

AMERICA'S NEXT MANUFACTURING WORKFORCE

Promising Practices in Education and Skills Building




FORESIGHT
ALLIANCE FOR MANUFACTURING FORESIGHT

America's Next Manufacturing Workforce

Promising Practices in Education and Skills Building

A report of the MForesight Education and Workforce Development Working Group

July 2017



MForesight: Alliance for Manufacturing Foresight serves as the voice of the national advanced manufacturing community, providing government and industry with information and analysis about emerging technologies, workforce training, and opportunities for public-private partnerships that strengthen U.S. competitiveness. MForesight is funded by the National Science Foundation (NSF) and National Institute for Standards and Technology (NIST).

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This material is based upon work supported by the National Science Foundation under Grant No. 1552534 through a cooperative agreement with the University of Michigan (Dr. Sridhar Kota, Director). Any opinions, findings, conclusions, or recommendations expressed in this material are those of MForesight and do not necessarily reflect the views of the National Science Foundation or the University of Michigan.

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ABOUT THIS REPORT

The promising practices presented in this report demonstrate some of the most encouraging approaches for education and skill building of America's new manufacturing workforce. These practices have been selected by a panel of experts from business, government, and education who serve on the MForesight Education and Workforce Development Working Group (EWD). These individuals are known for their leadership in and access to key public-private networks engaged in critical education and workforce development initiatives, including the:

- public-private workforce investment system;
- secondary and postsecondary career and technical education systems;
- community and technical college systems, with particular emphasis on the 175 centers focused on advanced technologies;
- Manufacturing Extension Partnership system;
- economic development system at the state and local levels;
- university systems, including R1's, state, public and land-grant universities;
- higher education systems broadly defined; and
- innovation institutes/centers associated with institutions of higher education.

The EWD adopted the following mission of MForesight to guide their selection process:

MForesight will articulate the principles underlying policies and practices to ensure an educated, skilled, and ready U.S. manufacturing workforce, competent and confident in using state-of-the-art and emerging technologies and new materials and processes in advanced manufacturing.

The group identified five governing themes that define areas of need and innovation in education and workforce programs:

1. Engaging Students in STEM & Manufacturing: Creating a Manufacturing Mindset
2. Building the Technology-Savvy Workforce: Creating an Ecosystem for Success
3. Targeting Special Populations: Capturing the Full Strength of Our Workforce
4. Re-designing University Curriculum: The Hard Science of Engineering is No Longer Enough
5. Involving Manufacturers in Education Reform: The Key to Successful Solutions

This report summarizes a sampling of replicable and scalable promising practices being pursued to ensure that America builds an educated, skilled, and ready workforce. MForesight has not endorsed any particular product or method in presenting these promising practices, and is pleased to invite learning institutions, professional organizations, and manufacturers to submit descriptions of additional programs and initiatives serving similar purposes. In this way, MForesight hopes to build a community of practitioners and learners to help build an educated, skilled, and ready advanced manufacturing workforce. Concurrently, the EWD will continue its work to translate the key characteristics of these promising practices into policy and investment guidelines for government, industry, and educational enterprises that will support efforts to bring such practices to scale.

CHAPTER 1

PROMISING PRACTICES *for* Engaging Students in STEM and Manufacturing



Creating a Manufacturing Mindset

If America is to compete globally as a leader in advanced manufacturing, the students who are entering our U.S. high schools, community colleges, and universities must see advanced manufacturing as a desirable and attainable career path. For more than a decade, leaders from government, business, and industry have bemoaned the fact that students and experienced workers view manufacturing jobs as dirty, dull, and (often) dangerous. We need to convince students—and their parents—early on that the current world of advanced manufacturing not only includes high-paying jobs, but also values high-level skills in science, technology, engineering and math (STEM); offers clean and safe working environments; and creates opportunities for multiple diverse populations. Bringing awareness to the wide world of engineering design and manufacturing opens minds of our youth to a wide range of career opportunities on and off the factory floor including, but not limited to: design engineers, analysts, managers, accountants, executives, line supervisors, patent attorneys and most of all, a pathway to be a creative, hands-on entrepreneur and innovator. Not only have manufacturing jobs become more attractive, but the demand for well-trained workers to fill them has increased.

The programs described here address these perception and skills problems in new and engaging ways. They offer workable solutions by providing accessible and dynamic resources to help students and parents access current information about careers in advanced manufacturing and by engaging students at all levels in hands-on activities that both inspire interest in advanced manufacturing and help them better prepare for future manufacturing careers.

Edge Factor: A Multimedia Resource to Engage Students, Parents, and Educators in Advanced Manufacturing

Edge Factor produces videos and TV shows for consumption on a digital platform. Called eduFACTOR, the platform is a membership-based, online library of multimedia resources, many of which inspire interest in STEM education and manufacturing careers. Subscription fees support a platform that allows an organization or school campus to access one or more of the Edge Factor media productions. The tools are designed to help science, technology, engineering, art, and math (STEAM) teachers make learning relevant for students, while highlighting manufacturing stories, technology and pathways, and building STEM awareness for students. Additional tools for parents highlight national investments in advanced manufacturing education, and show that manufacturing can provide their child a career upon high school graduation.

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Edge Factor provides access to multi-media packages that include clips from Edge Factor's TV series, The Edge Factor Show and LaunchPoint, technology and career pathway videos, hands-on computer numerical control (CNC) machining and 3D printing projects, leadership and soft skills videos, event resources, virtual field trip experiences, interactive classroom and STEM activities, tools to reach parents, career and technical education (CTE) training success videos, and more. Edge Factor's suite of educational materials is managed by the eduFACTOR support team which also works with subscribers to understand the challenges the manufacturing and CTE community is facing, and helps integrate feedback into the platform content. eduFACTOR resources give students an inside look at what modern manufacturing is. Sample Edge Factor Live Topics include:

- Inspiring the Next Generation of Makers
- Redefining Success
- Putting Career Pathways in Focus
- Advanced Manufacturing and Technology
- Bringing STEAM and CTE to Life

Scalability and Replicability

Edge Factor's goal is to change perceptions and build awareness in middle school on up through college. The platform is scaled for use nation-wide and potentially globally, and the learner community managed by the company's support team assures that successes in one community can be replicated in others through continuous improvement of and addition to educational materials. As the Strategic Content Partner for Manufacturing Day (MFG Day), Edge Factor has created a free turn-key package that allows schools and other institutions to easily join this nationwide initiative by providing access to promotional materials, main event presentation tools, interactive resources and hands on projects and post event tools. In 2015, 734 organizations including businesses, schools and government agencies hosted events using the Rock MFG DAY Kit,¹ and in 2016, 245 organizations accessed the Kit and planned to host a MFG Day event.

¹ Rock MFG Day Kit. <http://www.edgefactor.com/rockmfgdaykit>

MakerMinded is a new program supported by LIFT (Lightweight Innovations for Tomorrow), a public-private partnership operated by the American Lightweight Materials Manufacturing Innovation Institution (ALMMII). MakerMinded is being launched initially in Tennessee, home to its platform developer, Tennessee Tech University, and managed in the state by the Tennessee STEM Innovation Network (TSIN). The program aims to create the next generation of manufacturing leaders by helping students develop a manufacturing mindset, and bridging the gap between educational activities and the students who can benefit from them. It puts proven interventions and strategies in place specifically where the STEM workforce pipeline begins to break, during the formative years of 7th-8th grade when students make subconscious decisions about what, if any, higher education and career they will pursue.

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MakerMinded brings together user-based information, the excitement of competition, and community communication in a digital platform. It provides students a curated portfolio of national and local-level STEM and manufacturing career exploration activities, project-based learning, formal educational resources, and other experiential learning opportunities. The platform allows students to compete with other schools in a statewide MakerMinded campaign, where points for completing activities are tallied and tracked through a real-time leader board. Programs and activities range from “low-touch” or “short term” to “high-touch,” longer term experiences. Sample activities from the MakerMinded portfolio include:

- SkillsUSA
- Science Olympiad
- FIRST Robotics
- Project Lead the Way
- Team America Rocketry Challenge
- 4-H National Youth Science Day
- Learning Blade
- Manufacturing Maker Spaces
- MFG Day
- LIFT Oculus Game
- Future Engineers

The MakerMinded platform provides access to programs and activities from multiple STEM/manufacturing disciplines, offers diverse delivery methods, and supports multiple learning outcomes. Students and their schools select the activities and programs that best match their interests, resource capacities, academic priorities, curricula, and skill/knowledge levels. The portfolio provides students with alternative options to gain foundational STEM/manufacturing skills and experiences, with an emphasis on work-based, project-based, and problem-based learning. Featured are the use of cutting-edge technology, relevant “real-world” content, and access to industry partnerships that provide mentorship, subject matter expertise, and other learning experiences. The customizability of a school’s activity portfolio is essential to ensure that all schools—regardless of their resources, capabilities, or current involvement in STEM—can participate in the MakerMinded platform.

Scalability and Replicability

MakerMinded aims to have middle schools across the state signed-up and active on its platform. The program proposes a partnership model uniting the platform developer with a state-wide STEM network and the national LIFT program to achieve scalability, and offers a customization component that allows schools to choose activities and projects that work with their goals, easing replication of materials. A statewide rollout of MakerMinded across Tennessee is planned, as well as the development of national tools and resources that extend rollout of the platform to other LIFT-supported states. Kentucky will be the second state of implementation, with the Kentucky Association of Manufacturers as the implementation leader.

