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A Technology Education Collaborative Closes the Advanced Manufacturing Skills Gap

Education and workforce development are the bedrock of 21st Century Manufacturing. In the United States, this concept must be well understood in order to drive commitment by policy makers, industry and educators to educate current and future workers so that they may lead the pace of global advanced manufacturing and technology innovation.[1]

Advanced manufacturing embraces technology and innovation as the platforms from which it creates products for consumers, commercial, industrial, military and scientific markets. Rare is a market not touched by advanced manufacturing. The landscape has changed: "innovation, supply chains, production, distribution and customers may be geographically co-located in an industrial commons or spread across the world".[2]

"Manufacturing" has become a combination of technologies that are defined by a high level of innovation and collaboration. Automation has become a dominant force within the manufacturing environment and "workers will need to understand how to manage sophisticated robots and other automated technologies that are built upon information technology and advanced software [3]".
In addition, advanced manufacturing is the dominant type of manufacturing in the U.S. because it is driven by economics, competition and national security [4].

Workers in advanced manufacturing are working in a fluid, computational, additive digital environment. Innovative and new approaches in workforce development have been initiated and they need to be implemented and institutionalized so that the national *dialogue* about the "skills gap" may be transformed into *building* a pipeline of advanced manufacturing talent to support, sustain and drive economic growth [5].

The advanced manufacturing sector will provide economic development and high-paying jobs in regions that suffered from an exodus of traditional manufacturing jobs in the late 20th century, and economic stronghold nationally. In order to fulfill this promise, the American workforce needs technical, training in new manufacturing technologies. Ensuring that workforce skills keep pace with changing technology, is one of the key topics of discussion in public policy, educational policy and by industry. According to the Manufacturing Institute and Deloitte Consulting nearly 3.5 million manufacturing jobs will be filled over the next decade. That's the "good news." The bad news? The skills gap is expected to result in 2 million jobs that will go unfulfilled [6].

The skills gap is becoming greater based on new statistics provided by the Global Robotics Technology Market: Forecast, 2014 - 2020 published by Research and Markets, reporting that the worldwide robotics market is forecast to grow from the 2015 level of $26.9B, to $82.7B in 2020 [7]. This 11% compounded average growth in the next five years is unprecedented. Given the anticipated growth of the robotics industry - the platform for advanced manufacturing - the number of jobs that will be required to meet that demand will grow exponentially as well. The future is bright for careers in STEM fields; today, the average annual salary for a STEM worker is $33,200 more than the average salary of all occupations in the United States.

How complex is the skills gap for the advanced manufacturing sector? The same national study found that the majority of CEO's and manufacturing executives (70%) believe that incumbent and new workers lack technology and computer skills; 67% believed workers are lacking basic technical training, and 78% believe that the skills gap will impact their ability to implement new technologies, stagnating expansion and growth opportunity [8]. These workforce barriers not only impact local, regional and national competitiveness they represent serious barriers to competing in a global environment.

If advanced manufacturing has been identified by industry, government, and academia as an important driver of future economic growth in the U.S., impacting everything from the national economy to national security why has closing the skills gap been so challenging to address? The fundamental problem is that disruptive technologies bring with them disruption in worker skill requirements. When new skill requirements for the workforce are identified, they need to be understood in order to teach them. Since the manufacturing sector has been transformed from the Baby Boomer generation to the Millennial generation, the long lag has had a critical impact on updating the formal education and training process [9].

Across industry, education and policy makers, stakeholders have acknowledged that a key element in closing the skills gap is changing the public discussion of advanced manufacturing and workforce preparation; a new social identity for advanced manufacturing career paths must be created. Based on the history of dwindling manufacturing employment in the U.S., few parents want their children to train for manufacturing jobs. There is a demand that every student attends a four-year college in spite of more relevant, flexible and less expensive education alternatives.

