MANUFACTURING Institute

Roadmap for Manufacturing Education

Recommendations for Action: Promoting Industry Certifications and Enhancing Two- and Four-Year Articulation

The Manufacturing Institute

December, 2012

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The Manufacturing Institute is the 501 (c)3, non-partisan affiliate of the National Association of Manufacturers. The Institute is the leading research, education, workforce, and services group supporting U.S. manufactures.

This report was made possible by Lumina Foundation. Lumina Foundation, an Indianapolis-based private foundation, is committed to enrolling and graduating more students from college—especially 21st century students: low-income students, students of color, first-generation students and adult learners. Lumina's goal is to increase the percentage of Americans who hold high-quality degrees and credentials to 60 percent by 2025. Lumina pursues this goal in three ways: by identifying and supporting effective practice, through public policy advocacy, and by using our communications and convening power to build public will for change. For more information, logon to http://www.luminafoundation.org.

The Business Case for Change

The 2011 Skills Gap Report conducted by The Manufacturing Institute and Deloitte Consulting LLP reveals serious concerns about the ability of manufacturers to fill critical positions that require post-secondary education, including Associate of Applied Science (AAS), Bachelor's degrees and beyond.[1] The survey, which polled a nationally representative sample of 1,123 manufacturing executives across fifty states, finds:

- Sixty-seven percent (67%) of respondents reported a moderate to severe shortage of available, qualified workers.
- Fifty-six percent (56%) anticipate the shortage to grow worse in the next three to five years.
- Sixty percent (60%) of respondents said that they were experiencing a moderate-to-severe shortage of skilled engineering technologists (industrial engineers, manufacturing engineers, planners, etc.) and fifty percent (50%) in scientists and product design engineers.
- Five percent (5%) of current jobs at respondent manufacturers are unfilled due to a lack of qualified candidates. This equates to approximately 600,000 jobs nationwide.

When asked in which operational areas the companies had experienced the most difficulty due to workforce shortages or employee skills deficiencies, manufacturers responded with the following critical skills. All are vital competencies that must be linked to content in quality post-secondary manufacturing technology and engineering programs:

- Maintaining quality levels consistent with customer requirements (35%)
- New product development and innovation (27%)
- Implementing new technology (24%)
- Implementing quality improvement processes (20%)

Talent-Driven Innovation

These results underscore the tenacity of a worsening talent shortage that threatens the future effectiveness of manufacturing in America. In fact, as shown in Figure 1, the 2010 Global Manufacturing Competitiveness Index Report heralds talent-driven innovation as the number one driver of global manufacturing competitiveness.

Skill shortages are impacting all stages of manufacturing —from skilled production to engineering. The challenge will only grow as the demographics of our workforce drive "boomer" retirements and replacement requirements. Numerous factors are at play, including the changing nature of work, growing demand for critical thinking and problem-solving skills, and the Science, Technology, Engineering and Math (STEM) crisis.

Changing Nature of Work

The Skills Gap Report also highlights the changing nature of work in manufacturing over the past five years. "Many manufacturers have redesigned and streamlined production lines while increasingly automating processes. While some remaining jobs will require less technically skilled jobs, ironically, these trends and innovations actually demand more skilled workers, such as maintenance engineers."[2]

As shown in Figure 2, high-skilled jobs in the manufacturing sector grew by 12% from 2003 through 2010 while mid-skilled jobs decreased by 3% and low-skilled jobs fell 9% over the same period. The nation's manufacturers need more high-skilled workers with critical thinking and innovation skills to maintain a competitive advantage in the global marketplace. These higher skills are increasingly associated with post-secondary education experience.

Critical Thinking: Beyond Technical Skills

When manufacturers were asked what they considered to be the most serious skill deficiencies in their current employees, inadequate problem-solving skills topped the list. Many manufacturers and other employers are learning that skills such as critical thinking and problem solving not only allow an individual to digest, analyze, and communicate information, but are also needed across a broad range of disciplines.[3] They also serve as a critical platform on which leadership and entrepreneurial skills can be developed.

The STEM Deficit

An increasingly significant component to the skills gap challenge is the growing deficit in Science, Technology, Engineering and Math (STEM) skills. In 2008, 92% of workers in STEM-related occupations had at least some postsecondary education beyond high school, with 44% of those individuals having a baccalaureate degree and 27% having a master's degree or higher.[4] These rates of educational attainment are projected to remain steady through 2018 as STEM occupations continue to grow and expand, revealing the importance of pathways that begin at the associate level and culminate with the baccalaureate degree or higher-level credentials.[5]

Yet, the United States lags behind other countries in quality workforce preparation for STEM career fields. Talent is lost throughout the various stages of the educational pipeline, and women and minorities remain significantly underrepresented in STEM majors and careers.[6]

Calls for increases in STEM education, with an emphasis on post-secondary institutions as key providers of such education, have accentuated the need for credentialing at all levels. This need also extends to pathways and programs of study that extend from certificates and associate degrees to and through baccalaureate degrees, in part as a strategy to facilitate the continued growth and career advancement of adult workers.

2010 Global Manufacturing Competitiveness Index Report

Table 1: Drivers of global manufacturing competitiveness

Rank	Drivers	Driver Score
		10=High 1=Low
1	Talent - driven innovation	9.22
2	Cost of labor and materials	7.67
3	Energy costs and policies	7.31
4	Economic, trade, financial and tax systems	7.26
5	Quality of physical infrastructure	7.15
6	Government investments in manufacturing and innovation	6.62
7	Legal and regulatory system	6.48
8	Supplier network	5.91
9	Local Business dynamics	4.01
10	Quality and availaility of healthcare	1.81

Source: Deloitte and US Council on Competitiveness - 2010 Global Manufacturing Competitiveness index
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Figure 1