Learning Blade: Growing Interest and Sharpening Skills for STEM

Learning Blade is an online supplemental curriculum for middle-school students that is designed to grab students' attention while introducing them to the careers, tools, and technologies found throughout the STEM fields. The platform, offered by Thinking Media, provides high quality learning tools that are focused on giving students real-world learning experiences in STEM education. It does this by providing interactive missions that integrate the processes of developing a student's interest in STEM, building awareness of STEM career opportunities, and reinforcing academic standards and skills. The online platform is complementary to project- or lab-based activities. Learning Blade activities can be used both in an entertaining self-paced game environment or as skill practice within academic classrooms.

Learning Blade introduces more than 90 STEM careers and technologies through supplemental online missions that focus on how these jobs benefit people and society (e.g., Dolphin Rescue, Haiti Orphanage, Heart Surgery). The missions, presented in a game environment, are completed by learning about the careers and technologies that would solve these problems in real life.

In the game environment, students complete several short, online, interactive academic lessons that present questions or problems. The lessons focus on how people in STEM careers use the skills typically taught in middle school. Constructive feedback is provided if the student answers incorrectly. A narrative soundtrack ensures that students with low reading skills can both benefit from the curriculum and practice comprehension with informational texts.

Each Learning Blade lesson contains evaluations that provide information on student and class performance down to the level of individual skill standards and objectives. Each evaluation question is indexed to individual academic standards, and lessons are individually aligned to the standards of each state.

Data provided by Learning Blade developers show that after using Learning Blade, 70 percent of students said they learned about new careers; 75 percent of students said they learned about technology; 69 percent strongly agree that "what I learn in school will be useful later in my life"; and 79 percent strongly agree that "math is helpful when solving interesting problems." Learning Blade also claims that the curriculum increased the number of students who strongly agree that "I would like to be an engineer or scientist in the future" by 97 percent and "In high school, I plan to take advanced math classes or more science classes than required" by 56 percent.

Scalability and Replicability

Learning Blade is aligned to all 50 states' academic standards and provides robust reporting capabilities. The modular nature of the curriculum allows integration with existing curriculum and projects. If teachers do not have suitable project-based learning experiences, Learning Blade provides classroom-ready "Mission Challenges" for each mission. These include simple hands-on experiences that require common materials often found in classrooms or homes, team-based discussions, oral presentations, and open-ended writing assignments. The program has already demonstrated its capacity to scale across several states (including North Carolina, Illinois, Minnesota, Nevada and New Mexico), and replicability in a variety of classroom settings. According to a report from Battelle Education² students have completed more than 270,000 lessons with more

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² Learning Blade & Battelle Education. *STEM in the Middle: Improving Interest in STEM Careers in Middle School using Learning Blade*. http://www.learningblade.com/Learning_Blade_BattelleEd_Report.pdf

than 40,000 hours of online use. And more than 100,000 students have registered in the system from nearly 1,000 schools and organizations in 32 states.

High School evGrandPrix: Engaging High School Students in STEM Education for Manufacturing

The High School evGrandPrix (HSevGP) is part of the Indy 500 series of activities to advance Science, Technology, Engineering, Math (STEM) education focused on manufacturing. The program is operated by Purdue University and sponsored by LIFT (Lightweight Innovations for Tomorrow). Co-supporters include multiple government, education, and industry partners. Students in the program learn how to engineer, build, test, and even market their vehicle creations, highlighting all facets of the manufacturing process. The students then race their vehicles at the Indianapolis Motor Speedway (IMS). The high school event is modelled after the International Collegiate evGrandPrix, but will use lead acid batteries versus the higher energy (and more costly) lithium-ion batteries that power the collegiate event. Purdue University partnered with the United States Auto Club (USAC) to develop this electric powered go-kart competition for students. The High School evGrandPrix will give students the opportunity to work in a team to manufacture a go-kart requiring the academic mathematics/science content of engineering design, as well as the hands-on machining/electronics needed to transform that design into a working go-kart.

The High School evGrandPrix is not primarily about the go-kart race, but rather the engineering, science, organizational management, and marketing/advertising needed to design, build, test, and race the go-karts. Event scoring is: 40 percent race placement; 20 percent engineering design; 20 percent energy efficiency, and 20 percent community outreach.

The program anticipates achieving the following outcomes:

- introducing students to manufacturing in an engaging manner;
- encouraging students to continue their education in manufacturing and enter a BS/BA program, an associate degree in a manufacturing program, or an industry position;
- providing hands-on projects that illustrate science/math principles;
- showing a clear connection between STEM competencies and the skills needed for a productive career in advanced manufacturing; and
- showing how light-weighting is an important component of vehicular design.

Scalability and Replicability

The program started in Indianapolis in 2015 and engaged several rural schools as pilots to demonstrate how the program can scale into rural high schools where students with considerable hands-on skills often naturally lean toward a manufacturing career. Because of the partnership with USAC, the program is working towards expanding into neighboring midwestern states like Michigan, Ohio, Kentucky, and Tennessee in subsequent years.

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SkillsUSA: Empowering Young People to Become World-class Workers, Leaders and Responsible American Citizens

SkillsUSA, formerly known as VICA (the Vocational Industrial Clubs of America), is a nonprofit membership association of students and educators partnering with industry to close the skills gap and ensure America has a well-prepared workforce. SkillsUSA aims to improve the quality of America's skilled workforce through a structured program of citizenship, leadership, employability, and technical and professional skills training. The organization, operating at the national, state, and local chapter levels, serves more than 300,000 students and instructors annually and has 18,000 school chapters in 54 state and territorial associations. Membership in SkillsUSA grants access to the SkillsUSA educational programs and competitions.

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Membership fees for professionals and students are nominal and require affiliation with a state chapter for middle school, high school, or college memberships. In addition to membership fees, SkillsUSA is funded by donations and contributions from business and industry. At the annual national-level SkillsUSA Championships, more than 6,000 students compete in 100 occupational and leadership skill areas.

SkillsUSA programs help to establish industry standards for job skill training in the lab and classroom, and they promote community service. SkillsUSA programs and curricula include:

- SkillsUSA Work Force Ready System, a comprehensive tool to help students document entry-level skills as defined by industry and accepted by state education policy, offering over 40 technical and employability assessments in 11 cluster areas;
- Professional Development Program (PDP), which teaches 76 workplace skill competencies in a series of hands-on self-paced lessons;
- Career Skills Education Program (CSEP), containing 49 online lessons teaching basic employment and life skills to college/postsecondary students;
- Student2Student Mentoring, which gives high school students a chance to mentor younger students in the area of career development; and
- CareerSafe, a credentialed 10-hour online training program developed in cooperation with the Occupational Safety and Health Administration (OSHA) to provide students with basic knowledge of safety and a credential desired in the job market.

SkillsUSA students and advisors come from CTE programs that are arranged into 131 career clusters from Automated Manufacturing Technology to Entrepreneurship to Culinary Arts. Rigorous, academically aligned standards and authentic assessments were created by industry to ensure relevance to entry level skills, meet Perkins IV accountability requirements, and provide credentials to students who achieve industry-defined scores.

SkillsUSA assessment areas related to modern manufacturing include:

- Automated Manufacturing Technology,
- CNC Milling and Turning,
- Computer Maintenance Technology,
- Electronics Applications/Electronics Technology,
- Engineering Technology,

- Mechatronics,
- Power Equipment Technology,
- Robotics and Automation, and
- Welding.

Student competitions emphasizing skill development are also held in many of these areas; for example the Mechatronics competition consists of three events designed to measure the skills required in the modern automated manufacturing environment. Contestants are required to assemble, adjust and test an automated machine system, troubleshoot and repair a faulty machine system and take a comprehensive written test.

Scalability and Replicability

SkillsUSA chapters are already replicated across the U.S., so the program has demonstrated scalability and replicability. More than 300,000 students and advisors join SkillsUSA annually, organized into more than 18,000 sections and 54 state and territorial associations. Combining alumni and lifetime membership, the total number served this year is more than 360,000 and over its more than 50 year history the program has served more than 12.2 million members.

FIRST™: Game-based Programs to Inspire Interest in STEM

FIRST (For Inspiration and Recognition of Science and Technology) was founded in 1989 to inspire young people's interest and participation in science and technology. The mission of FIRST is to inspire young people to be science and technology leaders by engaging them in exciting mentor-based programs that build science, engineering, and technology skills that inspire innovation and that foster well-rounded life capabilities including self-confidence, communication, and leadership.

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FIRST runs four key STEM-based programs locally, nationally, and internationally for students age 6 through high school. The programs are competitions that are designed to inspire student interest in science and technology. Students are mentored by adults, largely volunteers, and coached to meet a specific “building” challenge, using everything from Legos (for younger children) to mechanical and electronic components. Teamwork, leadership, and respect for others is taught and expected as student teams compete for prizes and slots in regional and national/world competitions. Costs for participation are for team membership (no individual fees) and include parts for designing and building the mechanism that will meet the assigned challenge. Scholarships are available to support teams from low-income communities and to encourage diversity among participating teams.

FIRST combines the excitement of sport with the rigors of science and technology. Programs include:

- FIRST LEGO League Jr. introduces STEM concepts to children ages 6 to 10 while exciting them through building a mechanism with toys they know and love, LEGOs™.
- FIRST LEGO League (a FIRST and LEGO Group alliance) is composed of teams (up to 10 members, grades 4-8; ages vary by country participating) that participate in more advanced competitions by designing, building, and programming a robot using LEGO MINDSTORMS™.
- FIRST Robotics Competition has high-school students build robots to compete. Under strict rules, limited resources, and an intense six-week time limit, teams of 20 or more students are challenged to raise funds, design a team brand, hone teamwork skills and build and program industrial-size robots to play a difficult field game against like-minded competitors.