The stigma associated with manufacturing ignores newly available career opportunities, which may hurt U.S. economic competitiveness in the long run. American industry will need newly-trained workers to replace large numbers of retirees in the coming decades. The rapid pace of technological change makes updating worker skills ever more important. Now that industry, government, and academia have identified the promise of advanced manufacturing, they must also work together to ensure that American workers are equipped to fulfill that promise.

The "Next Generation Strategies" developed by the federal government's Manufacturing Extension Program (MEP) now in its 25th year, is charged with *workforce excellence* among four other key strategies. As part of the recommendations and actions designed to enable innovation, strengthen the U.S. workforce and accelerate investment in workforce development is to promote: "*verified, reliable, and standardized skill certifications to create reliability and validity in the training and recruitment process"* [10.]

The U.S. needs to ensure that "the national portable competency based skill certifications are aligned to secondary and post-secondary programs of study and to industry-relevant training needed for employment in advanced manufacturing. In addition, the alignment of military and civilian skill certifications must also be integrated into an agreed-upon certification taxonomy so that U.S. veterans can be placed in advance manufacturing jobs" [11, 12].

Recent innovation in science, technology, engineering and mathematics (STEM) curriculums and pedagogy have prompted development of innovative educational models that deliver these much-needed skills *with* competency based portable verified, reliable, and standardized skill certifications. Most importantly, these models are developed jointly by industry and education to ensure that the key problem in the past is addressed: Curriculums are *relevant to current industry technology* and *curriculums change with the changes that take place as new emerging technologies change the advanced manufacturing environment and worker skill requirements.*

These STEM curriculums, use state-of-the art technology such as industrial robotics to simulate a "real-world" manufacturing environment. STEM education is now being introduced as early as Kindergarten: Educational programs like F.I.R.S.T Robotics and Project Lead the Way (PLTW) encourage manufacturing career paths in middle school and high school. Today, a U.S. high school student can *graduate* with industry-recognized certifications that either lead to direct employment, or to the completion of postsecondary education to further STEM career paths.

Recent changes in new legislation and recommendations to Accreditation Board for Engineering and Technology programs for institutions of higher learning (ABET) to make changes in curriculum requirements, demonstrate the movement amongst stakeholders to support that these educational models are implemented and institutionalized. In addition, these recommendations are accelerating the dialogue to change the social identity of advanced manufacturing by creating robust programs with new career paths.

For example, the recently introduced legislation in the U.S. Senate would designate up to 25 institutions of higher education as U.S. Manufacturing Universities (USMU), and would receive funding in the amount of $5 million per year for a four year period; a total investment in advanced manufacturing higher education of $100M. This bill is responsive to the Advanced Manufacturing Partnership Subcommittee of the President's Council of Advisors on Science and Technology's call for greater investment in manufacturing in higher education [13]. Included in the legislation is a list of recommendations on metrics for the University program that include industry based capstone projects and apprenticeship programs.

Recent passing of the "Every Child Achieves Act of 2015", is an example of legislation passed recently that is also creating the opportunity for States to develop their own accountability systems ending the federal test-based system. This restoration of individual States' accountability for testing opens the door to: "Affirms the state responsibility for supporting the coordination and implementation of high quality programs and initiatives in order to disseminate best practices so that school districts can better meet the needs of their students". In addition, added to the legislation are key metrics that must be added to a State's accountability system including: "one measure of postsecondary education or workforce readiness" (Every Child Achieves Act, 2015). School districts across the nation are looking at innovative STEM based CTE programs to provide the most relevant education for their students to meet this new critical key education indicator.

In 2013, the Director of the National Institute of Science and Technology (NIST), Patrick Gallagher, wrote a letter to ABET, which included these recommendations for curriculum outcomes: "Through consultation with industry and academic leaders, this task team concluded the objective can be best

achieved by minor revisions to the ABET General Criteria 3 – "Student Outcomes" to explicitly include manufacturing. The team recommends ABET consider the following: "An ability to design, build and conduct experiments, as well as to analyze and interpret data; An ability to design and manufacture a system, component, or process and to meet desired needs within realistic constraints such as including economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability" [14].

