alliance of community colleges managed by Regional Technology Strategies and the Danish Agency for Universities and Internationalisation, and co-hosted by TA3 member Gateway Community and Technical College.

The presentations can be downloaded from links at:
http://www.ta3online.org/wp-content/uploads/2012/10/ta3_oct_agenda.pdf

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Stuart Rosenfeld, March 2013

I. Introduction

"Manufacturing Still Matters" could very well be a reprise of the widely cited 1987 book *Manufacturing Matters*.[1] Challenging "The Myth of the Post-Industrial Economy," the authors warned of the effects of moving manufacturing offshore. Their arguments ring just as true today. Exports, private sector investments in R&D, innovation, security, and—perhaps most important—skills and economic opportunity still are heavily dependent on retaining a manufacturing base in the United States. Moreover, on average every manufacturing job supports 2.5 jobs in other sectors—16 jobs for high tech manufacturing.[2]

When innovative and technologically advanced competition emerged in Japan and Western Europe in the 1980s, federal and state governments formulated new policies aimed at increasing investments in R&D and innovation, accelerating the modernization and re-organization of production facilities, and raising skill levels to adopt the new technologies. The National Institute of Standards and Technology and its Manufacturing Extension Partnership ultimately became the national leader in the nation's commitment to technology and innovation.

Community colleges were among the first responders to the call for modernization, especially from smaller companies. A report from The Office of Technology Assessment of the U.S. Congress "Making Things Better"[3] cites the precursor of the Trans-Atlantic Technology & Training Alliance, the Consortium for Manufacturing Competitiveness, as a national model "formed with federal as well as state support in 1988 with three goals: to demonstrate that … community colleges can help small and medium-sized manufacturers with new technology; to provide more information about the training needed for factories of the future; and to produce graduates who are able to not only adapt to technological change but to facilitate it."[4]

The same technologies that modernized and restored American industry, however, were diffused into developing and emerging economies more quickly than anticipated, dramatically transforming the global economic landscape.

If one accepts the importance of retaining a viable manufacturing economy, then the challenges facing community colleges will be to learn what skills and talents will be needed by companies in order to compete in tomorrow's market.

Automation and more intense global competition demand even higher levels of competence, innovation, creativity, and entrepreneurship. The work force coming out of and the knowledge residing in community colleges matched with the broader technical expertise and experience of the MEP will play a major role in resuscitating America's industrial base.

II. Manufacturing Moves into the 21st Century

The first Congressional discussions of federal assistance to small and mid-sized manufacturing enterprises (SMEs) focused on the needs to develop more advanced production technologies and on the lack of connections between SMEs and the R&D competences of higher education. As states developed industrial modernization programs, it became clear that inadequate diffusion of existing technologies and lack of the skills to adopt and effectively use existing technologies had to be addressed before developing even more advanced technologies. The early programs discovered that workplace skills were as important to SMEs as research. Therefore, community colleges, which were closer to the plant floor, became key players in demonstrating the value of modernization to SMEs and developing the skill base to make modernization possible.

The view of competitive advantage, however, was based on the economic environment of the 1980s. Due in large part to the success of America's "industrial" policies that produced a national support system, and to the aggressive marketing of digitized production technologies by their builders, advanced manufacturing has become quite common and is no longer the exception, even in many of the non-durable sectors that once operated at low technology and skill levels.

Despite the success of new public and private sector programs and incentives, both employment in manufacturing and enrollments in technical education have continued to decline—very likely less than they would have without adopting new technologies and best practices, but still substantially. With companies moving various parts of their production processes overseas to lower costs, the proportion of the work force employed in manufacturing dropped from 20 percent in the early 1980s to less than 10 percent today.

This time, however, the decline in manufacturing competitiveness isn't due to technological complacency or lack of investment in process technologies, as it had been in the 1980s. American companies today are operating with very high levels of technology and have among the highest levels of productivity in the world.

The questions facing the nation now are how to reverse the leakage of jobs, which is already happening in some places and in some sectors; how many jobs can a competitive manufacturing base be expected to maintain given the rapid advances in production technologies; what will produce tomorrow's competitive advantages; and, most importantly for education, where will America get the workforce, the innovators, and the entrepreneurs to support a modern and innovative manufacturing base?

A. Globalization

The gaps in both the development and uses of technologies and levels of productivity between advanced and less developed economies have narrowed. With assistance from educational institutions, non-profits, and consultants from the most advanced economies, often with their

governments' support, plus the digitization of information, many emerging and less developed economies have advanced to the point that they can produce high quality and timely goods at a significant cost advantage.

Recruitment of foreign students by American universities and community colleges has contributed to closing the gap between the have and have not economies. Many foreign students once came to America for higher education and remained because there were insufficient markets for their technical and entrepreneurial skills at home. Today, that is no longer the case, and many graduates choose to return home to work and start businesses.

With American support, over a relatively short time period, regions that had been designated as "less developed" have built the infrastructure and developed the skill base to utilize the newest technologies, but at much lower costs. Those costs in some places have been reduced even more by devalued currencies and subsidies.

As a result of their improved technological capacities, better transportation, and digitalized information, manufacturers substantially increased the sourcing and production of goods to low-wage countries that previously had not been serious competitors for advanced or high value-added goods. The outsourcing has expanded to almost any associated support services that can be routinized, including even some aspects of research and development.

B. Automation

The use of technology by companies to replace labor is accelerating. The levels of automation that had been predicted half a century ago to eliminate labor around the world, including by an "Automation Commission" formed by of the U.S. Congress, are now becoming a reality.[5] In 2012, 1,500 auto assemblers were able to do the work of 5,000 in 1965.[6]

Mass production factories that were once teeming with human activity increasingly are populated by rows of automated production and materials handling machines, approaching the futuristic full computer-controlled automation described by Kurt Vonnegut in *Player Piano* in 1952. "Factories are becoming vastly more efficient, thanks to automated milling machines that can swap their own tools, cut in multiple directions and 'feel' if something is going wrong, together with robots equipped with vision and other sensing systems…. The days of huge factories full of lots of people are not there any more."[7]

Automation and digital technologies also alter the staffing patterns of manufacturing. Higher proportions of employees work is offices and provide services—about 35 percent and over 50 percent in high tech industries—and fewer work directly in production.

C. Image

The changes taking place in manufacturing and the ways in which they are presented by the media have immediate and long-term impacts on the manufacturing labor force, education and training, and career choices. Despite the recent loss of jobs, manufacturing remains a large source of jobs with nearly 12 million employees, more than half of them working in small and mid-sized enterprises. The natures of careers and career planning, however, have changed. Young people today realize that they are likely to change jobs and occupations many times, and they no longer think about lifetime careers with a single employer with a pension at the end. They prefer to have the flexibility to be able to take on new and different challenges and responsibilities.

Manufacturing represents one starting point that can provide those challenges and opportunities. But if they perceive manufacturing as a high risk entry point because of its susceptibility to competition; if they lack the requisite STEM skills; if they are counseled by families and friends toward baccalaureate programs and "white collar" careers; if they view manufacturing as low in status and underpaid; or if they perceive it simply as uncool, they will avoid starting out on manufacturing career paths regardless of the number of jobs posted or wages promised.