- FIRST Tech Challenge teams (10+ members, grades 7-12, ages 12-18) are challenged to design, build, program, and operate robots to compete in a head-to-head challenge in an alliance format. Participants have opportunity to qualify for college scholarships.

Although there are costs involved, FIRST believes that no team that wants to participate should have to decline due to lack of resources, and will do everything possible to make funds available to all teams who need them.

FIRST emphasizes that its programs are “More Than Robots.” Ten years of evaluation data indicates that FIRST participants are two times more likely to major in science or engineering, 33 percent of female FIRST participants major in engineering, and over 75 percent of FIRST program alumni have entered in a STEM field as a student or a professional.

Scalability and Replicability

FIRST programs are branded and trademarked, and have been highly scalable and replicable. Now in its 26th year, FIRST has grown from 28 U.S.-based teams in the initial competition season to more than 44,000 teams today in over 80 countries, involving 400,000 kids and volunteers filling over 200,000 roles. FIRST evaluation data notes that 75 percent of FIRST alumni are now studying for or working in STEM careers, and female FIRST participants are four times more likely to study STEM subjects due to participation. FIRST also achieved its tenth consecutive four-star rating from Charity Navigator, certifying its continued commitment to accountability, transparency, and sound fiscal management.

To extend its reach, FIRST in November 2016 announced the launch of the 2017 FIRST STEM Equity Community Innovation Grant designed to help ensure that more underrepresented students and their communities are engaged in FIRST competitions, and otherwise improve opportunities for students. FIRST will provide funds to up to 15 communities in the United States and Canada.

Science Olympiad: Driving Students to Explore the World of Science

Science Olympiad delivers one of the largest K through 12, school-based team STEM competitions in the nation, with 7,600 teams in all 50 states competing in 400 one-day tournaments on college campuses. Science Olympiad competitions are like academic track meets, consisting of a series of 23 team events in two divisions—one for middle school and one for high school. The events are completed through classroom activities, research, training workshops and participation in intramural, district, regional, state, and national tournaments. The success of all Science Olympiad programs is driven by meaningful partnerships among community, businesses, industry, government, and education.

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Science Olympiad is a national non-profit organization dedicated to improving the quality of K-12 science education; increasing male, female, and minority interest in science; creating a technologically-literate workforce; and providing recognition for outstanding achievement by both students and teachers.

Each year, a portion of the Science Olympiad events are rotated to reflect the ever-changing nature of genetics, earth science, chemistry, anatomy, physics, geology, mechanical engineering, robotics, and software coding. The competition aims for a balance between events requiring knowledge of science concepts and those requiring

process skills and science applications. By combining events from all disciplines, Science Olympiad encourages a wide cross-section of students to get involved. Emphasis is placed on active, hands-on group participation.

Challenges posed each year are standards-based, developmentally appropriate, and include recognition of students' physical skills and cognitive abilities. As students move from station to station displaying their understanding and ability in science, members of the community (leaders from government, business and industry, professors, scientist, educators, and others) evaluate the students' science achievements.

The variety of events exposes students to practicing scientists and career choices, and energizes classroom teachers with a dynamic experience. The goals of the tournaments are to:

- bring science to life, to show how science works, to emphasize problem solving aspects of science and the understanding of science concepts;
- develop teamwork and cooperative learning strategies among students;
- make science education more exciting so more students will enroll in science courses and engage in other science activities like science reading, fairs, meetings, and field trips;
- promote high levels of achievement and a commitment to excellence in order to demonstrate that American students can perform at levels that surpass expectations of even practicing scientists and engineers; and
- attract more students, particularly females and minorities, to professional and technical careers in science, technology, and science teaching.

The culmination of regional and state tournaments is the Science Olympiad National Tournament, held at a different university each year.

Scalability and Replicability

Science Olympiad hosts competitions in all 50 states, allowing schools and students to participate regardless of geographic location. Science Olympiad strives to excel in both the classroom and out-of-school-time space with co-curricular activities designed to spur exploration, problem solving, and creativity. The roster of events enhances any school or district's educational mission and the events and lesson plans are aligned to NGSS, Math, and English Language Arts (ELA) standards.

Regional and State Science Olympiad chapters can seek grants from local businesses and foundations, and for about \$1,000 per team, schools with underserved populations can experience hands-on STEM competition, career preparation, and standards-aligned teacher training.

CHAPTER 2

PROMISING PRACTICES *for* Building a Technology-Savvy Workforce



Creating an Ecosystem for Success

In *America's Advanced Industries*, a 2015 report from the Brookings Institution,¹ researchers conclude that three principles must guide the growth of advanced industries in our country: commit to innovation, recharge the skills pipeline, and embrace the ecosystem.

Commitment to innovation requires the strength of our research universities, investments in science and technology, and nationwide encouragement of entrepreneurship. The tech-savvy skills pipeline is deeply dependent upon our public and private schools, as well as on programs that are industry-led and provide high-tech education and training. Perhaps the most elusive principle cited above is the need to “embrace the ecosystem,” which in its broad sense simply means to support the environment where advanced industries (or advanced manufacturing, as is our focus here) thrive. Yet economic success in the advanced industries sector is strongly linked to the health of and relationships among partners in their environments. And a healthy ecosystem shared among partners for advanced manufacturing is central to building a technology savvy workforce.

The approaches to building a tech-savvy workforce presented here have banked their success on building healthy ecosystems, systems that reflect strong relationships among educational institutions, developers of technology, and advanced industries that not only have need for a highly skilled workforce, but also are willing participants who are stretching the human pipeline from the classroom straight into the workplace. Key elements of these projects' success include: long-term relationships between educators and employers, a good deal of “skin in the game” in terms of physical and financial resources, and clear commitments from the communities and governments in the regional areas they serve.

The Francis Tuttle Technology Center's Advanced Manufacturing Program: Student-centric and Industry-specific

The Advanced Manufacturing Program at the Francis Tuttle Technology Center (FTTC) in Oklahoma City specializes in training highly skilled industrial maintenance technicians for regional manufacturers and energy companies. The FTTC is a vocational center for three school districts. The manufacturing programs are individualized and competency-based, free to high school students and offered to adults for a fee. Programs can often be completed within three semesters, after which graduates are placed into industry positions. Funding comes from the school districts as well as industry donations.

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The Advanced Manufacturing Program (AMP) is an individualized, competency-based program, in which students learn about everything from basic fabrication and fluid power systems, to programmable logic controllers (PLCs) and Supervisory Control and Data Acquisition (SCADA). Curricula for these competencies are available online and in day and evening programs in the class and lab.

The FTTC student-centric approach emphasizes meeting industry needs and student job placement rather than program completion; this approach has not negatively impacted the program's success. In fact, the Advanced Manufacturing program (both daytime and evening classes) has maintained enrollment in excess of 100 percent for the past several years and both those students who exit early and program graduates earn an average starting salary in excess of \$45,000 per year. Advanced manufacturing programs currently listed for enrollment include:

- Advanced Manufacturing Technician,
- Energy Technician,
- Instrumentation and Process Control Technician, and
- SCADA (Manufacturing and Energy Systems Emphasis).

These programs are also associated with the Get Skills to Work coalition, an association dedicated to connecting veterans with high-wage manufacturing careers. Other manufacturing programs offered by FTTC in alliance with the coalition include: Computer-Aided Design and Drafting; Precision Machining/ Computer Numerical Control; and Welding.

Many of the students are employable at an excellent salary well before they complete the program. In the 2015/2016 school year there were 14 program completers but a total of 24 students were placed in related jobs with an average starting salary of \$28.02 per hour. So far in the 2016/2017 school year there are 15 program completers but a total of 17 students have, thus far, accepted positions related to their training. The reported salaries for the students employed this year range from \$18.00 - \$35.00 per hour.

Industry members serve on the FTTC AMP Advisory Committee. The program has received more than \$300,000 in industry donations of equipment and resources in the past 3 years. Donations are often unsolicited and offered because a company has a need for employees trained on their particular equipment. Such industry support helps to create a vibrant, ever-evolving lab that meets industry needs.

Scalability and Replicability

Because the FTTC Advanced Manufacturing Program is offered both online and in the classroom, it transcends many of the “scalability” limitations of a traditional classroom program by offering flexible scheduling for its students. Replication of this program is achievable by any school currently using or willing to incorporate individualized and competency-based curriculum.

Learn Work Earn: A Minnesota Advanced Manufacturing Partnership Project

Learn Work Earn, the Minnesota Advanced Manufacturing Partnership (MnAMP), brings industry, state leadership, public education, and manufacturing associations together to develop educational concepts that will produce a highly-skilled workforce to meet the needs of the manufacturing industry now and in the future. MnAMP is a consortium of 12 geographically-dispersed community colleges and two universities from the Minnesota State System; the consortium was created to help close the skills gap in Minnesota. MnAMP established the Learn Work Earn project, which targets Trade Adjustment Assistance-eligible workers, veterans and other adult learners. Led by South Central College, MnAMP’s Learn Work Earn program focuses on career pathways in advanced manufacturing—specifically machining, welding, and mechatronics, all careers offering well-paid positions in Minnesota industries.