Figure 2

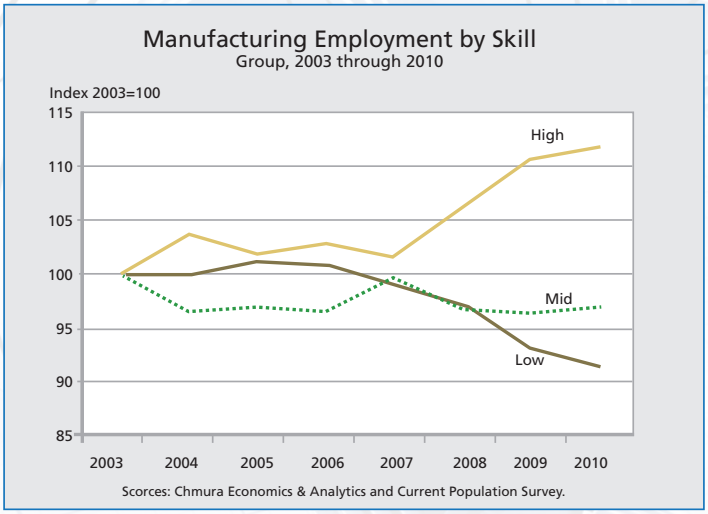
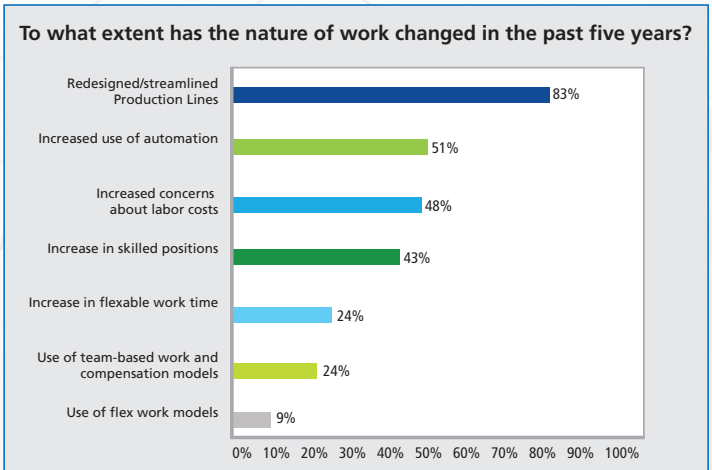
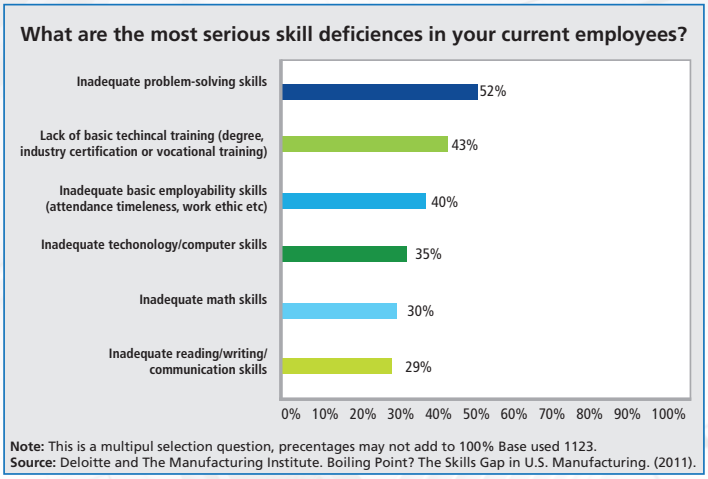


Figure 3



Note: This is a multipul selection question, precentages may not add to 100% Base used 1123.
Source: Deloitte and The Manufacturing Institute. Boiling Point? The Skills Gap in U.S. Manufacturing. (2011).

Figure 4



Note: This is a multipul selection question, precentages may not add to 100% Base used 1123.
Source: Deloitte and The Manufacturing Institute. Boiling Point? The Skills Gap in U.S. Manufacturing. (2011).

What Manufacturers Want:

A national renaissance in manufacturing education will incorporate:

- More technology-infused post-secondary education alternatives, meeting students and working learners "where they are" and "when they can learn";
- A heightened focus on Science, Technology, Engineering, and Math (STEM);
- Accelerated pathways to credentials and more "on and off" ramps to post-secondary education, to support lifelong learning and improve advancement opportunities;
- More Learn and Earn programs of study that translate prior experience and learning into credits toward degrees;
- More internships and mentorships to align higher education with industry competency and skill requirements; and
- **More competency-based post-secondary pathways with opportunities to earn interim industry-endorsed certifications with value in the workplace, in addition to traditional educational credentials such as certificates and degrees.**

Industry-endorsed certifications have value in the workplace. Industry certifications represent independent, third-party assessments based on standards that reflect the knowledge and skills required to do the work in a modern manufacturing workplace. For example, the American Society for Quality (ASQ) offers 16 different certifications including Quality Technician, Quality Inspector, and Quality Engineer. These do not substitute for, but rather complement, traditional education credentials.

Manufacturers advocate that educational institutions need to change their cultures and behavior so more students complete programs of study with real skills of value to industry, as assessed and represented by third-party, industry-based certifications. By design, this will involve more targeted communication with industry, curriculum development geared toward employer needs, and stronger linkages to economic development.