For example, with companies needing skilled welders, the *Wall Street Journal's* rankings of 200 jobs from best to worst placed welders at 194th, just one above garbage collectors, a view bound to discourage good potential applicants.[8] A recent Brookings Institution report cited a National Association of Manufacturers survey of high school students in Indianapolis that found only three percent were interested in manufacturing careers.[9] The situation has been exacerbated by cost pressures from low-wage regions that have reduced wages and benefits as well as manufacturers' own investments in workforce training.

If the result of low esteem for manufacturing is reduced demand for technical education, community colleges will shift resources to programs that generate higher student demand due to economic opportunities or interests, which may be health care, graphic design, or information technologies.

D. Geography

Once again, the geography of production is changing. It was originally concentrated in America's large cities, especially in the northeast and Midwest. Then, in the 1960s and 1970s the most labor-intensive manufacturing plants relocated to rural regions that offered lower costs and surplus labor, especially in the South. Part of that change is due to the way that manufacturing companies cluster, with the traditional and labor-intensive mass production goods industries the first to leave the cities.

The more traditional and labor-intensive rural industries, such as apparel and textiles, which saw

80 percent of its U.S. employment disappear over the past two decades, furniture, and consumer electronics have been the most susceptible to outsourcing. In contrast, the more innovation-driven "advanced manufacturing" and artisanal industries that tend to be attracted to urban amenities have been more resistant. As a result, by 2010, almost 80 percent of manufacturing employment was concentrated in metropolitan areas.

E. Meeting the challenges

Despite the rapid growth in the information and knowledge sectors, sustaining economic growth requires a sustainable industrial base. Dr. Phil Singerman, Associate Director for Innovation and Industry Services at the National Institute of Standards and Technology framed the challenges at the symposium with the statement that an economy "built to last" depends on manufacturing. That echoes the position of the President's Council of Advisors on Science and Technology (PCAST) and its concern with the importance of manufacturing to economic recovery. The White House established a team in 2009 to examine manufacturing policy and recommend a framework for revitalizing it.

In June 2011, President Obama launched the Advanced Manufacturing Partnership to "identify opportunities for investments… that have the potential to transform advanced manufacturing in the United States…." Recommendations focused on manufacturing policy, technology development, shared infrastructure and facilities, and education and workforce development. In July 2012, one of the three pillars for "Recapturing Domestic Advantage," was "Securing Talent Pipeline." The report recommended that the nation "Invest in Community College Level Education, "the 'sweet spot' to reduce the skills gap."[10] Further, the President, in his 2013 State of the Union address recognized the importance of accelerating innovation and announced plans for 15 manufacturing innovation institutes.

III. From Challenges to Opportunities

New opportunities are developing in manufacturing that hold promise for a recovery, and even resurgence, of manufacturing. Companies are beginning to reassess the value of proximity between production and innovation; to find added competitive advantage from the value of design, brand, and automation; and to reexamine, and in some instances reverse, their outsourcing and location decisions.

A. Proximity matters

Some companies not only are beginning to think differently about their outsourcing decisions but have begun to insource to U.S. companies—called "reshoring." A recent survey reported by *Forbes* found that about 22 percent of U.S. product manufacturers reported moving some production back to America in the fourth quarter of 2011, and one in three companies were studying the proposition. Walmart recently announced it will increase sourcing of American made goods by $50 million over the next ten years.[11]

While supply chains will continue to be global, rising costs in emerging economies combined with the value of keeping production near centers of research and design and changing customer demand is already altering the economics of location decisions. Companies also are rediscovering the value of the tacit knowledge and iterative innovation that have always underpinned the formation and growth of successful business clusters.

"Moving production a long way off and separating it from research and development risks harming a firm's long-term ability to innovate."[12] Stephen S. Cohen, co-director of the Berkeley Roundtable on the International Economy, warned that "in order to innovate in what you make, you have to be pretty good at making it—and we are losing that ability."[13]

Manufacturing also is an important part of a local culture that represents a source of pride and a brand. Some companies feel a responsibility to their birthplace and are willing to manufacture at home even if costs are slightly higher. Place offers the experience, tacit knowledge, community relationships, and brand not easily replicable elsewhere. Harley Davidson, for example, is a Milwaukee brand that is not likely to leave. The Boston Consulting Group predicts that during this decade two to three million manufacturing jobs will come back to the U.S.

One of the best examples is General Electric's (GE) Appliance Park in Louisville, Kentucky, described at the symposium by GE Director of Design Lou Lenzi. Once a booming manufacturing facility that had employed 23,000 workers, by the 1990s GE CEO Jack Welch, a champion of outsourcing, suggested shutting it down completely by 2003. GE's current CEO, Jeffrey Immelt, attempted to sell the entire appliance business, including Appliance Park in 2008. But with the economy in decline, he could find no buyers, and by 2011 the number of production employees at the site was down to 1,863. According to Lou Lenzi, "when you outsource the

making of your products, your whole business goes with the outsourcing.'"

Lenzi showed how the low energy heat pump, previously made in China, could be made as profitably in Louisville by redesigning it in an innovative environment.[14] Hourly employees were told to completely re-imagine dishwasher assembly; but the group was given a crucial guarantee that regardless of the efficiencies it created, "no one will lose their job because of lean." This is a prime example of how shop floor workers, if given the opportunity, can become sources of innovation. Appliance Park began an *integrated approach to design and production* and ended 2012 with 3,600 hourly employees—1,700 more than they employed in 2011.

B. Less labor, more technology

The face of manufacturing is now associated with a robotic, not human arm. The army of once feared robots is now the source of higher productivity that is another explanation for reversals of outsourcing decisions. The technologies that enabled companies to replace labor with machines and computers and reduce production labor make it less advantageous to outsource.

John Winzeler, President of Winzeler Gears in Chicago, described how his company became a pioneer in using technology to produce high-volume, high-precision, zero defect gears. The plant made 2 million gears a month with 60 people ten years ago. Today it makes 10 million a month with 40 employees. "It's the only way to compete in this part of the world. And if you're going to move a lot of product in the same way, you're going to want very, very little human involvement."[15] Apple's recent announcement that it would bring back the production of some MACs was due in part to the levels of automation in the production of the motherboards.

There is a growing debate about the increase in speed and extensiveness of automation, digitization, and artificial intelligence. Could they reduce levels of employment similar to what happened to the agricultural economy? A recent report from the National Academy of Engineering speculated that improvements on the factory floor will continue with the advent of smart sensors, and machines will continue to become more powerful. This will lead to more "'lights-out factories where processes are fully automated and require no human operators on the factory floor, just technicians to monitor the process."[16]

Recent projections from the U.S. Bureau of Labor Statistics appear to reinforce the findings. While manufacturing output is projected to grow by 2.8 percent per year between 2010 and 2020, manufacturing employment is projected to decline by 0.1 percent per year.[17]

Even as production line jobs decrease, valuable jobs in engineering, design, maintenance, repair, serving customers, and the manufacture of automated equipment provide steady employment. In addition, individualized, customized, and mass customized manufacturing is a growing source of employment. The new workplaces, however, are likely to require greater adaptability, flexibility, and ways to tackle problems that are more improvisational than algorithmic.

C. Customized goods

More and more middle class consumers are willing to pay a premium for all sorts of goods that reflect their values, cultures, or personalities. Increasingly segmented markets are looking for more and more differentiation and novelty in what they purchase, which is now possible with new technologies and techniques.