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Learn Work Earn was jump-started by a \$15 million Trade Adjustment Assistance Community College and Career Training (TAACCCT) grant awarded to the 12-member consortium offering the program. Learn Work Earn includes a standardizing manufacturing-based core curriculum at partner organizations, and it provides adult learners a path to education, credentials, and employment. Learn Work Earn has adopted the following strategies to help move adult learners into meaningful, industry-relevant educational pathways and ultimately into the workforce:

- Create seamless career pathways in advanced manufacturing academic programs that offer stackable and latticed industry-recognized credentials.
- Implement a core curriculum that directly aligns with the Certified Production Technician Certification awarded by Manufacturing Skills Standards Council.
- Develop a consistent competency-based approach to award credit for prior learning that aligns with national industry standards.
- Collaborate with MnSCU Centers of Excellence to expand/refine articulation agreements;
- Create/update academic programs in advanced manufacturing to match employer needs and industry-recognized credentials.
- Align curriculum with National Association of Manufacturers (NAM) endorsed credentials (NCRC, MSSC, NIMS, PMMI and AWS).
- Engage employers, faculty, and other stakeholders in development of course content, coursework, and learning experiences.
- Establish employer-driven OJT opportunities such as apprenticeships and dual-training opportunities.

Learn Work Earn pathways help participants move into education at various points in the process depending on individual skill levels. Participants can also have their prior education and experience assessed for possible credit in order to ensure an efficient and timely transition from training to degree completion. In addition to the strategies listed above, Learn Work Earn also promotes long-term collaborative partnerships with manufacturing employers, employer-driven apprenticeships and cooperative education programs, and professional development for employers and other stakeholders to instill the value of higher education and industry

credentialing. Improving job placement and retention through attentive advising and job placement services are also hallmarks of the program.

Three advanced manufacturing programs are offered at various sites among this consortium membership:

- *Machining*, which teaches students about multiple aspects of computer integrated machining, including working with engineering drawings, CNC programming, lathe turning, vertical milling, grinding, jigs, fixtures, molds, and dies, and provides students with the opportunity to receive industry-recognized credentials from national associations in machining (average salary \$49,950);
- *Welding*, which gives adult learners the skills needed for welding in construction, fabrication, plant maintenance settings, and more, and includes training in electric arc, wire feed, heliarc welding, oxyacetylene welding, and various flamecutting processes (average salary \$39,970); and
- *Mechatronics*, a new and rapidly growing field that integrates electronics, mechanics, pneumatics, hydraulics, and computer control systems to create new and improved automated manufacturing production systems that are required in the medical, electronics, agriculture, biotechnology, and automotive industries. (average salary \$60,095).

Learn Work Earn also offers the Advanced Manufacturing Core Curriculum and other manufacturing courses via telepresence through a new program called +Connect. Employees can train right at their company, making +Connect ideal for incumbent workers and those in apprenticeships or dual-training programs. +Connect is serving 342 participants and 46 industry partners.

Learn Work Earn is serving 2,204 participants, and of those, 583 have earned either an industry credential or an academic credential. 189 incumbent workers have received a wage increase after completing a training.

Scalability and Replicability

The Learn Work Earn program has demonstrated that with funding, industry support, and strong collaboration among regional educational providers, a consortium can duplicate industry-specific programs at several locations that allow students to prepare for possible employment in multiple state industries. This model can be replicated in other states with community college systems and scaled through liberal use of teleconferencing or other means of delivering programs at industry sites.

NC3—The National Coalition of Certification Centers: Learning that Works

The National Coalition of Certification Centers (NC3) was established to address the need for strong industry partnerships with educational institutions in order to develop, implement and sustain industry-driven and industry-recognized, portable certifications that have strong validation and assessment standards in the transportation, energy, and aviation sectors. NC3 is a non-profit network of education providers and corporations which develops and implements portable, stackable, industry-recognized certifications built on national standards for existing technicians, new students, and displaced workers in the transportation, aviation, manufacturing, and energy industry sectors. NC3 is funded through community colleges and industry contributions.

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NC3 is the outgrowth of the relationship between Gateway Technical College in Wisconsin and Snap-on Inc. In 2007, Snap-on teamed-up with Gateway to create a diagnostics training and certification center and has evolved today to become the NC3-National Coalition of Certification Centers.

Initial certifications were developed for automotive diagnostics and the process became a template to engage other educational providers and industry members nationally. The scale of the effort was then expanded to include truck diagnostics (diesel, natural gas, and hybrid). The initiative expanded to the energy industry to address the need for industry-recognized torque certification standards and their application to the construction, commissioning, and maintenance of wind towers. The latest offerings include commercial HVAC certifications that address the need for training in use of highly computerized controls and their performance maintenance.

NC3 mobilizes public-private partnerships between industry and educational institutions to provide comprehensive curriculum development and access to standards-based skill certifications. Credentials are developed at the national level that validate skill sets required to meet performance standards. Training is then designed and implemented locally with industry experts and educators collaborating. NC3 supports the work done on both platforms. NC3 equips its partner community colleges, technical schools, and high schools with a strategic plan, professional development support, turn-key implementation, and sustainable funding models, while always engaging industry at the very first steps in the process. The NC3 staff leverages its national network of business partners, such as Snap-on, Trane, Fiat Chrysler Automobiles, and L.S. Starrett, to build local industry support.

NC3 recruits membership from community colleges, high schools, and training centers. Members gain access to:

- nationally standardized certifications,
- best practices,
- real time expertise on industry-driven career pathways,
- world-class programs based on national skill standards,
- world-class facilities that reflect industry trends and vision,
- graduates prepared to industry standards, and
- professional development opportunities for incumbent workers.

NC3 credentials are an overarching system developed for specific tool use and centered on industry skills. The school's existing course curriculum is the basis of the training while the NC3 certification is a stackable component that complements the course. The NC3 certification pads the school's program with theory and hands-on practice with specific company-sponsored equipment and tools. Students graduate with transferable knowledge and competencies valued by the sponsoring company and any employer. This curriculum design approach avoids any need for rewriting and lends to a school's quick and low-cost implementation. Students have fast, easy access to their certificates anytime online upon successful completion of their exams.

NC3's "Train-the-Trainer" effort provides standardized, world-class training and guidance to new and experienced instructors. Instructors spend a week engaged in hands-on learning with other top instructors from around the country.

NC3 coordinates a National Signing Day at member schools to celebrate the incoming class of new "industrial athletes"; this event elevates career and technical education students to the ranks of star scholars and athletes in a community. The idea is to replicate a similar feeling of accomplishment and pride for students dedicating their time and effort to focus on CTE careers.

Scalability and Replicability

The NC3 strategy provides the platform for member schools to extend their work with other educators, industry partners, and organizations to a national level. The strategy to grow the network is implemented through regionally located NC3 leadership schools. Leadership schools work with new schools to serve as models and mentors, conduct Train-the-Trainer activities, and assist with national certification development. NC3 has attained rapid year-to-year growth since its inception, doubling the number of certifications awarded to students every year since 2009. The current consortium includes 43 leadership schools and industry sponsors and 10 global industry partners and professional organizations working with educational administrators and instructors to ensure that centers are equipped with leading-edge technology and relevant and effective learning environments.

360 eTech: Online Training for Careers in Manufacturing

360 eTECH is part of 360 Manufacturing and Applied Engineering Center of Excellence, which is a consortium of 15 institutions led by Bemidji State University and includes 14 technical and community colleges. The 360 eTECH curriculum is administered by 360 and offered online, with skills labs held on weekends. Students can earn certificates that are aligned with national standards and are prepared to take certification exams, dependent upon their enrolled program. Courses are for credit and offered throughout the year in eight week modules toward certificates in Automation Technologies, Welding Technologies, and Production Technologies. 360 eTECH is supported by a National Science Foundation (NSF) Advanced Technological Education (ATE) Program Grant.

360 is a member of the Minnesota State Colleges and Universities system and a collaborative effort between education and industry to recruit, educate, and train workers for dynamic careers in advanced manufacturing. 360 leads Dream It. Do It. in Minnesota, collaborating with Minnesota industry and educators to present modern manufacturing as career of choice. Dream It. Do It. Minnesota is a recruitment campaign that provides resources for educators, hosts STEM events that connect youth to manufacturing, and promotes modern manufacturing in Minnesota.

360 received a National Science Foundation grant in 2012 to become an Advanced Technological Education Regional Center offering the 360 eTECH program. To produce the program, the center adapted and developed a 165-credit curriculum to be delivered in a blended format, combining traditional classroom and lab education with online course delivery. This curriculum allows students to work toward either a two- or four-year degree. Goals for the curriculum include: increasing the supply of technicians and engineers in manufacturing jobs in Minnesota, implementing innovative education strategies, and expanding accessibility for students through the use of distance learning technologies.

360 eTECH makes online and hands-on manufacturing education available to those who may not be able to access it in a traditional manner. A consortium of colleges across the state of Minnesota has adopted the 360 eTECH curriculum. 360 eTECH helps different groups of people access higher education for manufacturing careers including: incumbent workers seeking advancement, students at rural high schools with limited

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resources, students with full-time job schedules that do not align with traditional course times, and employers seeking new-employee training.

Four certificates are available through 360 eTECH that enable individuals to gain the needed skills to pursue in-demand manufacturing careers. Production Technologies is a 16-credit certificate that introduces students to production technologies and the foundational skills to start on a manufacturing career pathway. Building on this certificate, three additional 30-credit industry specific certificates are available: Automation Technologies, Machine Technologist, and Welding Technology.