MANUFACTURING Institute

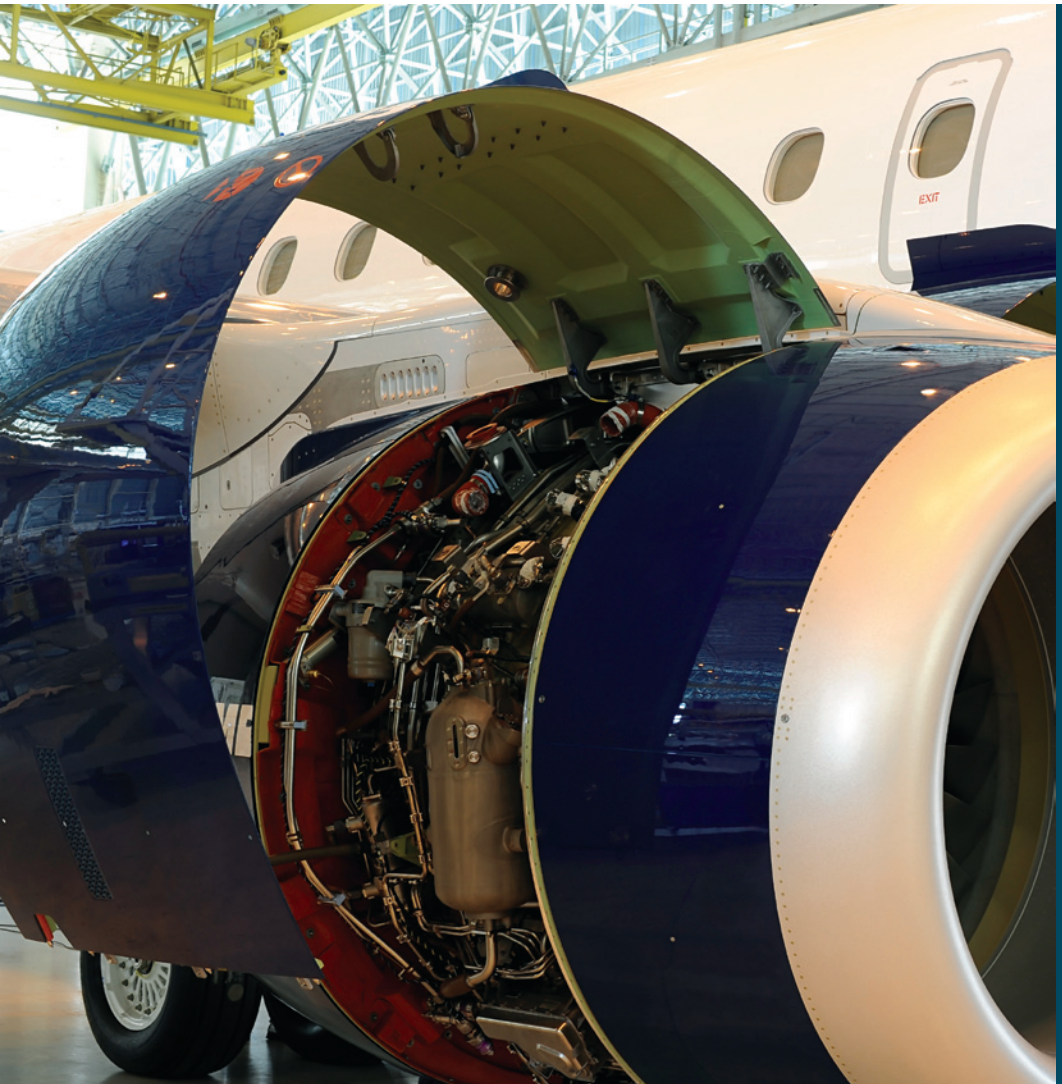
Call to Action

Employers need an available pool of skilled workers—from entry-level through engineers—to address their skill shortages. This business-driven agenda outlined in this paper is based on three fundamental assumptions:

- Embedding industry-based certifications in education pathways provides third-party validation of skills and minimizes hiring risk for employers;
- Aligning education and training to nationally portable, industry-driven certifications developed by employers increases placement and wage gains for students; and
- Embedding industry-based certifications in education pathways increases the acceptance of credits for articulation across programs and institutions, enhancing efficiencies of the educational delivery system and promoting student completion.

To field test these assumptions with a goal of seamless manufacturing career pathway development, the Institute and Purdue University convened a Manufacturing Articulation Roundtable with leaders from two- and four-year institutions. The purpose of the Roundtable was to explore the validity of these assumptions. Additionally, the intent was to identify challenges and opportunities related to articulation and transfer of credit between two-year and four-year schools in support of embedding industry certifications into programs of study as a "link" between education pathways and career pathways.

Following the Roundtable, The Manufacturing Institute engaged with other thought leaders similarly concerned with getting more students enrolled in, completing, and earning credit for industry-validated competencies mastered in manufacturing programs at the post-secondary level. That dialogue will escalate, as the urgency to provide college graduates jobs and to help manufacturers find skilled workers continues to build.



FOCUS OF THIS ROADMAP

This Roadmap is intended to launch a continued dialogue among manufacturers and post-secondary leaders about the urgency to move forward with new models and different approaches to manufacturing education. Articulation among institutions generally has been the focus of much research and many studies. The topic remains complex and multifaceted, with many entrenched interests. Taking a deep look at the issue with the lens of industry-endorsed skills certification is an opportunity for a fresh perspective. It may also illuminate areas for agreement that may provide pathways forward in the larger debate on articulation generally.

The Manufacturing Skills Certification System

In 2009, the Manufacturing Institute launched the cornerstone of manufacturers' answer to the skills gap challenge—the NAM-Endorsed Manufacturing Skills Certification System (SCS). The certification system provides industry's voice and expertise in leveraging change and helping schools provide competency-based, customized education and training calibrated against the skill standards of the industry.

The visual below illustrates the fundamental construct behind the Skills Certification System— "stackable" industry certifications that serve to link and validate content mastered in educational programs of study with real jobs. Generic educational pathways (left column) and occupational pathways (right column) in manufacturing are aligned through "stackable" industry-based certifications (middle column). While nationally portable, certifications are typically embedded in curricula based on regional employment needs.

The Skills Certification System is applied STEM. Embedding industry-based certifications in manufacturing-related programs of study will help ensure colleges and universities are graduating technicians and technologists with the skills manufacturers need.

Students completing programs of study earn not only an education certificate or degree, but also the relevant, transportable, industry-based certifications. The curriculum in each program of study is aligned with the requirements of relevant industry-based certifications, ensuring graduates have the knowledge and skills required for jobs in the modern manufacturing economy.

While initial certification efforts were intentionally placed at the community colleges, it is now imperative to extend the pipeline to include higher-level skills certifications in specific industries and occupations which can be aligned to baccalaureate and graduate degrees. Embedding industry-based certifications in manufacturing-related programs of study, and increasing articulation between two-year and four-year institutions, will help ensure colleges and universities are graduating engineering technicians and technologists with the skills manufacturers need.

Why Articulation Matters

We are facing unprecedented, fundamental challenges and are surrounded by dramatic, rapid changes. This is not simply a difficult moment for higher education: it is the dawn of a very different era. The institutions that will succeed—indeed, thrive—in this era will be those that constantly innovate.