This demand is also expanding rapidly in those countries that replaced U.S. production. The new wealth is creating larger middle classes with disposable incomes that become new markets for high value-added goods. McKinsey forecasts that the market for the two billion people living in a dozen emerging nations is $6.9 billion and expected to reach $20 billion during the next decade. The Boston Consulting Group reported that more than 60 percent of Chinese consumers are willing to pay more for a product made in the U.S. than for a product made in China.[18] This creates new opportunities for companies to produce a variety of limited scale, more granular, tailored products that match, and even generate, market demand for imported goods.

Thus, the future of manufacturing may be related more to its distant past than Taylorism and mass production. Up until about 80 years ago, "competitive strategy involved differentiating products and marketing capacities for novelty and quality. The ability to make different goods well and/or meet complex specifications often helped make price a secondary consideration in sales."[19] Today, at the far end of the segmented markets continuum, a form of highly specialized manufacturing is emerging as a force in manufacturing, albeit still small scale in terms of employment.

Recent advances in scaled down, affordable desktop Computer Numerically Controlled (CNC) equipment and in microwave-size 3D printing combined with open source design have created a "maker revolution."[1] Users can create a design or go online, find a design they want, and download it to a 3D printer. The technology has moved rapidly from the size of a large industrial refrigerator to something that resembles a sleek, desktop microwave. The cost of 3D printers has dropped even more dramatically than the size, now as little as $500, about the same price as a high-end laptop. The printers are even being installed in libraries for public use, much as "Xerox" machines once were. The new Hunt library at North Carolina State University's Centennial Campus has such printers, exposing the public to "cool" manufacturing.

Maker "Faires" across the country draw tens of thousands of people with ideas who want to turn them into products themselves. Artisanal firms and cottage industries are sharing spaces called TechShops and FabLabs. Such places, which provide artisanal manufacturers with common access to equipment and services, are opening up across the nation to accommodate the

[1] The term "maker" is used to describe individuals who choose to make concrete things with small scale, affordable technologies, often beginning as a cottage industry.

burgeoning interest in making things. The Georgia Tech Makers Club, for example, has 50 volunteer undergraduate students who train other students and give lessons in prototyping, manufacturing processes, and advanced manufacturing. The club serves more than 500 students each semester.

Ted Hall, President of ShopBot in Durham, North Carolina, a very early proponent of cottage industry manufacturing, produces equipment affordable to individuals, large manufacturers, and educational institutions. His www.100kgarages.com, cited in the *Economist* in December 2012, is an effort to promote a network of "garage," i.e., small scale, manufacturers as a "new 'industrial' revolution [with] social, open, distributed, local, small-scale, production."[20]

Adam Friedman from the Pratt Institute spoke about the rise of micro-manufacturing as an urban phenomenon, and its growth in the Brooklyn Navy Yards. Cottage industries may not yet be showing a significant impact on manufacturing employment, but the small-scale technologies also are being adopted by large employers to customize products, and they are creating a new, modern image of manufacturing that may affect career plans of youth as well as generate new products. And, as companies become more adept at mass customization, larger companies will be able to achieve both variety and scale.

D. Releasing creativity and innovation

Innovation is one of the leading sources of competitive advantage. Technological breakthroughs, often the result on investments in R&D, can lead to product innovations such as a new biomedical product or a creative application of nanotechnologies. The typical measure for product innovation is patents filed, but using that criterion, America was surpassed by China in 2011.

Process innovations, the development of technologies and techniques that increase productivity, quality, or delivery and are not often patented, receive less recognition and support but in fact are the more common approach to achieving competitiveness, especially among SMEs that rarely invest in R&D and are often reluctant to invest in modernization. Innovation can originate in all aspects of the manufacturing process and from any employee, from a technician retrofitting a machine for a unique application or finding a way to reduce waste to a data analyst finding a new supply chain model or a technician suggesting a new material flow pattern.

While R&D driven innovation receives most of the policy attention and funding, product innovation is also—and very likely much more often—generated by creative designers who find ways to add value by responding to needs of the users or producing a special experience. Many successful firms rely on design to build their own brand and identity, target niche markets, establish a reputation, and grow consumer loyalty.

User- and design-driven innovation, however, has received very little attention from

policymakers or public sector investment in the U.S., especially given how much it contributes to competitive advantage. Europe, and particularly the Nordic countries, has long been adept at gaining competitive advantage from design and supporting that kind of innovation. The Finnish Institute of Mass Customization and Personalization, for example, was founded in 2003 to address the growing demand for such goods. The Danish Design Centre "offers advice to Danish companies on the use of design as a tool of innovation."[21]

Design-driven product innovation is as apt to generate as to respond to demand. It assumes that certain segments of the market value authenticity, sustainability, and individuality and the consumers in those segments are willing to pay a premium for things that reflect their personalities or values or meet individual needs.

At the symposium, George Konstantakis used a Venn diagram describe the unions of areas representing technology, business and human values as sources of functional innovation (e.g., ergonomics, product integrity), process innovation (quality, productivity), and emotional innovation (e.g., brand identity, relationships). At the intersection of the three was innovation, defined as human experience and behavioral change.

Design-oriented innovation can originate anywhere—with an industrial designer, artist, creative employee, competitor, or user or customer or, most often, from some combination. Design is an iterative process that involves producers, users, and customers. It tools are market research, ethnographic research, user interface development, and rapid prototyping, all tools that Brooks Stevens in Wisconsin has used for almost 80 years according to its President, George Konstantakis.

Lou Lenzi from GE Appliance spoke about the importance of design, consumer behavior, and listening to the customer and described how General Electric's Innovation Center at Appliance Park operates. George Konstantakis explained how design thinking can achieve competitiveness. Hanne Shapiro from the Danish Technological Institute explained why creativity is necessary for solving ill-defined problems that can be viewed from many perspectives and are open to multiple interpretations.

E. Sustainability

Concerns about global warming and energy efficiency present an opportunity to build green products that reach markets. Respondents to a survey defined sustainability as part of a desired triple bottom line approach (economic, social, and environmental), but most also reported investing primarily in environmental initiatives in part to gain competitive advantage but also to build community relations.[22] A McKinsey report of CEOs found that more than 60 percent were taking steps to reduce energy and waste and more than half were managing their corporate reputation for sustainability. Only 28 percent, however, were "leveraging sustainability of existing products to reach new customers or markets."

Adam Friedman from the Pratt Institute for Community Development described the value of conservation and ways that green design has influenced the industrial resurgence in New York. He described how green manufacturing as a business strategy is providing a market advantage and contributed to the success of industrial development at the Brooklyn Navy Yards. Green manufacturing is similar to lean manufacturing but permeated by thinking about sustainability.

One effect of conservation efforts is that companies are paying more attention to the energy consumption and costs associated with offshore production, which already keep the assembly of many large and heavy products in the U.S. The European Union is concerned, however, about the slow pace of the diffusion of green skills and awareness into the labor force, which could slow the transition to a lower-carbon economy.[23] Thus, green skills are a priority in matching new skills to new jobs, an emerging priority in the U.S.

IV. The Workforce Imperative

The linchpin of almost any manufacturing operation is its work force. Competitive strategy ultimately depends on the knowledge, skills, and innovativeness of its employees, as acknowledged in a recent report of the President's Council of Economic Advisors. "In the long term, the strength of our innovation system depends on the skills of our workforce. Manufacturers increasingly need employees who bring substantial technological abilities."[24]

Surveys of manufacturers nearly always confirm the value they place on human capital. Companies surveyed to learn what would help improve their businesses the most over the next five years ranked a highly skilled and flexible workforce at the top of the list, ahead of product innovation, increasing market share, and low-cost producer status.[25]

Our colleagues across the Atlantic also find that innovation depends on the workforce and its creativity. As Hanne Shapiro from the Danish Technological Institute explained, innovative workers don't just do, they question, observe, network, experiment, and tinker. Two thirds of manufacturers surveyed about design and creativity by Regional Technology Strategies responded that they sought creative workers.