The entire 360 eTECH program is designed for individuals to both build their education and enhance their careers. Individuals gain the foundational skills to start careers, and they have the opportunity to continue their career pathway beyond entry-level jobs by earning additional certifications.

The 360 eTECH program is comprised of 8-week courses with four starting points throughout the year. Instructor-led lectures are offered 100 percent online with hands-on skill labs scheduled on weekends. The curriculum was jointly developed by faculty from multiple colleges, and teaching resources are shared among multiple campuses. The Production Technologies certificate is aligned with the Manufacturing Skill Standards Council (msscusa.org) Certified Production Technician (CPT) certification, a nationally recognized credential. Students completing the program are prepped to take the CPT exam.

360 eTECH programs do not require enrolling for a full-time course load (12+ credits) each semester. Flexibility in course scheduling allows students to take one or many courses each term. A full-time student can complete a 30-credit certificate in one full academic year. In FY 2017, there were 103 participants in the 360 eTECH program.

High schools can enroll students in the 360 eTECH program to earn certificates in Production Technologies and Welding Technology. Through the 360 eTECH High School Program, students:

- Earn college credit;
- Prepare to test for an industry-recognized credential from the Manufacturing Skill Standards Council;
- Start their career pathway with the opportunity to continue their education; and
- Advance their careers in welding and fabrication at various locations throughout the state.

Scalability and Replicability

Since its inception, 360 eTECH has made an impact with nine participating colleges offering the curriculum. In addition, two subsequent federal grants have adopted the 360 eTECH model as a requirement to meet the goals specified in the grants. However, the most growth has been seen in the adoption of 360 eTECH by high schools, allowing students to earn college credit in technical programs that may not be available to rural high schools, and by manufacturing companies as part of new-employee training programs to establish foundational knowledge in a format that does not interfere with production schedules.

Lorain County Community College: Innovative Talent Development Models for Advanced Manufacturing

Lorain County Community College (LCCC) in Ohio collaborates with a number of Manufacturing USA institutes to identify, pilot, and scale gamechangers for advanced manufacturing education and workforce development. Most recently, LCCC became the lead institution of Ohio Tech Net, a collaboration with 11 other community colleges (initially sponsored by a \$15 million grant) which offers workforce training in techniques of advanced manufacturing. Currently, aided by a grant from LIFT (Lightweight Innovations for Tomorrow), LCCC is leading a state-wide effort among community colleges to offer common courses in advanced manufacturing foundations. Other LCCC innovations include building the nation's first FabLab maker space; establishing GLIDE, a technology incubator on campus; creating the first innovation fund for start-ups; and developing and expanding the Great Lakes Technology Park. Existing partnerships include: America Makes, LIFT, NextFlex, and Digital Manufacturing Design Innovation Institute.

Lorain County Community College offers over 120 associate degrees and certificates aligned to in-demand careers. The college's university partnership program offers students the opportunity to earn one of 30 Bachelor and 12 Master degrees on the LCCC campus. The college also partners with secondary schools to maximize opportunities for students to earn college credit at no cost while still in high school.

Lorain County epitomizes the shift from traditional, labor-intensive manufacturing to technology-intensive, highly adaptive advanced manufacturing, with resulting dislocation of jobs and need to upskill our workforce. Today, in Lorain County only 13 percent of the employment base is in manufacturing, yet manufacturing is still the economic engine of the community and will continue to be so as new technologies and innovations bring manufacturing back. In response, LCCC has developed programs in workforce and talent development, entrepreneurship, innovation, and manufacturing/ commercialization. LCCC assists companies during the innovation process, providing commercialization services, business coaching, pre-seed capital, and talent.

LCCC is progressively developing and linking assets that can build an educated and skilled advanced manufacturing workforce that recognizes, through seeing these linkages, the importance of tying innovation, technology, advancement, economic development, and workforce development together to continuously build and improve industries.

Among LCCC's historical and continuing achievements are:

- Great Lakes Technology Park development and expansion (1984);
- GLIDE – a 20,000 plus square foot technology Incubator on campus (2001);
- Great Lakes Innovation and Development Enterprise (2001)
- FabLab – open makerspace factory with rapid digital prototyping capability (2005);
- National Science Foundation Weld-Ed Center (2007), expanded to a National Resource Center (2014);
- Innovation Fund – earliest pre-seed investment fund for technology-based start-ups (2007), designed to fill the gap between funding from family/friends and angel/equity-based investment funds (5 vested college/university partners);
- Blackstone LaunchPad – student-centered start-up incubator (2012);
- Lorain County Small Business Development Center (2012);

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- Desich SMART Commercialization Center – development and manufacturing resources to design and develop sensor-based products, funded by state, federal, and philanthropic sources, and training center for clean room technicians (2013); Office of Community Technology Transfer (2013); and
- Ohio TechNet – a collaboration of 11 community colleges focused on accelerating the readiness of adults for advanced manufacturing careers (2014).

Scalability and Replicability

The model of having a community college lead a state’s initiative to adopt common Manufacturing Foundation courses across all community colleges is scalable and replicable in other states. All states have community college networks in place, and funds can be used to support connecting the colleges to their local manufacturers and curriculum modifications.

Purdue Polytechnic High School: A New Partnership for STEM-focused, Experiential Learning

Purdue Polytechnic High School (PPHS) is an Indianapolis, Indiana, charter school launching in fall 2017. The school represents a collaboration among the Purdue Polytechnic Institute at Purdue University, Indianapolis Public Schools (IPS), and industry partners across the state. PPHS will target IPS students who are interested in Science, Technology, Engineering and Math (STEM) and prepare them for STEM careers, with a focus on high demand sectors in Indiana such as advanced manufacturing. PPHS’s mission is to create an environment of academic excellence characterized by industry-focused experiential learning; mentors who nurture, guide, and trust; and students who develop a natural thirst to learn in preparation for their lifelong journeys. The vision is to develop a new generation of skilled talent by seamlessly transitioning graduates from high school to college to high-tech, high-wage jobs. PPHS students who meet Purdue University’s admission criteria will have direct admittance to the Purdue Polytechnic Institute’s college programs.

PPHS was announced in 2015 with the goal of “increasing the number of low-income, first-generation and minority students who are prepared for success.” The school is designed to bring more inner city students into programs that prepare them for admittance to colleges and universities, particularly into STEM programs. The school has been authorized as a charter school, making it eligible for public funds and also for some non-profit grants. USA Funds supplied a \$500,000 planning grant, administered by EmployIndy, for the planning of the school. If the PPHS is successful, Purdue will consider establishing other polytechnic schools across the state.

Purdue University and Purdue Polytechnic Institute will play a major role in the PPHS programs. PPHS students will have on-campus experiences, with multi-week camps and research opportunities available in the summer. During the school year, Purdue faculty and students will be regular visitors to the high school, acting as instructors and mentors. Purdue alumni will be similarly engaged as the school takes advantage of a major Purdue presence in technology, advanced manufacturing and engineering, and agricultural companies in Indianapolis. In addition, all students will have the opportunity to complete at least one extended experience on Purdue’s main campus in West Lafayette, Indiana.

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Industry partners are included in curriculum design, project development, skill instruction, evaluation of student work, mentoring, and internships. Local advanced manufacturing and logistics companies and workforce development organizations have had significant engagement in initial curriculum design.

Design-based learning is the backbone of PPHS's innovative educational model. Student work will be focused on solving problems through design challenges and projects. These problems are to be presented in the context of real world issues that come from the cities and neighborhoods in which the students live as well as from business and industry partners. Students will work with others to develop solutions to complex issues, navigate barriers, and arrive at successful outcomes.

Scalability and Replication

Indiana needs high quality schools with a focus on STEM education and industry collaboration, particularly in advanced manufacturing. The partnership with Purdue University provides an optimal opportunity to expand the PPHS network to cities that align with Purdue Polytechnic Institute locations across Indiana. By taking the best practice model developed in collaboration with the Polytechnic, industry partners, and workforce development organizations, each high school campus can be differentiated based upon the needs of local industry and workforce needs. The vision is to have Purdue work with industry partners around the state to provide continuous professional development for staff in a network of schools, helping teachers provide the most up-to-date curriculum, guided by the needs of industry.

Michigan Coalition for Advanced Manufacturing: A Collaboration among Community Colleges to Offer Skill Certifications

Through a Department of Labor grant, the Michigan Coalition for Advanced Manufacturing (M-CAM) brought together eight Michigan community colleges, workforce development agencies, and employers to build talent capacity to meet the workforce needs of manufacturing employers for today and their future workforce. M-CAM provides training and certifications in welding, precision machining (CNC), multiple-skill/mechatronics, and manufacturing production. A mid-term report concludes that the grant strengthened the collaborative capacity of the eight participating colleges; aligned programs to industry-recognized standards; improved coordination among faculty, advising and career staff; improved student databases and tracking; and stimulated progress in collecting wage data and outcomes for students.

CONTACT

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M-CAM brings together the state of Michigan, community college leaders, employers, workforce development agencies, and other community partners to create education and training programs that lead to employment. With the award of \$24.9 million under the U.S. Department of Labor's Trade Adjustment Assistance Community College and Career Training (TAACCCT) grant program, M-CAM is creating a 21st century workforce through the development of seamless and responsive career pathways, credentials that have labor-market value, and strategies that connect to the needs of employers. The TAACCCT grant is a major investment to increase the ability of community colleges to address the challenges of today's workforce. Grants are designed to help workers eligible for training under the TAA for Workers program, as well as a broad range of other adults.