Challenge and Change
George L. Mehaffy
Vice President for Academic Leadership and Change
American Association of State Colleges and Universities (AASCU)

Since substantial numbers of students began moving from one institution to another nearly a half century ago, particularly from community colleges to four-year colleges, transfer and articulation practices have been problematic. Students who begin at community colleges, often with the intent of saving time and money, frequently find that the transfer track takes longer and costs more than if they had just begun at a four-year institution. The roadblocks to articulation end up disproportionately damaging the prospects of disadvantaged and minority students, and they dampen the numbers of students overall who progress in STEM education tracks.[7]

While progress has been made and promising practices exist, students, elected officials, and employers all question the complexities involved in "switching schools" and advocate for easier processes and more logical policies than exist in most states.

Today, in an era of declining resources and diminishing investments in education, it is a social imperative that we improve the efficiency of our educational systems. The changing nature of the student population—with a substantial increase in the number of returning older students, the need to balance work and school, and variable attendance patterns—all require enhanced attention to the policies and practices around transfer and articulation.

In a marketplace characterized by increased competition among institutions for students, there is also a greater need for transparency related to costs and performance outcomes. Institutions that can show strong links to industry, flexible delivery systems, and high placement rates for students will likely gain a competitive advantage.

Industry-based credentials embedded in manufacturing programs of study can serve as a powerful hook to attract students, win support from employers and promote articulation and linkages across educational institutions.

Some progress is being made. Since 2006, laws to improve transfer and articulation were passed in 29 states.[8] Several states, including North Carolina, Ohio, Texas, Florida, and Washington—all early adopter states of the NAM-Endorsed Skills Certification System—have launched strong initiatives making transfer and articulation from community colleges to four-year institutions easier to accomplish. [9]

In addition, the continued enrollment growth at both for-profit and non-profit four-year institutions that offer online education programs is being partially accomplished by concerted efforts to increase transfer and articulation agreements with two-year institutions across the country. In particular, these partnerships have a strong focus on facilitating successful transfers and pathways towards baccalaureate degrees for adult learners who have earned credits at multiple institutions over the years and in a variety of ways, including competency-based programs and prior learning assessments.[10]

Manufacturers want a clearly articulated, seamless roadmap from middle school through graduate school, with multiple on- and off-ramps, so potential workers don't drop off or fall between the cracks. They want policies and practices that allow potential workers to maximize their limited time and money. Manufacturers also want to know that the tuition assistance support they provide incumbent workers who return to school for classes achieves maximum impact for their business and their employees' long-term prospects. Renewed focus on term-to-term and year-to-year persistence and improved graduation rates is critical to addressing the skills gap. Articulation matters.

A common metric of standards and competencies, as reflected in industry-based certifications, can serve as the bridge that connects manufacturing-related programs of study across educational levels and institutions.

Jennifer McNelly, President
The Manufacturing Institute

In a marketplace characterized by increased competition among institutions for students, there is also a greater need for transparency related to costs and performance outcomes. Institutions that can show strong links to industry, flexible delivery systems, and high placement rates for students will likely gain a competitive advantage.

While broad-based articulation and transfer of credit are moving the needle in the right direction, change is not happening fast enough to address the skill gap needs of manufacturers.

Roadmap for Manufacturing Education

The focus of this Roadmap is on promoting manufacturing education pathways with embedded industry-recognized certifications, articulated from high schools to four-year institutions.

The premise is that there is no "one size fits all" model that fosters greater articulation and transfer of credits as relates to programs with embedded industry skill certifications, but there may be certain factors that tend to support greater alignment of systems. This roadmap identifies what some of those factors are and promotes them – defining the "best shot" for manufacturers moving forward.

A Pennsylvania Case Study

A Seamless Pathway from High School to University with Embedded Industry Certifications

Driven by the needs of regional industry, a Bachelor of Applied Science (BAS) in technical leadership degree program was created through a cooperative effort among three institutions: Lehigh Career & Technical Institute (a secondary career & technical school), Lehigh Carbon Community College, and Bloomsburg University (part of the Pennsylvania State Schools of Higher Education system). This is the first program of its kind in the state and is a career-oriented degree based on knowledge and skills needed by technical professionals.

Students begin their college education while in high school at Lehigh Career & Technical Institute (LCTI) through dual enrollment at Lehigh Carbon Community College (LCCC) and Bloomsburg University. In some cases, students can begin as early as ninth grade preparing for industry credentials used for advanced standing at LCCC and the award of college credits in the Bachelor of Applied Science (BAS) program. For instance, Welding Technology and Machine Technology students can be awarded up to 30 college credits by earning AWS or NIMS certifications while still in high school.

The BAS degree provides a seamless pathway for students who have earned an AAS degree which was previously thought of as a "terminal" degree. The program is offered in a 2+2+2 format with multiple entry points to serve students in career-technical high schools, community colleges and working professionals.

A Professional Advisory Board will be actively involved in the program, providing feedback that connects with industry trends and needs and ensuring program graduates have the credentials employers seek. This degree program is designed to be replicated in the other Pennsylvania state universities with partnering community colleges and career technical schools.

Challenges to Articulation

The issues of articulation and transfer of credit have been the subject of extensive research studies and papers, but very little research has focused on articulation between two- and four-year technology programs. [11] To gain some insight, the National Science Foundation, with staff from the accreditation entity ABET, conducted preliminary research to identify factors that impacted articulation of technology programs. [12]

Not surprisingly, given the pace of change in this policy arena, the Manufacturing Institute-sponsored engagement process identified basically the same set of organizational and cultural challenges identified by researchers over the years. However, with their focus on manufacturing programs of study, and specifically the inclusion of industry certification in those programs, additional external factors surfaced that can make a major difference in the extent to and speed with which changes in articulation can take place. Three major sets of factors emerged, as identified in the chart below.

External Factors	Organizational/ Programmatic Factors	Internal/ Cultural Factors
• Funding • Legislation • Employer Engagement • Industry Image • Measures of Success • Accreditation	• AS vs. AAS Degrees • Transfer Mechanisms • Financial Aid • Math Requirements • Embedding Certifications into Courses	• University Mission • Leadership • University Faculty • Perception of Community Colleges

While declining revenues are a major challenge, renewed requirements for increased accountability, improved performance outcomes, and greater institutional collaboration create an environment that potentially bodes well for the integration of industry certifications into post-secondary curriculum nationally.