The primary sources of the technical and mid-skilled workforce and future entrepreneurs, and increasingly also the pathway lead to a more qualified high skilled workforce, have been, and still are community colleges. That puts educational institutions squarely in the middle of the recovery of America's manufacturing sectors, with community colleges, in particular, the leading sources of a qualified workforce.

For decades, education has been viewed as both the cause of, and solution to, American industrial competitiveness. *A Nation at Risk* took the public education system to task in 1983 for not just failing to meeting the needs of the nation's youth but "committing an act of unthinking, unilateral educational disarmament." "Our once unchallenged pre-eminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world."

Yet, despite continuing critiques, and regular reforms recommended by task forces and commissions, schools still do not meet the expectations of employers or parents. With secondary schools focusing more on raising levels of basic skills and employers asking for more advanced technical skills, community colleges have replaced vocational education as the primary source of the skilled work force.

The major challenges for manufacturers emerging from the symposium and the literature are a shortage of sufficiently skilled new workers, misalignment between programs and the workplace, their own diminishing, and sometimes disappearing, investments in skill development and upgrading, and a growing demand for more innovative employees and better problem solvers.

The set of workforce issues that relate most directly to manufacturing competitiveness can be sorted into three buckets:

- Ensuring a flow of qualified applicants
- Aligning the skills being taught with the skills needed today but also in the future
- Producing creative and entrepreneurial employees capable of becoming the innovators and sources of new business development

A. Generating a workforce for tomorrow's manufacturing

Perhaps the most pressing and prominent problem facing the resurgence of manufacturing at present is a shortage of skilled workers. There is little argument in the U.S., or in other advanced economies, that a gap exists between the skill needs of manufacturers and the skills possessed by the emerging and incumbent work force. But the size, nature, and cause of the workforce gaps are in some dispute.

More than half of U.S. companies reported difficulty in filling jobs in 2012, with almost half citing lack of hard or technical skills and 35 percent citing lack of work experience.[26] This gap exists despite there being 12.2 million people unemployed in the U.S. in December of 2012. The manufacturing skilled workforce is aging while youth are becoming less interested in pursuing careers in manufacturing. The most frequently cited and pressing shortages are for middle-skilled workers, those requiring more than a secondary but less than a baccalaureate degree.

The Boston Consulting Group, however, found in 2012 that "the skills gap in the U.S. manufacturing is more limited than many people believe and is unlikely to prevent a projected resurgence in U.S. manufacturing by the end of the decade…. only seven states—six of which are at the bottom quartile of U.S. state manufacturing output—show significant gaps."

Assuming that serious gaps exist, though uneven across places and sectors, what needs to be done to ensure a pipeline of qualified employees? How much of the responsibility come from the supply side and how much from the demand side?

Manufacturers overwhelmingly ask for a pipeline of better-prepared and, if possible, more experienced applicants from which to choose, and if not experienced, at least with certified skills. They would like to find applicants who can move right into a job and be fully productive with minimal, if any, training. It used to be relatively common to begin a career as a trainee with the expectation of a period of time to learn the job and company culture. Now firms expect hires to walk into a position very nearly, if not completely, job-ready. One study of U.S. employers found that nearly 80 percent of the workforce has had no recent instruction over the past five years.[27] Narrowing hiring specifications to distinctive skills for a particular position greatly reduces the pool of applicants and may explain a large share of the skill shortages cited by employers.

The pipeline also is limited by the fact that a much smaller number of young people are choosing to pursue careers in manufacturing; and more are not enrolling in the educational programs designed to prepare for manufacturing employment. Many students are completing high school deficient in the foundational skills needed to even enter a manufacturing program and need remedial or development education to become college and work ready. The National Association of Manufacturers' Manufacturing Skills Certification System requires the ACT National Career Readiness Certificate for a foundation level credential.

On the demand side, widely publicized declines in manufacturing employment are influencing students' choices of career paths. Twenty years ago manufacturing promised job security, opportunities for advancement, and good wages. Therefore it was a popular career choice for motivated young people. But the double whammy of declining manufacturing employment (only nine percent of Americans worked in manufacturing in 2011) coupled with declining manufacturing wages, e.g., from $28 per hour to $15 per hour in Midwestern auto factories,[28] has led many of those students to choose other career paths that they believe offer more promising futures.

Students' choices also are influenced by the pressures and resources applied to raising states' rates of college degree completions. More than half of education leaders believe a majority of Americans should have a bachelor's degree,[29] These goals may not be compatible with the immediate needs of industry, leaving too few people available for the middle-skilled jobs that are most in demand by manufacturers[30] and too many for jobs that actually require a baccalaureate.

From 1992 to 2008, 60 percent of the college graduates were employed in jobs requiring less (sometimes far less) than a 4-year degree.[31] A recent report out of the Harvard School of Education warned that "a narrowly defined 'college for all' goal—one that does not include a much stronger focus on career-oriented programs that lead to occupational credentials—seems doomed to fail."

The most pressing demands from manufacturers indeed do appear to be for a mid-skilled labor force, one that needs a different kind of education that includes more workplace learning and certifications but not necessarily college credentials. This workforce once came through vocational education, followed by community colleges as skill requirements grew.

Vocational education, once a valued course of study for hands-on and experiential learners and still highly valued in many European countries, once drew young people who liked to make things into manufacturing. In the U.S., however, vocational education has become so disparaged that even the name has been replaced by career and technical education. Since the 1990s, secondary school career and technical education has become more academic and oriented towards teaching STEM skills, and the manual arts that once represented pre-vocational education is mainly special education for those with learning disabilities. According to the OECD, in 2011 the United States ranked last among 29 countries in enrollment in vocational and technical education as a share of all secondary education.

B. Aligning and certifying skills

One of the most common criticisms of new employees heard from manufacturers is that their skills are not closely enough aligned with and relevant to the immediate workplace needs. Alignment can be viewed in terms of the workplace tasks and company culture. Moreover, public sector institutions must balance the needs of the local economy with the desire to develop and award credentials that are portable and transparent across regions and states.

Workforce education policy has been the subject of debates for decades about whether employers want skills tailored to a specific workplace or more flexible, "soft" employability skills including adaptability. Actually, the debate over how narrow vocational education should be began a century ago, when America's most renowned educator, John Dewey, wrote that "nothing could be more absurd than to try to educate individuals with an eye to only one line of activity."[32]

The answer is generally that they want both, the specific skills to step right into a position and be productive as well as the employability skills needed to solve problems, work as a team, and be flexible and adaptable, among others. When asked to choose, however, adaptability is rated more highly than experience and technical skills. Business leaders realize that both the workplace and the workforce are changing so quickly that adaptability and ability to learn now trump specific technical skills. They seek employees with the ability to quickly communicate and respond to problems and adapt to change. But for the most part, they are dissatisfied with what they get, and they have been for decades.