The M-CAM Consortium under the TAACCCT grant includes eight Michigan Community Colleges: Bay de Noc, Grand Rapids, Kellogg, Lansing, Lake Michigan, Macomb, Mott, and Schoolcraft. The advanced manufacturing certifications offered are in four areas: welding, CNC/machining, multi-skill/mechatronics, and production operations.

A key focus of the grant has been on aligning training curricula across each of the eight colleges to industry standards and industry-recognized credentials. In order to develop a comprehensive career pathways system, colleges also focused on developing intensive upfront assessment and career counseling, foundational skills training, and job placement services. The majority of the colleges spent between 20 and 40 percent of their grant funds on new equipment. These purchases increased the availability of hands-on, experiential learning for students on the types of equipment used by industry partners. Nearly half of the equipment purchased was used to strengthen the Multi-Skill Technician/Mechatronics pathway.

Across the consortium, the number of reported employer partnerships nearly doubled, from 204 in Fall 2014 to 392 in Spring 2016, and 356 employers across the colleges (91 percent of total employer partners) assisted with job placement for students. These employers interviewed participants at the colleges, participated in job fairs, and actively coordinated with M-CAM staff members to hire students. Ninety percent of students surveyed were satisfied or very satisfied with the training they had received. There were no significant differences in student satisfaction by college or by career pathway. Students who were interviewed appreciated the high quality of instructors, whom they viewed as having deep-levels of industry experience, and the hands-on and applied approach to learning. Employer partners strongly emphasized the need for colleges to focus on strengthening students' soft skills, such as punctuality and communication skills.

Colleges awarded the following professional certifications: 671 AWS, 289 NIMS, 175 MSSC, 44 PMMI and 20 Siemens. The percent of students completing any credential varied significantly by college. Earning a professional credential seemed to improve participants' employment prospects more than earning a college certificate alone. About three out of four exited participants who completed the survey felt that their training helped them obtain their most recent job. More than 80 percent of those employed after exit were employed in manufacturing-related industries.

Scalability and Replicability

Outcomes of the program have been substantial. Of the 40 percent of M-CAM students who have completed their studies, 1,727 earned college certificates, 1,482 earned professional credentials, and 83 earned degrees. By the time they exited TAACCCT services, the majority of participants (87 percent) left their college with at least one of these certifications. Close to three-quarters of participants who successfully completed their programs were employed by the end of the first quarter after exit. Two percent of participants were enrolled in further education and not employed, and about one-fourth were neither employed nor enrolled in further education. These statistics appear to point to the value of infusing funding into collaborative partnerships of institutions so that they can collectively improve their programming, share resources, and foster more permanent and productive partnerships with employers.

CHAPTER 3

PROMISING PRACTICES *for* Targeting Special Populations



Capturing the Full Strength of Our Workforce

America's competitiveness in a global economy not only requires a well-educated advanced manufacturing workforce, but also a much larger workforce. Our aging population and depleting workforce combined with the rising dominance of world manufacturing markets with able, ready workers demand that the U.S. expand its workforce potential or risk ceding our competitiveness to other nations. Expanding our workforce to meet this demand will require using the talents of all of our population, not just those whose economic backgrounds and social opportunities have ensured that they are well-educated and ready for employment today.

Currently, we are leaving far too many potential workers behind. As an example, we have 5.5 million "opportunity youth," defined as young people age 16-24 who are neither in school nor at work,¹ at a time when we project 2 million manufacturing jobs going unfilled for several reasons, including not finding candidates with the requisite skills.¹ This presents an opportunity for manufacturers to engage, educate, and employ young people who have been disconnected from our economy and provide them with a pathway to economic success.

The promising solutions that have been gathered for this section are engaging a range of populations whose potential remains untapped; these include students who are at-risk of not graduating from school, workers with disabilities that have excluded them from workplace settings, skilled veterans returning from the armed services who lack educational credentials, ethnic populations underserved by school systems, women underrepresented in technical careers, and poverty-stricken youth and adults whose means and locations have kept them from viable work. The solutions proposed are as varied as the populations they address and are workable today.

Southwire's 12 for Life: A Learn and Earn Program for At-Risk Students

Southwire's 12 for Life program is a work-based contextualized learning and education program designed to appeal to at-risk students and improve high school graduation rates. Southwire Company, LLC is North America's leading manufacturer of wire and cable used in the distribution and transmission of electricity. Southwire and the Carroll County School System in Georgia and the Florence City Schools in Alabama are working together on 12 for Life, an innovative program that places students in real jobs at Southwire, allowing them to earn wages while earning credit toward a high school diploma.

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The 12 for Life program at Southwire allows students to combine a four-hour shift at a specially designed Southwire plant with a work schedule built around their academic class requirements. The program runs three shifts between 8:30am and 9:30pm, and Carroll County Schools use their open campus night school to accommodate this schedule. At the 12 for Life plant, students rotate among workstations so they gain experience in the entire manufacturing process. They also earn two high school credits per semester. Because the workers are students, Southwire has made some modifications in the plant and processes; however, the plant functions like other production facilities. Materials the students manufacture are sent to large distributors across the country, and they become part of a stream of Southwire products that supply wiring to one in three new homes in the United States.

The 12 for Life partners collaborate to ensure the program maximizes the success of students. The Carroll County Schools, which understand Southwire's systems, processes, and products, select 12 for Life participants, manage onsite instruction, provide transportation, and facilitate students' postsecondary placement. The school system also tracks student progress and program success. Also, Southwire has invested \$2.5 million plus in 12 for Life, providing facilities, equipment, tutors, and jobs.

12 for Life offers STEM-related education in an innovative, high-impact, applied learning setting as part of the Georgia Race to the Top Innovation Fund project sponsored through the Georgia Governor's Office of Student Achievement. The Carroll County School System was awarded a \$1 million grant for 12 for Life to implement the project. Through the grant, 12 for Life has enhanced instruction by providing advanced academic opportunities to students traditionally underrepresented in STEM education. A key component of this project has been Southwire's in-kind contribution of a Quality Assurance Lab combined with a traditional chemistry lab. Over 300 products packaged at 12 for Life as well as competitor product samples are collected for students to evaluate, cross compare, and record in a computer program designated specifically to the 12 for Life facility. Another initiative engages students in the process of inventory management through the Raw Materials Warehouse where materials are received, managed, and shipped.

12 for Life students participate in contextualized classroom instruction, on-the-job training, and a life skills development initiative. Working from individualized instruction plans, the curriculum focuses on instilling a strong work ethic through responsibility, teamwork, communication, attitude, and other important workplace skills. Forty Southwire employees, ranging from vice presidents to engineers, volunteer to provide one-on-one mentoring to students. These employee mentors work with on-site managers and school representatives to form a support system designed to encourage the 12 for Life students and make their success possible. For those students who need assistance academically, Southwire provides incentives for tutors, brings in additional resources to help students prepare for their high school graduation exam, and provides opportunities for summer school.

Scalability and Replicability

By mid-year in 2015, more than 1,100 students had graduated from 12 for Life. Forty percent of those went on to post-secondary education, while another 30 percent joined the military. Another 20 percent went to work for Southwire or other employers. The State of Georgia's Great Promise Partnership is based, in part, on the 12 for Life model and other companies and communities have formed similar programs under this umbrella. The Georgia Department of Community Affairs (DCA), along with key partners, launched the Great Promise Partnership (GPP), Inc. in January 2012. As a 501(c)(3), GPP became affiliated with the Georgia Department of Economic Development, Workforce Division. The GPP program invites other communities to follow the model developed by Smartwire and its partners.

Pathways to Manufacturing Initiative: A Collaboration of Capital Workforce Partners, Our Piece of the Pie, and Asnuntuck Community College

The Pathways to Manufacturing Initiative (PMI) is an extension of Asnuntuck Community College's (ACC) Pathways to Success program. With funding from Capital Workforce Partners (CWP) and Our Piece of the Pie (OPP), ACC has developed the PMI program to provide Opportunity Youth (OY, youth 18-24 who are out-of-school and out-of-work) with a supported postsecondary experience culminating in their achievement of a postsecondary credential in Advanced Manufacturing. Students exit the program with knowledge and skills that make it possible for them to compete and enter into high-demand manufacturing labor markets where they can earn sustainable wages.

CONTACT

opp.org/contact/

<http://capitalworkforce.org/sector-focus/business-partnerships/#sthash.JFchwPzO.dpuf>

Video: www.youtube.com/watch?v=NH9rlcnEZ-U

The Pathways to Manufacturing Initiative combines the strengths and assets of ACC, CWP, and OPP, all operating in the state of Connecticut. CWP helps individuals overcome barriers to employment and closes the gap between skills and business hiring needs. The organization is guided by a consortium of the region's chief and elected officials and by representatives from business, education, and labor serving on its Board of Directors. CWP invests in youth development, develops sustainable career paths for adult workers, and assists employers with a variety of programs and services provided through the American Job Center network.

Asnuntuck Community College, located in Enfield, CT, has expanded its transfer opportunities to four-year institutions with guaranteed admission to the University of Connecticut and other state universities. ACC offers 17 associate degree programs and 31 certificate programs, with special strength in Advanced Manufacturing, Healthcare, Technology, and Business and Industry. Youth can enter the PMI program as seniors in high school.