External Factors

Funding. State budget appropriations for public colleges and universities declined significantly during the economic downturn. Boosting college completion rates in an austere funding environment has led to a national productivity agenda for higher education. One component of the productivity agenda involves performance-based funding, linking state funding for public colleges and universities with institutional performance, as a means of improving institutional effectiveness.[xiii] Performance-based funding represents a fundamental shift in higher education finance—a shift from state inputs to campus outcomes, and from institutional needs to state priorities.

Legislation. Legislation has emerged as particularly important in mature manufacturing states, such as Ohio, Illinois, and Indiana, where community colleges and universities have played a significant role in manufacturing workforce development for decades. While legislation varies, the bottom-line intent is to ensure efficient and appropriate transfer from one post-secondary institution to another during the course of a student's undergraduate education. Colleges with state policies that mandate credit transfer within educationally credible parameters claim it shifts the conversation from "Should we do this?" to "How do we do this?".

Ohio Policy Initiatives Facilitate Articulation in Manufacturing Programs of Study

In Ohio, articulation and transfer were strengthened in 2003 with H.B. 95, which created faculty-developed Transfer Assurance Guides (TAGs) to create discipline-specific pathways from any state-assisted institution to another. The legislation allows for the transfer of many pre-major and beginning major courses as equivalencies among Ohio's public institutions of higher education. In 2005, H.B. 66 expanded Ohio's articulation and transfer efforts by providing students in Ohio's secondary and adult career-technical institutions with a similar guarantee for career-technical courses/programs. This became known as Career-Technical Credit Transfer (CT). It reduced institutional barriers and unnecessary course duplication by articulating courses that adhere to recognized industry standards and are deemed equivalent and common among institutions.

Employer Engagement. Employer engagement emerged as the critical catalyst for change. When employers ask for skills certifications as part of their hiring processes, both faculty and students will take note. Strong state or regional manufacturing associations can play a critical role in aggregating industry needs, advocating for new legislation/investments, and advising on curriculum changes.

Industry Image. A closely related issue is the continued challenge of getting students of all ages to view manufacturing as their career of choice. Several institutions spoke about the "double whammy" in their states of declining enrollments at the secondary level and the continued lack of information about career opportunities in the industry.

Measures of Success. What gets measured gets done. While federal policies and funding initiatives are increasingly incorporating requirements for third-party validation of skills and alignment with industry credentials, states have been slow to count industry certifications as measures of completion. Such a shift would have a significant impact on the uptake of industry certifications at both the two- and four-year levels.

Accreditation. ABET and other accreditation agencies accredit applied science, computing, engineering, and engineering technology programs at two- and four-year institutions. Accreditation signifies that a collegiate program has met certain standards necessary to produce graduates who are ready to enter their professions. More and more, accreditation entities are emphasizing relevance and public engagement in their accreditation criteria. Relevance to industry needs could and should be part of these criteria.

Organizational/Programmatic Factors

Increased articulation of manufacturing-related AAS degrees via applied baccalaureates would be a major step toward the integration of the Skills Certification System at the university level.

Associate of Science (AS) vs. Associate of Applied Science (AAS). Industry certifications are typically embedded in technical programs associated with certificate or AAS degrees where the content focuses on technical workplace skills plus a few general education courses. AAS degrees are often referred to as "terminal" degrees, because historically articulation agreements and transfer of credit to four-year universities have focused on AS degrees. Joint admissions or dual admissions articulation models have begun to change that dynamic, with students able to receive full credit. Increased articulation of manufacturing-related AAS degrees via applied baccalaureate degrees would also be a major step toward the integration of the Skills Certification System at the university level.

Transfer Mechanisms. In terms of academic or curricular elements, common practices to support transfer include establishing a general education "common core," common course numbering, competency-based articulation and transfer, statewide program major articulation and transfer, block credit transfer, and transfer associate's degrees. Each state has a unique governance structure, transfer committee approach, and various transfer practices that stem from historical and political realities. Block credit transfer avoids course-by-course evaluation of transferability, and is most commonly used by those community colleges with active articulation agreements affecting programs with embedded industry certifications.

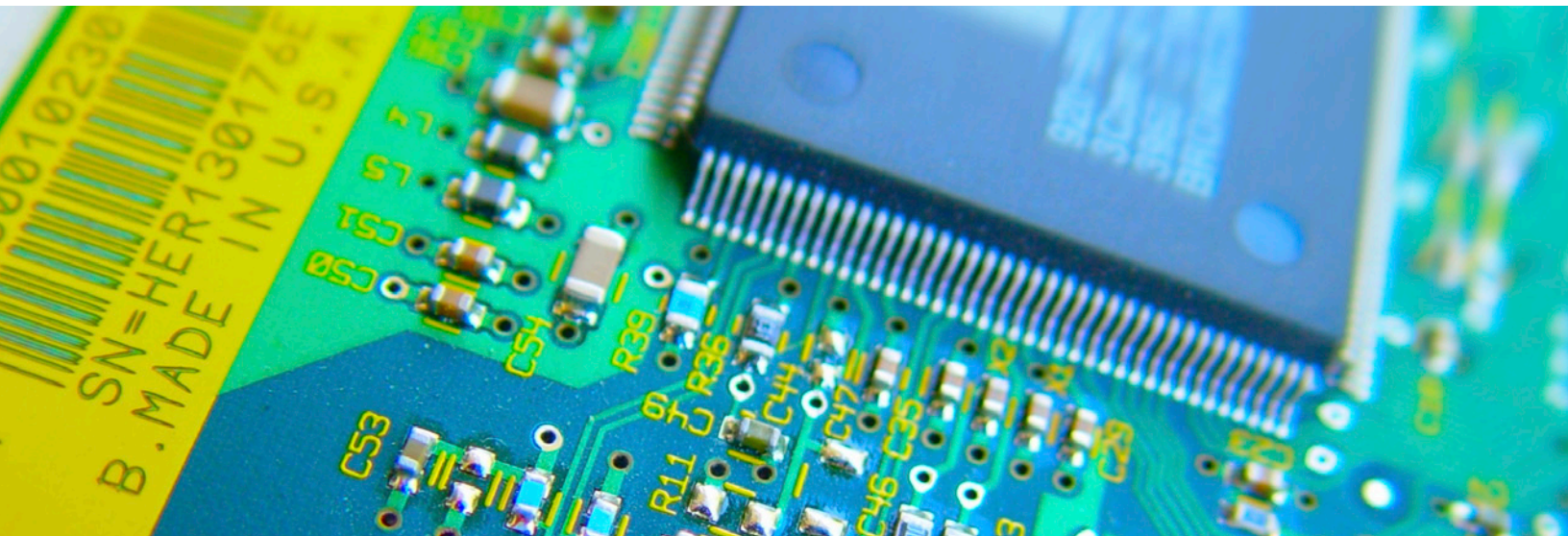
Associate of Applied Science in Advanced Manufacturing at Ivy Tech Community College, Indiana