Businesses in regional roundtables organized by an affiliate of the U.S. Chamber of Commerce last year expressed dissatisfaction with both job specific and soft skills. Participating employers concluded that the "country's education and workforce systems are broken…and not producing the skilled workers that employers need."[33] Causes cited included the mismatch in types of workers wanted by employers and the types seeking work, business needs that are not understood by educators; a poor feeder system, from primary through higher education; lack of awareness of career opportunities; desire for further education after high school, although in another employer survey 63 percent replied that a four-year degree was necessary to be successful in the workplace;[34] poor skill assessments; and cultural and societal attitudes leading to lack of work ethic.

The National Association of Manufacturers (NAM) repeatedly reports on the supply of qualified workers. In 1998 in a NAM survey nearly two-thirds of manufacturers reported serious workforce skill deficiencies in basic skills, and three in five in basic math skills.[35] In 2001 among companies surveyed by NAM, 80 percent reported serious or moderate shortages of

qualified applicants, with 26 percent due to insufficient technical skills and 34 percent due to inadequate work experience. In 2009, the Manufacturing Institute reported that while educational levels of the manufacturing workforce are rising, there remains a "disturbing gap in the math and science skills of U.S. students relative to those of key competitors."[36]

Ross Meyer, CEO of Partners for a Competitive Workforce (PCW), reported at the symposium on the issue facing manufacturing in the Northern Kentucky Industrial Park where 53/22 percent of employers report "major/moderate" skill deficiencies in basic employability; 31/47 percent as "major/moderate" in technical skills; 31/42 percent in problem-solving skills; 31/17 percent in math skills; and 28/31 percent in reading skills.

In contrast to the generic blame placed on education and training, employers that know, work with, and talk to community colleges have quite different opinions. Ross Meyer at PCW has formed an Advanced Manufacturing Partnership with industry, education, and non-profits to ensure the alignment. Every member college of the Trans-Atlantic Technology and Training Alliance has some form of formal alliance with business and industry and integrates their advice into their plans.

Despite the rapid expansion of postsecondary technical education and the decline of employment, manufacturers remain less than satisfied with the quantity or the quality of the workforce. A CEO of a successful firm complained that "schools don't produce skilled trade [workers] like they used to."[37] At the same time, very few American employers have been willing to take on European style dual education or workplace learning programs that combine classroom with paid on-the-job education.

Achieving optimum, or at least better, alignment nearly always implies greater public-private cooperation in developing curricula, something common via the social partners (i.e., industry, labor, and government) in most European countries.

C. Releasing creativity and innovation

As early as 1983, the Southern Growth Policies Board published a newsletter for policymakers in the South stating that "The key to the survival of manufacturing industries in the South is the ability to innovate, and most of the responsibility for innovation rests on the technical skills of the labor force… to respond quickly and independently to the inevitable problems that occur whenever programmed technologies replace craft and experience…."

In today's global economy, creativity and innovation are more important than ever to advanced economies because they are what distinguish their workers from others who have perfected the technical skills and achieved our core standards in lower wage countries. It's the added value that gives the American and European worker competitive advantage. Risto Raivio, representing the European Union Directorate of Culture and Education, explained that innovation cannot be

disconnected from production.

John Winzeler encourages creativity in his company by using the arts to display and brand products and processes. Winzeler Gears entered into a partnership with the School of the Art Institute of Chicago to stimulate creativity in his work force and demonstrate the creative potential of gears by inviting students to produce unusual fashion apparel and accessories from gears. "We filled the building with art and creative ideas because we believe that in doing that, we are a much more creative company."

V. Responding to the Challenges of Tomorrow's Manufacturing

Community colleges have always been the most flexible of America's educational institutions, able to adapt their programs and even expand their missions to serve their communities and economies. But that flexibility was in part due to their position in the education spectrum, for decades squeezed between the historically prominent and federally funded vocational education programs in the secondary schools and more prestigious higher education institutions. As the levels of skills required to understand and use advanced technologies rose, especially in manufacturing, so did the stature of community colleges, propelling them into an indispensible role in the new economy.

Community colleges were among the nation's first institutions to recognize and respond to the needs of advanced manufacturing. By the mid 1980s, a number of leading community colleges had established advanced technology centers to enable small and mid-sized manufacturing enterprises (SMEs) to observe and learn about the latest computer-aided production technologies and, at the same time, upgrade the skills of the workforce for the new technologies. The Trans-Atlantic Technology & Training Alliance and the National Coalition of Advanced Manufacturing are examples of coalitions of colleges that represent the leading edge of education and training for manufacturing.

This begs the question of whether the community colleges have been able to continue to innovate and stay on the cutting edge of industry skill needs as demand for overall manufacturing employment diminishes but with skill shortages remaining, increasing demand for higher levels of education increases, budgets shrink, and forms of competitive advantage change.

How are community colleges adapting to and coping with these challenges? Since there is no national system of community colleges, most of what has been implemented has been left to individual state systems or to institutions. Innovation is ultimately a result largely of local leadership and is shaped by local circumstances.

Some very good and innovative ideas have been suggested and adopted in some places, and there is no doubt that access to and quality of pre-baccalaureate postsecondary education have improved immensely. Some proposals that have been recommended repeatedly over the years, such as greater emphasis on workplace learning, have never reached any significant scale. Other recommendations, heard repeated for many years, include better alignment between education and workplace needs; changing people's perceptions of manufacturing and the required levels of education as well as the potential wages; and the need for increasingly higher levels of skills.

Perhaps the most successful innovations are driven by exposure to new ideas and the willingness to be innovative. The overarching objective of the symposium in Covington, Kentucky in October 2012 was to provide such exposure, to encourage re-assessing the future of manufacturing, learn how others are adapting and changing, and to improve the ability of the

work force to think and act creatively.

This section focuses on changes in the new manufacturing economy and how that affects what have been best practices. The suggestions are drawn from the speakers, discussions during and following the symposium, literature, members of the Trans-Atlantic Technology & Training Alliance, and research.

A. Improve alignment between education and work

Employers often are asked what they need and want. But in most cases they are not engaged in the process of setting standards and designing programs. Meaningful partnerships, as described by some of the speakers, should give employers more responsibility for preparing the workforce.

The general dissatisfaction with education expressed by employers may in part be a result of their unfamiliarity with the curriculum development process. It does almost always includes some employers. Every member college of the Trans-Atlantic Technology and Training Alliance is or has been in some form of formal alliances with business and industry and integrates their advice into curricula, standards, and plans. Part of the dissatisfaction expressed in surveys may be from the large majority of companies that are not engaged and possibly unaware of the programs of community colleges. One recent survey of businesses about skills gaps found only 13 percent engaged with postsecondary institutions or programs for employees and only 11 percent participated in industry consortia of employers and postsecondary institutions.[38]

Even more likely, those companies that are involved may not reflect the needs and interests of all manufacturing sectors and all sizes of enterprises. To better meet the needs of industry, community colleges may need to draw not on selected individual companies but on different types of manufacturers or cluster associations.

1. Create meaningful partnerships.

Successful alignment will depend heavily on the ability to develop effective employer engagement strategies beyond the traditional advisory groups that typically meet once or twice a year on a restricted agenda. The *Automotive Manufacturing Technical Education Collaborative* (AMTEC), for example, demonstrates that developing industry relevant skills standards, assessments, and credentials can be taken to a scale that significantly impacts a major industry. AMTEC, called the "big collaboration" in a National Governor's Association Center for Best Practices publication, involves 30 community colleges and 34 auto-related plants in 12 states.