ACC delivers a comprehensive, contextual learning experience combined with Occupational Skills Instruction in these certificate programs: Manufacturing Technology: Precision Machining, CNC Technology, Electronics and/or Welding. The hands-on courses offer a blend of technology, math, and science on either a full- or part-time schedule that prepares graduates for high-demand positions. To further certify hands-on experience, youth complete Career Competency Development Training taught by an OPP Workforce Development Specialist. In addition to training for their ACC certificate or degree, youth are helped through the following during their completion of Career Competency Development Training:

- Work Readiness Credential—a credential of the American Council on Education (ACE) which helps youth explore and enhance job interests and abilities through career assessments, career counseling, portfolio development, paid internships, job coaching and job retention services.
- Customer Service Certification—a program, distributed through the National Retail Federation, which develops transferable skills for youth to carry into their careers.
- Construction 101—a course delivered by an experienced OSHA-authorized trainer which leads to OSHA 10 certification to promote workplace safety and prevent health hazards.

Our Piece of the Pie (OPP) is a human services charity functioning as a youth development agency. OPP matches youth with youth development and workforce development professionals to assist them in: identifying their needs and strengths; setting appropriate academic, postsecondary, career, and personal goals; and acquiring the necessary strategies, resources, and support toward reaching those goals. Upon enrollment, each youth is provided with a caring, committed, proactive adult staff member. OPP operates both in Capital Community College (Hartford, CT) and at ACC. At ACC, in addition to the life skills OPP program, the focus is on Advanced Manufacturing. OPP’s program model covers three areas of practice:

- Youth Development Services—Features an ongoing relationship with a caring adult, goal setting, creation of an Individualized Success Plan (ISP), emergency support, personal development, barrier reduction, and connection to both internal and external supportive services.
- Academic Support and College Retention Services—Includes individual tutoring and homework help. OPP’s academic services are provided by academic specialists, and participants have access to ACC’s faculty and other academic supports. OPP holds individual progress meetings with each PMI participant and their postsecondary instructional team and communicates with them daily to ensure that any academic issues are addressed as soon as they arise.
- Workforce Development Services—Includes Career Competency Development Training (CCDT), job shadowing, internships, job placement assistance and retention support, and job coaching after employment is achieved. OPP’s workforce development services are provided by Workforce Development Specialists (WDS); participants also have access to ACC’s industry partnership opportunities.

The CWP, ACC, OPP partnership expects participants to meet these outcomes: attainment of stackable postsecondary credentials such as OSHA 10, Customer Service and a nationally recognized Work Readiness Credential; and Career Competency Development Training in leadership, life skills and financial literacy training. Industry-specific credentials lead to the following jobs and earning potential:

ADVANCED MANUFACTURING	LOW	AVERAGE	HIGH
CNC Machine Tool Programmers	\$32,500	\$46,400	\$70,900
Manufacturing Production Technicians	\$44,200	\$62,200	\$92,900
Inspectors, Testers, Sorters, etc.	\$25,800	\$42,000	\$71,200

Through ACC, OPP has served a total of 235 youth since 2015, in both their Advanced Manufacturing and Allied Health pathways. 125 youth have been placed in employment and 144 youth have earned credentials.

Scalability and Replicability

The PMI program at has become scalable through new partnerships among CWP, OPP, and other organizations. For example, CWP and the Connecticut Center for Advanced Technology convene the Advanced Manufacturing Employer Partnership (AMEP), an employer-led network of over 50 companies that connects regional OY programs to employment opportunities, including apprenticeships, paid work experience, on-the-job training, and direct job placement using resources provided by the Workforce Innovation and Opportunity Act (WIOA) and Workforce Solutions. The AMEP assists employers with strategies for recruitment, retention and incumbent

worker training that help grow businesses, provide solid jobs, and improve the regional economy. The group works closely with the Department of Labor and local colleges, meets quarterly, and receives funding from Workforce Solutions.

Gateway Technical College: Bootcamps for Training in Manufacturing and Computer Numerical Controls

Gateway Technical College (GTC) offers “Bootcamp” training programs for dislocated and underemployed workers in three counties of Wisconsin that are designed to make them ready for employment in local manufacturing settings. The Bootcamps are tailored to skills needed for the computer numerical control (CNC) sector and also serve to train machine operators, welders/fabricators, and machine repair technicians. Students are expected to meet basic math and reading requirements, adhere to strict attendance policies, and pass certification requirements. All programs are designed with employer input, and immediately upon graduation, students are offered the opportunity to interview with potential employers.

Gateway Technical College, serving Kenosha, Racine, and Walworth counties in Wisconsin, laid the cornerstone of career training in 1911 as the first compulsory, publicly-funded technical school in Wisconsin—and, in doing so, also became the first in America. From its inception, Gateway has provided students with education and training tailored to the needs of the industry of the day, addressing traditional as well as emerging, in-demand career fields. Enrolling more than 25,000 students, Gateway supplies local industry with trained workers and residents with opportunities to gain solid paying careers. Gateway’s graduates report high satisfaction rates with their education (near 100 percent) and employment rates are around 80 percent or better.

In 2005, Gateway Technical College was approached by local employers with a need for CNC operators based on projected retirements. Gateway offered a one-year CNC Production Technician Technical Diploma which typically graduates 12 students per year. This volume was not meeting the expanding needs of employers who required a more rapid process to fill open positions. Employers were concerned not only about the lack of skilled workers, but also about the difficulty in finding workers who possessed basic employment skills, such as being on time and avoiding absence.

Gateway’s Workforce and Economic Development Division employed a manufacturing instructor to gather specific information from more than a dozen employers about required entry-level skills. Gateway aligned these skills with existing Gateway courses as well as with two new courses. About 30 manufacturing employers in Gateway’s district reviewed the resulting curriculum which includes instruction on safety, quality, math, blue print reading, introduction to CNC, CNC machine tool operations and offsets, and precision measurement. The curriculum also includes NOCTI’s Precision Machining assessment tool which is used as a pre- and post-test to measure each individual’s abilities. (NOCTI is the largest provider of industry-based credentials and partner industry certifications for career and technical education [CTE] programs across the nation.)

Roles for all partners participating in the curriculum delivery (i.e., Gateway, workforce development center staff, and employers) have been assigned and agreed to for each partner, including processes for recruiting, screening, training, and placing participants in employment. The Bootcamp format imitates the work environment: classes

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meet Monday through Friday from 8:00 a.m. to 4:30 p.m. with strict attendance policies. Additionally, intensive wrap-around case management services are available for those participants requiring additional support to address common barriers to attendance such as transportation and childcare needs. Courses are for credit and can apply to a college program. The format also includes mandatory tutoring sessions for all students who receive a grade lower than a “B” on a test or quiz, resumé writing workshops, and interviewing skill sessions. Employers are invited to assist with mock interviews near the end of the Bootcamp to provide feedback to participants about their strengths, areas needing improvement, and ways to improve interviewing skills. Employers also provide industry tours prior to Bootcamps so participants can see the work environment and learn about employer expectations. Three weeks before the end of the Bootcamp, participant resumes are collated into a booklet and distributed to employers with open positions along with an invitation to attend the completion ceremony. Space is made available following the completion ceremony for employers to conduct interviews with new program graduates.

Scalability and Replicability

Since 2005, Gateway has offered 15 CNC Bootcamps to almost 200 students resulting in a 93 percent job placement rate. Over the years the college has added certifications to the Bootcamp including ACT’s National Career Readiness Certificate (NCRC), the Manufacturing Skills Standards Council (MSSC) Safety certification, Lean Six Sigma Yellow Belt Certification, and the Wisconsin-developed Critical Core Manufacturing Skills for soft skills. The Bootcamp model has been adapted for welding and machine repair technicians. To date, seven welding Bootcamps and three Machine Repair Bootcamps have been offered with similar placement results.

Initially, funding from the Workforce Investment Act supported most Bootcamp participants, with a limited number of self-pay participants. In 2012, SC Johnson, located in Racine, WI, donated \$1 million to Gateway Technical College to support additional Bootcamps in multiple sectors. The funding allowed the college to offer three CNC, two Welding Fabrication, one Machine Repair, and two Certified Nursing Assistant (CNA) Bootcamps each year for the next two years, including case management services.

CHAPTER 4

PROMISING PRACTICES *for* Redesigning University Curriculum



The Hard Science of Engineering is No Longer Enough

Engineering education underwent a dramatic change in the early 1950s and 1960s when an emphasis on hard science and technical skills transformed university engineering curricula. Changes in the world economy, especially globalization, have now once again inspired clarion calls to re-design engineering education. Former University of Michigan president and engineering dean James Duderstadt and his colleagues made the case just a decade ago for adopting curricula that emphasize professional skills, multi-disciplinary knowledge, liberal education and opportunities for life-long learning. Arguing why “the hard science of engineering is not enough,” Richard K. Miller of Olin College called for the restoration of professional skills that foster ethical behavior, trustworthiness, employability, effective communication, collaboration, leadership, resourcefulness, independence, entrepreneurial and business acumen, empathy and social responsibility, and global awareness and perspective. On today’s engineering website for Purdue University’s School of Engineering Education (ENE), the school declares its goals are to: “empower our people,” “set a global standard for engineering education,” “tackle the big (research questions),” and “build strategic global partnerships and collaborations.”

The curricular programs cited in this section reflect educational paths that emphasize hard science, practical knowledge, professional development, cultural sensitivity, and meaningful connections to problems that are tackled in the workplace today, as well as societal challenges yet to be met. They all engage the university faculty, administrators, industry leaders, and the public they serve. In short, they demonstrate that the hard science of engineering has cracked open and brought inside the multi-disciplinary perspectives, professional engagement, global awareness, and hands on practical knowledge needed to fuel our economy’s industries in the 21st century.