FANUC America CERT education group has worked with industry technology leaders in the robotics, automation, advanced manufacturing and the connected enterprise and educators to develop the Robotics and Advanced Manufacturing Technology and Education Collaborative (RAMTEC) to train the workforce with an innovative model that has been established as best practices model on a national basis. The RAMTEC model delivers national, portable, competency based skill certifications, aligned to secondary and post-secondary programs of study and to industry-relevant training needed for employment in advanced manufacturing.

The model's competency based curriculums, can be mapped to align military and civilian skill certifications to support U.S. Veterans placement in advanced manufacturing jobs" [15, 16]. In addition, as the Workforce and Innovation Act of 2014, is implemented, RAMTEC's curriculums align with the U.S. Department of Labor, Employment and Training Administration's Advanced Manufacturing Competency Model [17]. RAMTEC's stackable industry certifications address Tiers 4 and 5, of workplace competencies that are specific to the *industry or industry sector* [18]. In accordance with the Advanced Manufacturing Competency Model, deliver "the cross-cutting industry-wide competencies that demonstrate the career lattices that allow workers to move easily across industry sub-sectors…resulting in a model that supports the development of an agile workforce that does not need to follow a single occupational ladder" [19]. The alignment of RAMTEC's curriculums to the Department of Labor, Employment and Training Administration's Advance Manufacturing Model uniquely supports the public and private partnerships that are being sought to deliver a sustainable workforce pipeline.

This robotics and advanced manufacturing technology educational model provided a framework for industry, education and government to work together to close the skills gap. The prototype model was implemented in 2014, at Tri-Rivers career center through an innovative collaboration between Tri-Rivers Career Center, Marion Technical College and The Ohio State University at Marion. The model is a national response to deliver competency-based, stackable industry training leading to certifications for future workers in robotics, automation, advanced manufacturing and the connected enterprise.

RAMTEC also delivers career pathways for learners in grades 6 -16, to explore and succeed in a chosen path. In addition, the model teams with workforce training programs, adult education and post-secondary educators in the cooperative conveyance for instruction. This educational model delivers this curriculum through E learning, hands-on learning, authentic based learning, STEM and blended learning. This innovative model builds and leverages "Project Lead the Way" (PLTW) manufacturing programs through blended E-learning experiences and "hands-on" activities correlated to Common Core Standards. The model then continues in the 11th and 12th grade with a competency-based curriculum in advanced manufacturing certifications adding STEM based activities for learners enrolled in a robotics and advanced manufacturing technology educational collaborative programs that meet the RAMTEC designation.

The model is designed and operationalized so that all RAMTEC partner programs replicate the program by delivering the curriculum and certification process as defined and stipulated by the model. The critical and key element of this model is that: curriculum, teaching technology and equipment and the criteria for instructional personnel are *driven* by industry; ensuring that this robust model remains relevant. The key to closing the skills gap, is delivering education and training that mirrors what is taking place in industry. – As disruptive technology emerges, disrupting worker skill requirements, education is shadowing and collaborating with industry to ensure that education and training are moving at the same speed.

This educational model has successfully been implemented nation-wide. The model is designed to deliver education in robotics, CNC, PLC, integration and applications providing academic and community based workforce training solutions. In 2016, within the FANUC CERT Education network of 415 schools, in addition to the nine programs in Ohio, there are thirty-eight (38) similar robotics and advanced manufacturing collaborative programs that offer extensive courseware of integrated and networked solutions delivering stackable industry certifications. The table below identifies the states that have notable academic programs that meet the intent of the Robotics and Advanced Manufacturing Technology Education Collaborative designation and represent this important industry-education partnership.