Ross Meyer of "Partners for a Competitive Workforce (PCW)," has established successful collaboration through the Advanced Manufacturing Partnership. It currently has more than 150 members representing industry, labor, education and training, chambers of commerce, and non-

profits. The PCW works with educational institutions to make sure programs match industry needs, offer boot camps to upgrade skills of incumbent workers, develop career pathways for entry level workers to advance, and generally enhance the understanding of current and future industry needs.

In Chicago, a coalition of manufacturers, unions, and community-based organizations connected to the Chicago Manufacturing Renaissance Council took matters into their own hands and established Austin Polytechnic Academy. Called an "innovative anachronism, it became a vocational school when work-place learning had gone out of vogue, an advanced metalworking academy at a moment when the manufacturing industry seems in a state of advanced, ever-accelerating decay."[39] The Academy has expanded into the Austin Manufacturing Training Center, Austin Polytech Career Center, and Austin Innovation Park. In December 2012, Chicago Mayor Rahm Emanuel announced an investment of $1.25 million in advanced manufacturing education led by the Renaissance Council.

Ideas for community colleges

- Partner with MEP to get company buy-in and develop inclusive sector-specific partnerships
- Identify leading companies, with advice from MEP, and ask them to project future needs for aligning programs
- Distinguish special workplace needs of very small companies

2. Improve relevance and alignment

Cluster connections, and in some places sector strategies, are methods for building partnerships that build on the associational infrastructure formed around a cluster strategy.[2] It's a natural relationship since most cluster organizations begin by addressing its members' common workforce needs. Risto Raivio, representing the European Commission, described the Commission's interest in achieving "smart specialization," which translates sector-based information into education and training needs. Both European sector- and cluster-based initiatives and the National Governors Association have documented the value of employer-education partnerships in workforce development.

Many of the early advanced technologies centers at community colleges, for example, were a result of cooperation between educators and business leaders representing a particular cluster; for example, the advanced furniture production at Itawamba Community College in northeastern Mississippi, the Hosiery Technology Center at Catawba Valley Community College in North Carolina' and the defense electronics industry cluster at Okaloosa-Walton Community College in

[2] Sector strategies target businesses in specific or similar sectors, while cluster strategies address the needs of similar and interdependent sectors and enterprises plus the specialized organizations that support them. Cluster organizations include a wider range of members than do sector associations

Ft. Walton Beach, Florida.

Vice President Rebecca Nickoli of Indiana's Ivy Tech has forged relationships with an orthopedics cluster and a power technology cluster. The former includes an orthopedic certificate program that includes hands-on learning about federal regulations, ISO, and lean manufacturing in the context of the industry.

At Northeast Wisconsin Technical College, President Jeff Rafn formed an alliance with The North Coast Marine Manufacturing Alliance, a Lake Michigan marine cluster with seven major shipbuilders anchored by Marinette Marine Corporation. Working together, the college embedded a training project manager at the company, developed two new degree programs, one in marine engineering and one in Marine Construction, and invested in a training center to support marine occupations that was walking distance from the client companies. According to Dr. Rafn, the keys to success included forming partnerships, not contracts; demonstrating flexibility; and creating multiple lines of communication.

Ideas for community colleges

- Become part of existing cluster association or council
- Work with industry sector organizations to identify competencies/ skill needs through structured, evidence based models such as job task analyses and work with local MEP centers to ensure addressing the needs of SMEs
- Employ staff who are from, or intimately familiar with, regionally concentrated industries
- With business input, contextualize curricula to match the culture and language of the cluster but use core standards

3. Certify skills

Despite the failure to develop a National Skills Standards Board (NSSB), the effort provided the impetus for various organizations to develop and certify skill standards that apply to manufacturing.

- The leading source is the National Association of Manufacturers-endorsed Manufacturing Skills Certification System of portable, industry-recognized credentials.
- The Manufacturing Skill Standards Council, an industry-led training, assessment, and certification system, focuses on the core skills and knowledge needed by production and material handling workers. That Council grew out of the National Coalition for Advanced Manufacturing, which formed in parallel with the MEP, and National Skills Standards Board.
- The National Institute for Metalworking Skills similarly was formed by the sector's trade association. Its industry-led, training, assessment, and certification system focuses on the core skills and knowledge needed by the nation's front-line production and material handling workers, which are accredited by the American National Standards Institute.

There also are a number of specialized agencies that certify skills acquired. Florida, for example, has identified 96 certifications related to manufacturing. Further, a growing number of institutions are focusing on competency measures rather than the outdated concept of the credit hour as a measure of learning. Competency-based education, supported by the U.S. Department of Education, would ensure that the right skills are identified and serve as the basis for an outcome-based performance system that aligns with employers' expectations for higher education.

Ideas for community colleges

- Develop certifications based on competencies based on prior knowledge and non-credit education as well as credit courses
- Coordinate efforts with the many U.S. and European efforts to develop transparent and transferrable certifications
- Award credit for prior experience
- Provide recertification training as technologies change

4. Integrate classroom and workplace learning

There are indications that workplace learning is about to be taken up once again as policy in the U.S., after decades of dancing around the edges with short-term internships and selective non-school based Department of Labor programs. Part of the impetus is coming from a manufacturing sector seeking applicants with a greater appreciation of the workplace, and part from the growing number of European companies in the U.S. that have experienced the benefits of a "dual system." In fact, a standard definition of skills is "proficiency, facility, or dexterity that is acquired or developed through training or experience."

A continuing shift from hands-on to theoretical learning has reduced the experiential learning that once took place in vocational education and is still prevalent in the European vocational education and training, particularly in dual systems. The President of Hahn Automation reinforced the need stating there is "more know how in Europe than in the U.S." But, he continued, in his company that gap is narrowing. Effective online learning blends theory that can be learned at a distance with lessons that require interactive learning but also demands substantial hands-on learning.

Prof. Nichola Lowe from the University of North Carolina argued that the cause of skills mismatch is a skills re-interpretation. The sources of specific worker competences are context dependent and learned on the job—a case for greater investment in on-the-job learning opportunities. Hanne Shapiro's research findings that "qualification levels are a poor proxy for actual skills" confirms the value of workplace learning.

Yet workplace learning in the U.S., despite strong expression of interest from business and industry, has never had the stature it has had and still has in western European countries or the

necessary support from government, business, and labor as the "dual" system. There is a reluctance to test the system despite many delegations of U.S. educators and policy makers traveling to Europe to observe and learn about the apprenticeship programs, and returning to recommend an American version. A true workplace learning system, however, requires deep employer involvement and educational institution commitment, which have proven difficult to execute in the past in an American industrial culture that has lacked an apprenticeship tradition for almost a century. In contrast, in the European Union 3.7 million students are in company-based apprenticeship programs and 5.7 million more in school-based simulated apprenticeship programs.[40]

In the U.S., there are only about 18,000 apprentices, even though about 12 million people are employed in manufacturing.[41] Many of these are in European-owned companies where the necessary culture does exist. Hahn Automation, which is a German company with a history of the dual system, supports workplace learning according to its Kentucky-based President John Baines. Siemens also employs apprentices.

For an apprenticeship, or "dual," system to work in today's economy, it will have to include pathways to higher education so that no one is excluded from going on to higher levels of education. And it will require employers willing to provide and pay for the experience, and serve as mentors and evaluators. And it would need recognition as a high-skill, high-status career path.