Associate of Applied Science degree programs are two-year programs that prepare students for careers, career changes and career advancement. Students who need to take longer to complete the degree because of job or family obligations can take the program over a longer period of time. AAS programs may also prepare students for transfer to four-year institutions. These programs offer education in recognized technical areas and specialties with emphasis on analysis, synthesis and evaluation. The program content, which is approximately 30% general education and 70% professional/technical, provides depth and breadth in conceptual and professional/technical skills. The general education courses equip students with the problem solving, communications, scientific and mathematical skills to compete successfully in the job market. Professional/technical courses equip students with the skills to obtain employment and to advance in the workforce.

Financial Aid. Current federal policy does not allow students to receive aid at two institutions simultaneously because the loan and grant aid eligibility stipulated by the U.S. Department of Education must be monitored by institutions in order to ensure that students are not over-awarded. If students are dual-enrolled and have pending aid at their home institution, the other host school normally will not package the students with further aid. However, when students are dual-enrolled, some institutions may allow students to enter a consortium agreement which allows students to receive aid based on the combined hours from their home and host school institution. Consortium agreements are an important piece of promoting the Skills Certification System.

Math Requirements. Math is the fundamental discriminator between students who complete production-level programs and those who pursue pre-engineering programs of study—the classic algebra II vs. calculus divide. Math skills are also critical underpinnings to many of the technical skills required to pass some of the occupationally specific technical certification tests, particularly in machining. Contextual math instruction can help motivated students bridge the divide, including online instruction, project-based learning, additional focused classes, and peer mentoring.

Embedding Certifications into Classes. Community colleges with experience incorporating industry certifications into programs of study advocate for embedding certifications into regular classes, not as stand-alone activities. Important issues include the proper sequencing of program content to align with certification requirements and the appropriate time to administer the certification exam. These lessons learned can help inform four-year institutions that begin to embed industry-certifications. Testing should occur when appropriate content has been mastered, which may be in the middle of a course or course sequence. This will require a shift in thinking for faculty who may typically administer only end-of-course assessments.



North Carolina CODE Green Super CIP

In January 2010, the North Carolina Association of Community College Presidents requested a Curriculum Improvement Project (CIP) to rejuvenate existing curriculum programs and integrate energy efficiency skills into all aspects of technical education pathways. Results to date include the following:

1. **Streamlined program structures that reduce the number of curriculum titles.** To minimize redundancies, the CIP consolidated more than 80 curriculum standards into only 32 standards. This reduction standardized curriculum models, allowing similar program majors to be grouped together under curriculum programs that share a common academic and technical core.

2. **Curriculum competencies that allow for non-credit certified students to transition into credit programs.** The CIP developed competency-based courses to facilitate the awarding of academic credit for equivalent course work taken on a non-credit basis.

3. **Students with industry-recognized credentials.** Recognizing the important role employers play in defining workplace competencies, the CIP revised curriculum courses and programs to include skill sets like those endorsed by the National Association of Manufacturers (NAM). Students can now earn multiple, nationally recognized industry credentials while working toward an associate degree in a related field of study. With credentials under their belts, students emerge with skill levels that are more adaptable, technology-savvy and recognized by industries.

Internal/Cultural Factors

University Mission. Many four-year colleges and universities do not consider workforce development as part of their mission. They see that more as the role of community colleges, with a few exceptions. Different rhetoric might be needed to engage university partners, using such terms as supporting business competitiveness, innovation and entrepreneurship, or professional development.

Leadership. Leadership is a critical variable in promoting articulation in general and industry certifications in particular. Personal engagement on the part of a visionary president, provost, dean, or department chair can be the pivotal point in promoting the importance of seamless pathways for students through strong articulation agreements and supporting embedded industry certifications in programs of study. Governors and elected officials can be critical in developing and passing supportive policy that eliminates the need for debate about the issue.

Engaging University Faculty. Community colleges experienced in the SCS system highlight the importance of "getting the faculty heart." Because faculty own the curriculum and manage curriculum committees, having faculty understand the benefit of industry-certifications to their students is critical. It is important that faculty not perceive this as an attempt to "take over" their curriculum, but rather as a tool to enhance it and provide an additional verification of content mastered.

View of Community Colleges. Institutional pride can play a role in inhibiting articulation, with faculty at the institution to which a student wants to transfer believing that the courses taken at another institution can't possibly measure up to theirs. The critique often surfaces relative to community college faculty credentials, particularly in career technical programs where instructors may have significant work-related expertise but little formal pedagogical training. Focusing on learner outcomes and competency-based evaluations, such as are embedded in the Skills Certification System, actually helps to mitigate this dynamic.

Purdue University Articulation Initiative

With support from the Lumina Foundation, Purdue University has implemented a series of conversations with Ivy Technical Community College and other four-year institutions across Indiana about the challenges and opportunities of embedded industry-based certifications, and associated issues of articulation and credit transfer. Progress to date highlights that for culture to change, faculty need to be engaged, curriculum needs to be developed or modified, and partnerships with industry need to be strengthened.

Selected examples of progress to date include:

- A new course – ENGT 120 – Engineering Concepts and Technology will provide a common gateway course in which Ivy Tech and Purdue students can interact through a virtual learning committee (VLC). The structure of the VLC will allow Purdue and Ivy Tech students to collaborate on assignments, projects, and communications.