Alabama	5		Louisiana	1		N. Dakota	1
Arizona	1		Michigan	5		Tennessee	3
Arkansas	1		Minnesota	2		Texas	2
California	1		Mississippi	1		Utah	1
Indiana	5 (9 planned)		Missouri	1		Virginia	1
Kentucky	2		Nevada	1		Wisconsin	4

States with Notable School Programs that Meet the Intent of a Robotics and Advanced Manufacturing Technology Education Collaborative

The manufacturing workforce requires a new focus; the manufacturing paradigm continues to shift away from labor-intensive activities towards automation, knowledge based and technological problem solving, and from commoditized to customized production [20]. Times have changed, manufacturing has changed with them, so that not only skills, but also new combinations of skills, are required of a manufacturing worker [21]. Today's requisite skills are being defined and certified and they will continue to evolve as industry and technology evolves [22]. The Robotics and Advanced Manufacturing Technology Education Collaborative model is designed to evolve; curriculum delivery ensures that education and training are state-of-the art driven by industry. Closing the skills gap in robotics and advanced manufacturing is successfully being achieved with this industry-education partnership model.

References

1. Wagner, S. J., (2013) “Creating a Skilled Workforce”. *Remaking America.* The Alliance for America Manufacturing. Washington D.C.
2. Pisano, G. & Shih, W. (2009). “Restoring American Competitiveness,” *Harvard Business Review* July-August, 2009. The resurgence of the U.S.’s “industrial commons” should be strongly encourage for advance manufacturing.
3. Markoff, J. (2012). “Skilled Work Without the Worker”. *The New York Times,* August 18th, 2012. Atkinson, R. (2012). “Worse than the Great Depression”. Information Technology and Innovation Foundation (ITIF).
4. President’s Council on Advisors on Science and Technology, “Report to The President: Accelerating U.S. Advanced Manufacturing.” (AMP 2.0 Report), Office of the President, Oct. 2015; PCAST, “Report to the President on Capturing Domestic Competitive Advantage in Advanced; PCAST, “Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing, Annex 3: Education and Workforce Development Work-Stream Report”. Office of the President, July 2012. Manufacturing”, (AMP 1.0 Report), Office of the President, July, 2012.
5. Wagner, et, al.; PCAST, “Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing, Annex 3: Education and Workforce Development Work-Stream Report”. Office of the President, July 2012. Manufacturing”, (AMP 1.0 Report), Office of the President, July, 2012.
6. The Skills Gap in Manufacturing, 2015 and Beyond. Manufacturing Institute and Deloitte, 2015
7. Global Robotics Technology Market: Forecast 2014 – 2020. Published by Research and Markets, 2015
8. Manufacturing Institute, et, al.
9. Wagner, et, al.; PCAST, “Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing, Annex 3: Education and Workforce Development Work-Stream Report”. Office of the President, July 2012. Manufacturing”, (AMP 1.0 Report), Office of the President, July, 2012.
10. Wagner, et, al.; Advanced manufacturing Initiatives: a National Imperative. A NARMI/SME Position Paper, 2014
11. Wagner, et, al; American Society for Training and Development, “State of the Industry Report 2011”.
12. Wagner, et, al.: Hiring Heroes Act of 2011 (S-951, HR 1941). “Military Skills for America’s Future: Leveraging Military Service and Experience to Put Veterans and Military Spouses Back to Work,” The White House, 2012, may 31st, 2012.
13. Support for the Manufacturing Universities Act, 2015. Recommendations for Leadership, Metrics and Execution. A NARMI/SME Position Paper, 2015
14. Wagner, et, al.: Advanced manufacturing Initiatives: a National Imperative. A NARMI/SME Position Paper, 2014; American Society for Training and Development et, al.
15. Wagner, et, al: Hiring Heroes Act of 2011 et, al.
16. Department of Labor, Employment and Training Administration, “Advanced Manufacturing Competency Model”. Updated, April, 2010.

17. Department of Labor, et, al.
18. Department of Labor, et, al.
19. Department of Labor, et, al.
20. Wagner, et, al.
21. Wagner, et, al.
22. Wagner, et, al