South Carolina, which has the highest concentration of European companies in the U.S., is making progress. Greg Rutherford at York Technical College in South Carolina described how his college addresses labor market shortage with an innovative approach to workplace learning. The college's employer-sponsored Tech Scholars program matches half-time paid work with classroom-based education and results in a degree and possible job. Tri-County Technical College in South Carolina places interns at businesses that have benefited from the European apprenticeships, like Michelin, BMW, and Schneider Electric. The BMW Scholars Program allows, and provides tuition assistance to, students to attend class full-time at one of three community colleges while working part-time to further their education requirements, gain hands on experience, and become candidates for full-time positions at BMW.

Ideas for community colleges

- Explore collaborative work-based education environments and apprenticeships with business networks, where students rotate among small companies, a model used successfully by members of the National Tooling and Machining Association
- Work with employers to create credit-bearing apprenticeship positions that lead to academic credentials and offer training and support to optimize learning opportunities
- Examine European dual system programs and assess possible modifications that align with U.S. education

B. Keep the pipeline filled

This represents perhaps the greatest challenge—maintaining interest in manufacturing among talented young people in the face of technological advances and rising educational aspirations. It will require realignments in how manufacturing education is presented and delivered and in employers' expectations.

1. Take advantage of small-scale 3D and CNC technologies

The new maker (desktop 3D and CNC) technologies offer secondary schools and community colleges an opportunity to rekindle the interests of young people in both designing and making things and, by inference, in design and manufacturing by giving them access to and training in using the very latest small-scale technologies.

Ever since the industrial arts were squeezed out of career and technical (a.k.a. vocational) education to make room for more knowledge-based information technologies, interest among students in making things has waned except as an art form. Deploying small-scale maker technologies into classrooms and common spaces, much as computers are available for information-based work, offers a low cost means for allowing the young and old to experience manufacturing on a small scale and possibly change their perceptions about employment and entrepreneurship.

Ideas for community colleges

- Revive middle school shop course as "maker" programs using the advanced technologies to develop interest in manufacturing early
- Develop college based tech shops equipped with CNC and 3D equipment for students and others to use technologies to develop new products and start new businesses
-

2. Showcase manufacturing

Even though manufacturing has been adopting advanced, computer-based technologies since the 1980s, it has been beset by a pre-technology image of low-skill and repetitive work that discouraged its choice as a career path. In 1992, RTS awarded a subcontract from the Alfred P. Sloan Foundation to the two-year branch of Oklahoma State University at Okmulgee to design and establish a Summer Institute for middle school students and their teachers to expose them to manufacturing in a modern, technology-intense, environment. Many of the participating students tracked did in fact choose careers in manufacturing.

Bellingham Technical College in Washington and Sheridan College in Wyoming are examples of colleges that, to make welding more attractive, have held "welding rodeos." These are challenges to welding and metal fabrication students to produce a piece of art within eight hours from scrap metal they are given. The events are typically linked to larger food and crafts fairs

and end with an auction of the students' art.

Ideas for community colleges and public schools

- Conduct maker and technology fairs and competitions that are open to the college and secondary schools to demonstrate the creative aspects of making things
- Promote the entrepreneurial and creative potential of the programs
- Establish a permanent design exhibit at the college of the most creative work of students and firms in the region
- Develop "magnet" programs in U.S. high schools (e.g., Jefferson Public Schools in Louisville) and summer "boot camps" that expose students and teachers to modern, advanced manufacturing and career possibilities and develop early interest in manufacturing

3. Expand and certify on-line education

Although learning on-line appears to run counter to hands-on and experiential learning, if used properly it can both generate interest and complement and supplement skill development, particularly among K-12 students. On-line learning, whether the more conventional distance learning classes or rapidly growing MOOCs that can reach thousands with content, can be used to expose young people to manufacturing, teach some of the basics about and soft skills for the manufacturing workplace, and be used to engage students and draw them into a more comprehensive program. Midlands Technical College in South Carolina, for example, offers online courses in manufacturing applications, manufacturing fundamentals, and distribution and logistics management.

Ideas for community colleges

- Provide introductory on-line dual credit courses to expose high school students and entering community college students to advanced manufacturing operations and the industry and the career options available
- Use on-line courses to introduce and teach the latest production operations and management techniques
- Develop blended e-learning models with the latest virtual tools and assessments as well as hands-on techniques to provide technical skills

4. Recruit diverse talent

Many segments of immigrant and minority populations come to the U.S. with skills and experience in making things. Because many are weak in language or STEM skills, they have been shunted into low-skill occupations. But with the right support and additional education, many in this population could fill employment gaps facing manufacturers. Nichola Lowe's research has discovered high levels of informal learning, innovation, and skill levels among immigrant construction workers. The immigrant population, whose entrepreneurial and technical

skills are widely recognized, could boost the manufacturing workforce and bring new sources of innovation.

Ideas for community colleges

- Recruit students with trade and industry experience from among immigrant populations
- Provide contextualized English as a Second Language (ESL) and, where necessary, family services to support immigrants' education

C. Innovate!

In 1983, when the South's manufacturing growth had seemingly slowed and even halted in some rural areas, the Southern Growth Policies Board stated that "The key to the survival of manufacturing industries in the South is the ability to innovate…." Further, the Board continued, "most of the responsibility for innovation rests on the technical skills of the labor force…to respond quickly and independently to the inevitable problems that occur whenever programmed technologies replace craft and experience…."[42]

Even though the value of innovation has been recognized for decades, it still is not an easily defined, achieved, or measured talent. It often results from combining right-brain thinking not typically associated with technical education with the more analytical left-brain thinking. Educating innovative employees suggests broader technical education curricula that include art or design and projects that draw on a wide range of disciplines and talents to solve problems. Innovation, so often associated only with technology and research-driven ideas is in fact more often associated with design and comes from users or efforts to create demand. As Gregg Bennet from the Alabama Technology Network believes, "the future of manufacturing will be based on innovation and most successful companies in the future will have an innovation management system along with their lean manufacturing, safety, and six sigma quality control.

1. Integrate design and creativity in technical education

This may offer the biggest window of opportunity for community colleges and require the most creative solutions. Neither design nor creativity have been priorities in past efforts to reform or improve education, nor have they been high priorities among employers. Yet they may be the single most distinguishing difference between the past and the future of manufacturing. As Chris Anderson told the audience of North Carolina's annual Emerging Issue Forum, this year on manufacturing, "we are all designers now so we may as well get good at it."

Lou Lenzi described how he used the concept of the "big room" at GE, an open environment where front line workers meet with designers, manufacturing engineers, and marketing and sales staff to listen to each other, hear from customers, analyze consumer behavior, and tackle problems colletively. They have equipment at their disposal to design and develop prototypes, including 3D printers and CAD, and sufficient room for full-scale mockups to try out new

products and processes. Line workers are expected to be as creative as the designers.

This requires not only a different manufacturing model but a different approach to technical education, one that challenges the right side of the brain with design and design thinking. The University of Alabama-Birmingham has the state's only program that trains artists-engineers. Its Leonardo Art and Engineering Certificate program puts art students into a technical, science-based environment and engineering students into an aesthetic, creative environment with 3D modeling and simulation technologies.