- Purdue and Ivy Tech are collaborating to form the Indiana Next Generation Manufacturing Competitiveness Center (IN-MaC) where both institutions will offer classes, create proof-of-concepts, complete advanced prototypes, and engage industry with applied research, including workforce development that supports Indiana's high technology, advanced manufacturing firms.

- Joint planning is currently under way for the spring 2013 Engineering Technology Summit, which will bring together Ivy Tech and Purdue students and faculty members where they will interface with industry representatives for the annual meeting and provide examples of existing work products developed within the AS and BS degree structures.

Indiana State University Strategies for Competency-Based Education Utilizing Certification Mechanisms

Indiana State University (ISU) is currently developing two strategies to prepare its graduates for industry competencies before graduation. One track represents students who enroll in the manufacturing program as freshmen (the traditional student). The other track represents students who transfer from the statewide Ivy Tech Community College (the nontraditional student).

ISU is laying the groundwork for the incorporation of the SME-Certified Manufacturing Technologist (CMfgT) as a graduation requirement, an effort to improve industry readiness. In an effort to revamp its manufacturing program, ISU is proposing a Bachelors of Applied Science for nontraditional students. This program will not be accredited by external accrediting bodies; instead, SME certifications will be utilized to validate that students are industry ready. The CMfgT exam will be a focal testing point from which all our graduates can advance to become Certified Manufacturing Engineers (CMfgE).

At the core of this strategy, ISU is revamping the following courses: (1) Fundamentals of Manufacturing Processes, (2) Manufacturing Processes and Materials, (3) Production Planning and Control, and (4) Industrial Organization and Function. Students who have earned the MSSC Production Certification and the Manufacturing Maintenance Certification are exempt from taking this class, which typically includes nontraditional students who earn these certifications as part of their course work at Ivy Tech.

B.S. Degree in Technology at Northern Illinois University (NIU)

Technology education at NIU is centered on applications and engagement of our students in industrially based projects. The NIU Department of Technology strives to provide students with state-of-the-art laboratories and a curriculum that mirrors the needs of industry today. The department offers electrical engineering technology, manufacturing engineering technology, industrial management and technology, energy and environmental technology, and aviation management technology.

The programs in industrial management and technology and aviation management technology can be taken as a "3+1" program where three years of the program may be taken at a near-by community college, and the remaining year is taken at NIU, either on-or off-campus. The program is in the process of developing online courses for the last year of study to be taken at NIU. The balance of the programs follow a "2+2" design, which allows students from community colleges who have followed program guidelines to fully transfer credits towards completion of NIU technology degrees.

Toyota Motor Manufacturing Supports Internships and Certifications

Toyota has helped to drive change in San Antonio, Texas, by offering internships and preferring industry-based certifications in its Motor Manufacturing facility. In partnership with Alamo Community Colleges Advanced Technology and Manufacturing Academy (ATMA), high-school juniors and seniors spend 2½ hours each day at Alamo campuses completing an industry-driven, contextualized curriculum to develop work ready skills in manufacturing. The dual-credit program of studies, which is at no personal cost to students or parents, allows participating students to graduate high school with 34 credit hours and earn a college Level I Certificate of Completion for Tool Operator/Maintenance Assistant. Students also earn two of the Manufacturing Skills Standards Council (MSSC) Certified Production Technician (CPT) individual certificates: the Safety and Quality Practices & Measurement Certifications. With support from the San Antonio Manufacturers Association (SAMA), students participate in internships – like those at Toyota – and can earn over $2,400 during the summer.

RECOMMENDATIONS

Five recommendations emerged as next steps to advance the articulation and transfer of credit at the post-secondary level in the context of industry-endorsed skill certifications. Business and education leaders alike argue that action and investments in these five areas would yield significant results that could then be leveraged for even greater systemic change.

It is important to acknowledge that the recommendations included in this Roadmap are intended to support all post-secondary institutions, even those with small technology departments and/or schools that are not ABET accredited or have a history of research or technology transfer. All post-secondary institutions are viewed as "stewards of place" – supporting the economic development of their communities is a legitimate part their role.

Action #1:
Increase Employer Demand for Industry Certifications

Manufacturers can change the behavior of institutions and adult learners alike by requesting industry certifications when interviewing and hiring new workers, and when considering individuals for internal promotions.

With a goal of increasing the number of skills-certified individuals, it is important that employers begin to make certification a job requirement, or at least an expectation. Manufacturers need to start asking about skills certification when they hire graduates from both two-year and four-year schools. Then faculty and students will take note. Manufacturers can also build certifications into training for incumbent workers, and link certifications to expectations for promotions within the company.

Action #2:
Link Industry Certifications to an Agenda of Business Competitiveness and Innovation

Business and university leaders should promote manufacturing education pathways linked to industry standards as an imperative of business competitiveness, innovation, and entrepreneurship.

Many four-year schools, particularly research universities, don't perceive of themselves as being in the "workforce development" business and have been largely absent from this landscape. Manufacturers can drive change by repackaging the message: industry certifications are a tool for linking economic and workforce development. Leaders must demonstrate the critical importance of linking the two efforts—of creating manufacturing education pathways based on industry standards as an imperative of business competitiveness, innovation, and entrepreneurship. Such an approach and language is more likely to gain attention at the university level.

Action #3:
Influence Accreditation Standards Completion

Getting accreditation criteria adjusted to include relevance to industry needs, as reflected in industry-based certifications, would be a game changer.

Institutions value their accreditation highly. It is a powerful force to drive change in institutional policy and practice. Increasingly accreditation entities are emphasizing relevance and public engagement in their accreditation criteria. Getting them to adjust accreditation criteria to include relevance to industry needs, as reflected in industry-based certifications, would significantly impact institutional behavior at both the two- and four-year levels.

Action #4:
Advocate for Industry Certifications as a Measure of Completion

Encouraging states to track and count industry certifications as a measure of completion would have a significant impact on their uptake at both the two- and four-year levels.

While federal policies and funding initiatives are increasingly incorporating requirements for third-party validation of skills and alignment with industry credentials, states have been slow to count industry certifications as measures of completion. Supporting the adage of "what gets measured gets done," promoting technical industry certifications as a bona fide measure of completion at the postsecondary level could be a major lever for change. The Manufacturing Institute will explore forming partnerships with critical two- and four-year associations and professional organizations that share this agenda to maximize the leverage potential.