Hanne Shapiro talked about the need to rethink the delivery of technical education to produce creative as well as technically competent completers, technicians capable of "design thinking" so they see the "architecture of problems" and new opportunities for innovation.[43]

Ideas for community colleges

- Offer degree or certificate programs in industrial design
- Include introduction to forms of industrial design in technical education programs so that students have an appreciation of design as an innovation
- Include product designers on technical education advisory boards
- Hold annual contests for best student product or process designs

2. Promote and promulgate entrepreneurship

Rapid advances in micro-manufacturing, as generated and described by Ted Hall, founder and President of ShopBot in North Carolina, are generating a new generation of maker entrepreneurs, makers who can take an idea, produce it, and sell it without having to build a large company. A whole new set of shared spaces and services are forming to support startup micro-manufacturers, or "Makers," in the form of Tech Shops or, as they have been called in Europe, Fablabs.

ShopBot's efforts to develop 100kGarages.com is aimed at helping "America reinvent its economy, one maker, and by implication, one entrepreneur at a time." Although this strategy may not appear to have the scale to create a manufacturing renaissance, taken collectively it does. The strategy has implications for integrating the requisite design, marketing, and business skills and knowledge into technical education or offering them as electives.

Jose Luis Maure from the Basque Country of Spain reinforced the importance of a form of entrepreneurship. In his region where effective entrepreneurship no longer depends on growth, businesses can remain small and be successful. (In the Italian region of Emilia-Romagna, frequently cited as a model for the America's early efforts to promote modernization, the average size of the region's 40,000 manufacturers was less than five people.) His agency supports entrepreneurs in school from teaching the skills, through business development, and follow-up consulting and networking.

Marjut Salminen from Tampere College in Finland described the college's program for the fashion industry, which integrates design with business and entrepreneurial skills. Once a center for the textile industry, companies now outsource to Asia. The college has shifted its programs to both employment along the value chains in design, marketing, and buying and to entrepreneurial opportunities associated with designing and producing fashions for niche markets that can compete on the basis of design, brand, and authenticity.

Ideas for community colleges

- Include small-scale entrepreneurial companies on employer advisory boards to understand the particular skill needs in microenterprises
- Develop college-based "Tech Shops," i.e., advanced technology facilities, equipped with CNC and 3D equipment for students and others to use to develop new products and start new businesses
- Embed entrepreneurial education in technical education so that all students have an appreciation of the potential for forming their own businesses

3. Establish innovation and entrepreneurial spaces

Just as the advanced technology centers formed by community colleges in the 1980s and 1990s diffused technology to small and mid-sized enterprises (SMEs), innovation and entrepreneurship centers would adopt the multi-disciplinary innovation center used by GE at Louisville. These centers would provide a place for SMEs, designers, artists, and business people to interact with students, and to network, generate, and test new ideas.

In contrast to the proposed approaches that use incentives or vouchers or connections to research centers, these hubs would be aimed at building and enhancing innovative capacities. They could be user- or consumer-driven innovation counterparts to the National Science and Technology Council's National Network for Manufacturing Innovation, which targets science and technology and involves scientists and engineers but not designers and consumers.

The key to the success of the centers will be their ability to stimulate new solutions and products and become active networking sites, such as the culture of innovation MiKE (http://innovationinmilwaukee.com) has created for companies in the Milwaukee area. Dan St. Louis at the Manufacturing Solution Center at Catawba Valley Community College provides implicit innovation and networking space and support for the hosiery businesses in North Carolina's Catawba Valley.

Innovation is accelerated in a space that exposes participants to formal and informal learning, and new and different ideas and methods that may in turn trigger a different approach to a process, solution to a problem, or new product, market, or business. They can include advanced 3D printing and prototyping equipment and CNC equipment and workspaces to experiment with new ideas. College students would participate in the networking that occurs in a

multidisciplinary innovation environment, contribute to it, and learn from it.

Ideas for community colleges

- Establish innovation spaces and host networking events
- Create innovation networking forums for students and graduates
- Match students to participants embarking on innovative enterprises or products and offer internships or reward class projects

4. Emphasize sustainability

Increasingly, consumers want green products, look at how products are made, and will pay a premium for sustainable processes. Meeting the rigor of new green standards not only involves corporate management but requires new skills and attitudes throughout the workforce. Further, it gives manufacturing a green image that appeals to many young people concerned about the environment.

Jeaninne La Prad, CEO of the Corporation for a Skilled Workforce, discussed manufacturing innovations in energy and the environment and described Indiana's support for the Frontline Green Worker certificate funded by the U.S. Department of Labor's State Energy Sector Partnership. The new certificate, which draws on Purdue's Green Enterprise Development curriculum, is used by community colleges, the MEP, unions, and other organizations in 16 states. New knowledge and skills include water conservation, air pollution reduction, solid waste management, toxic waste minimization, and energy management.

Hans Lehman, Vice Principal at EUC-Syd in southern Denmark, described his school's comprehensive approach to sustainability and its connection to the region's plans to be carbon neutral by 2029. EUC-Syd works closely with industry to make sure that every graduate has the skills and knowledge to work in sustainable and energy efficient environments and to fill the labor market need for producing alternative energy and energy efficient products and buildings. Adam Friedman from the Pratt Institute described the value of conservation and how green design has influenced the industrial resurgence in New York.

Ideas for community colleges

- Integrate sustainability as a skill and value into all technical programs
- Market green image of manufacturing to appeal to students concerned about sustainability
- Develop or adopt green/sustainability certification processes in collaboration with the U.S. Department of Energy, energy business associations, and non-profits to ensure industry and consumer recognized programs and credentials
- Emphasize manufacturing applications in sustainability programs in other fields

VI. Putting it all Together

Community colleges, once again, are a key factor in the future of manufacturing in America. As in the past, the breadth of their capacities is underestimated by focusing solely on their education and training capabilities. While this is undeniably their core competency and primary mission, community colleges also are repositories of knowledge, deployers of technology, extension agents for the very small and mid-sized businesses, forums for associational behavior among firms, and pathways of opportunity for underserved populations.

While the better-known and -endowed research universities develop and commercialize new technologies, community colleges concern themselves with effectively using the best technologies already available, and working with and supplementing the work of Manufacturing Extension Partnership.

The main challenge facing community colleges will be to adapt their programs, services, and missions to a new type of manufacturing enterprise, which on the one hand will require much higher levels of skills and knowledge and will offer more and affordable entrepreneurial opportunities, and on the other hand will value creativity and innovation within the workforce as much as the conventional "good work habits."

The colleges' programs and credentials should involve employers in every phase of development and implementation, from setting standards, to developing detailed lists of competencies, and formative and summative assessments and credentials all fitting in with quality career pathways that are transparent and portable for students across sectors. Programs should fully integrate existing industry-recognized certifications and licensures into their programs to ensure alignment, e.g., the credentialing system established by NAM and the Manufacturing Institute.

While universities continue to be the sparkplugs for advanced manufacturing, providing the cutting edge research and supporting the scientific and engineering talent, the successful community colleges will be the engines that diffuse and ensure the skills to use the technologies, that move innovation deep into the firms, from back office services to technicians, from technology to product design and appearance; and that create a new generation of entrepreneurial makers. The community colleges are also the entry points to economic opportunity for previously disenfranchised populations.

Appendix A: Speakers and Moderators

John Baines, President, Hahn Automation, KY
Gregg Bennett, Director, Bevill Manufacturing Technology Center, Gadsden, AL
Adam Friedman, Director, Pratt Center for Community Development, NY
Michael Gould, Assistant Director, Dept. of Employment and Learning, No. Ireland
Ted Hall, President, ShopBot Tools, Durham, NC
Mitch Hamm, Director, Muscle Shoals, AL
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