Action #5:
Launch the Manufacturers Endorsed Education Alliance

The Manufacturing Institute has launched the Manufacturers Endorsed Education Alliance, or "M-list."

The Alliance represents the nation's top-of-the-line community colleges, technical schools, K-12 institutions, and universities that deliver credentialed workers to meet the needs of manufacturers in their communities. It represents the recognition of quality for companies looking to hire skilled workers, students and career changers looking to upgrade their skills, and site selection agents looking for a region with a commitment to manufacturing skills. To apply, institutions of higher education should access the application on the MI website.

Next Steps

This Roadmap is intended to launch a dialogue among manufacturers and post-secondary leaders about the urgency to move forward with new models and different approaches to manufacturing education. The examples included in this Roadmap reflect innovation at two- and four-year institutions that were part of the initial Manufacturing Articulation Roundtable, but there is broad acknowledgement that there are many "pockets of excellence" across the country not reflected in this document. This Roadmap was designed to draw major themes, not site every example.

Next steps for The Manufacturing Institute and key stakeholder in support of identified recommendations include:

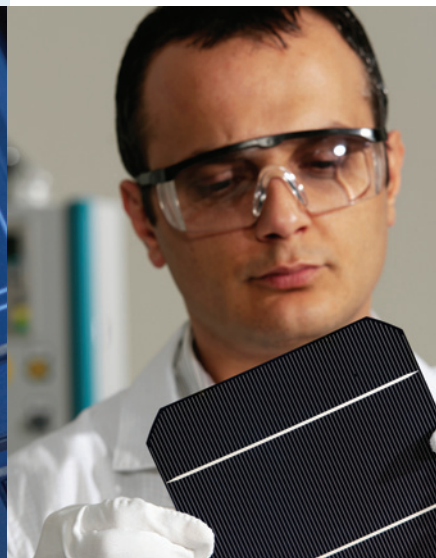
1. **Expand employer engagement.** Launch an employer pledge initiative to get manufacturers to "sign on" in partnership with educational institutions to address the skills challenge.

2. **Engage four-year institutions and policy leaders.** Take advantage of forums to engage four-year institutions and policy leaders in states that are working to adopt the Skills Certification System, and with leadership groups such as the American Association of State College and Universities (AASCU) and the Transformational Regional Engagement (TRE). Lead the national dialogue on the relevance of skills certifications to economic competiveness and innovation.

3. **Define and refine metrics.** Work with educators to determine appropriate metrics for tracking progress and defining success. Support key post-secondary leaders in working with accreditation bodies to influence accreditation standards and promote technical industry-endorsed certifications as a legitimate measure of completion.

4. **Capture promising practices.** Build a database of existing promising practices to enhance the knowledge base in this area, particularly as relates to the development of partnerships and alignment of curricula with the requirements of industry-based credentials.

5. **Promote a recognition initiative.** The Institute will promote its Manufacturers Endorsed Education Alliance to provide recognition to two- and four-year institutions that have embraced skills certification. Where possible, the Institute will explore focused and funded demonstration projects to reward employer/education relationships that yield win/win outcomes.



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The Institute thanks all those who participated in the Roundtable; this Roadmap represents a synthesis of their collective input. Attendees represented a cross-section of America's two- and four-year institutions. Many of the community colleges were already engaged with the NAM-endorsed Skills Certification System, and lent their significant expertise to the discussion. Representatives from the four-year institutions shared openly about the external, organizational, programmatic and cultural challenges inherent in embedding industry-certifications into manufacturing programs of study, as well as promising practices that present opportunities for expanding pathways development.

Thought leaders from numerous institutions not in attendance at the Roundtable have also reviewed and commented on various drafts of this paper. We greatly appreciate their time and strategic input. We also thank the Lumina Foundation for its support of this project and vision for educating a credentialed workforce.

Have Comments or Additional Promising Practices?

This Roadmap in intended to launch a continued dialogue among manufacturers and post-secondary leaders about the urgency to move forward with new models and different approaches to manufacturing education. The promising practices put forward are by no means exhaustive, only illustrative.

If you have comments on this Roadmap document, or have a promising practice you are willing to share, please forward them to Dr. Audrey Theis, consultant to The Manufacturing Institute, at astheis@keylinksinc.com. Promising practices will be posted on the MI website at www.themanufacturinginstitute.org.

Key Links

Content for the Roadmap for Manufacturing Education was compiled by Key Links Inc., with design by Dorey Design Group

ddg
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Endnotes

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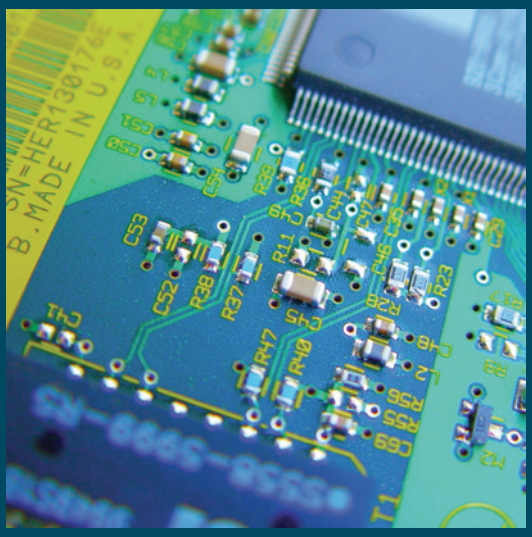
Today, in an era of declining resources and diminishing investments in education, it is a social imperative that we improve the efficiency of our educational systems. The changing nature of the student population—with a substantial increase in the number of returning older students, the need to balance work and school, and variable attendance patterns—all require enhanced attention to the policies and practices around transfer and articulation.

In a marketplace characterized by increased competition among institutions for students, there is also a greater need for transparency related to costs and performance outcomes. Institutions that can show strong links to industry, flexible delivery systems, and high placement rates for students will likely gain a competitive advantage.

Manufacturers advocate that educational institutions need to change their cultures and behavior so more students complete programs of study with real skills of value to industry, as assessed and represented by third-party, industry-based certifications. By design, this will involve more targeted communication with industry, curriculum development geared toward employer needs, and stronger linkages to economic development.



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