Haley Barbour Center for Manufacturing Excellence: Innovative Practices for Modern Manufacturing

The Haley Barbour Center for Manufacturing Excellence (CME) at the University of Mississippi prepares young men and women for meaningful careers in modern manufacturing. CME programs combine traditional learning models with progressive, hands-on opportunities designed to expose students to the realities and challenges of the manufacturing industry throughout Mississippi and beyond. The CME was created when Toyota placed a new manufacturing facility within Northern Mississippi. The Toyota company, previous university administration, and former Governor Haley Barbour shared a vision for a center that could develop young professionals within the fields of accountancy, business, and engineering. The center focuses on creating a cross curricular/multi-disciplinary environment in which students from these three fields can learn the languages of engineering, business, and accounting. Manufacturing serves as the common language connecting the programs offered.

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The Haley Barbour Center for Manufacturing Excellence (CME) is located on the University of Mississippi's Oxford campus. The CME was established in June 2008 to provide unique opportunities for students interested in manufacturing that are not available to undergraduate students at other universities in the United States. The CME is developing interdisciplinary educational activities within an innovative academic learning model that provides students with the practical experiences, fundamental knowledge, and creative skill sets needed to lead the world of modern manufacturing. The CME is working with companies who express a strong desire to become industry leaders and who wish to work with CME staff and students. Together, the CME and these business partners are striving to serve their employees, improve business conditions, and promote economic growth.

Students within the CME can currently pursue one of five different degrees:

- Bachelor's in Business Administration with a Minor in Manufacturing Engineering,
- Bachelor's in Accountancy with a Minor in Manufacturing Engineering,
- Bachelor's of Science in Mechanical Engineering with an Emphasis in Manufacturing,
- Bachelor's of Science in Chemical Engineering with an Emphasis in Manufacturing, and
- Bachelor's of Engineering with an Emphasis in Manufacturing.

The CME academic experience involves 21 hours of coursework built into these degree programs. This combined program achieves academic credibility with potential employers or post graduate programs and differentiates graduates from their peer group who may not be a part of the CME program. The curricula include courses that emphasize team work, workplace ethics, innovative technologies and design skills, basic manufacturing processes, experience using modern manufacturing equipment, and business skills, such as strategic planning and ways to market a project. The CME facility is a 48,000 sq. ft. space including a factory floor, laboratory environments, cubicle/student work-spaces, and professional meeting rooms. This facility allows CME students to become acquainted with professional surroundings within the academic career. This environment is used by all CME students, whether their focus is engineering, business, or accounting. Anticipating potential employment at Toyota, students also are taught Toyota Production Systems Philosophy (TPS), which in turn is referenced throughout the CME course offerings. TPS covers such topics as continuous flow, standardized work, and factory floor problem solving.

During their senior year, CME students bring together all of their coursework in a realistic, experiential capstone course where they pitch ideas to make a product, form companies and assume positions in them, and make multiple presentations to faculty/staff/advisory board members regarding their learning points. A final presentation allows each student company to demonstrate the process of their production and the functionality of their product.

To effectively recruit students and interest them in manufacturing, the CME developed the Make It Mississippi™ program. This program is designed to encourage students to be creative and make things with their hands. Often, problems facing Mississippi are highlighted as students work together to “make” a product. Other activities are designed to highlight critical thinking, problem solving, budget creation and use, making deadlines, and other manufacturing constraints. These programs emphasize developing seven traits associated with career success: ability to adapt to a changing environment, ability to learn, willingness to learn, self-confidence, humility, perseverance, and open-mindedness. The CME hosts two “Discovery Days” every spring that invite students onto campus for a closer look at the program, and offer opportunities to observe students engaging one another in activities designed to highlight these personality traits. Decisions regarding membership in the CME are in-part based upon these Discovery Day events.

The CME recruitment and instructional processes include:

- *Assessment*—Students are interviewed to determine knowledge base of manufacturing, expectations for the education and subsequent career, as well as work experience;
- *Experiential Learning*—Students’ experience here provides them with a working knowledge of a real factory environment (CME also strongly recommends that students participate in an internship, but more preferably, a CO-OP);
- *Reflection*—Upon completion, the CME reviews students’ internship/CO-OP experiences, which involves each student completing a journal detailing their own experience as well as a survey completed by the employer after which CME helps each student establish growth goals toward, and prior to, employment; and
- *Integration*—Using these growth goals/milestones, CME students are encouraged and coached as to how to integrate their learning points into the academic career.

The CME Advisory Board includes Toyota, GE Aviation, and Huntington-Ingalls Ship Building, and also enjoys input from sources in economic development, higher education, public policy, and financial institutions. The CME also benefits from the vision and continued input of former Mississippi Governor, Haley Barbour, and from organizations that promote manufacturing, including the Mississippi Manufacturers Association (MMA), Mississippi Automotive Manufacturers Association (MAMA), and the National Association of Manufacturers (NAM). The CME routinely meets with area economic development agencies and serves as a resource for economic development projects of local chambers of commerce, the Mississippi Development Authority, the Tennessee Valley Authority, and other agencies.

Scalability and Replicability

In 2010, the CME’s student team was comprised of 27 students. Nearly 100 percent were engineering students. In 2016, the CME had over 200 applications to fill 50 spaces. The CME is challenged by growing demand to balance the desire to serve more students with the goal of meeting individual needs. Other challenges include: keeping up with changes in manufacturing, adapting to changes in the marketplace, ways to include community college transfer students in the program, and achieving accreditation within traditional academic programs. The CME relies upon the input of its advisory board and partners to assist in meeting these challenges. Programs wishing to replicate the CME’s success will require active partnerships among academic departments, professional organizations, and industries, and a dedication to gaining support for the new model of interdisciplinary and hands on engineering education it has achieved. New partnerships with industrial as well

as educational members are required to scale up and grow regionally, nationally, and globally as a collaborative, proactive program that works to improve the overall health of the manufacturing sector.

Clemson University Center for Workforce Development: Building a Knowledgeable and Sustainable Workforce

The Clemson University Center for Workforce Development (CUCWD) supports education, research, dissemination and outreach activities to develop the next generation of technicians, engineers, and scientists. The CUCWD is a P-20 initiative, approved by the South Carolina Commission on Higher Education, to improve workforce educational capacity in STEM fields across South Carolina within 2-year colleges. With support from the National Science Foundation (NSF) Advanced Technological Education Program (ATE), the CUCWD has developed extensive experience in e-learning research and application. The center houses the EducateWorkforce platform of workforce training tools for two year colleges, supports an active laboratory that produces virtual reality learning modules, and conducts educational research on aspects of digital learning.

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The CUCWD mission is to provide educational resources to 2-year colleges, industry, and individuals that help prepare a highly-skilled workforce to meet the needs of the advanced manufacturing industry. The CUCWD supports demand-driven education, research, dissemination and outreach that will advance economic development and enhance employment opportunities for South Carolinians; strategic goals include:

- design and develop high quality digital learning tools including curricula, virtual reality simulations, and teaching and learning resources for online and hybrid environments;
- facilitate and accelerate distribution and implementation of the digital learning tools developed by CUCWD and its partners;
- increase diversity and quality of the technological education pipeline through sustainable pathways and innovative STEM integration;
- provide rigorous evidence-based research in the technological education and workforce development fields; and
- sustain a leadership role and prominent network focused on developing and advocating a national model for workforce development initiatives.

The CUCWD has been successful in leveraging multiple public-private partnerships, and it has secured multi-million dollar foundation partnerships to implement workforce development solutions in the K-20 pipeline throughout the Southeast.

NSF ATE funding is being used in Clemson's Regional Center for Aviation and Automotive Technological Education, which employs Virtual E-Schools (CA2VES) to train a highly skilled aviation and automotive technology workforce. CA2VES creates original digital learning content and state-of-the-art virtual reality simulations.

EducateWorkforce is an online learning solution that helps integrate web and digital solutions into existing courses. The platform was designed by multiple instructional design, usability, and computing experts to include research-based learning features. The portal replicates the structure of many notable Massive Open Online Course (MOOC) platforms, such as industry leaders, edX, Coursera, and Udacity, but is the first specifically built for and tailored to the unique needs of two-year education. It consists of both basic and advanced courses focusing on the needs of technician students and provides a selection of courses free of charge. Students may

have access to self-paced learning tools or faculty may choose to integrate modules, iBooks, brief video lectures, virtual reality simulations, and instant feedback assessments into their existing courses. Educateworkforce.com offers a robust catalog of state-of-the-art materials and digital learning resources through the integration of courses developed by CA2VES, two-year college partners, and other NSF ATE Centers to support technician education in advanced manufacturing careers.

Scalability and Replicability

Educateworkforce.com is currently being used in 34 states and by over 7,500 consumers. It offers more than 75 virtual reality modules and twelve courses including 95 e-learning modules. The CUCWD has designed and implemented innovative tools to help meet the growing needs of both industry and educational institutions through the development of technologies in distance education. These tools bring new perspectives and opportunities for authentic workplace experiences to traditional technician education.

University of Louisville Engineering Co-op Program: Opting Out is Not an Option

The mandatory co-op program at the University of Louisville J.B. Speed School of Engineering is one of the few mandatory co-op programs in the United States; it guarantees that 100 percent of the university's engineering students graduate with engineering experience. The co-op is an ACCE accredited academic program that integrates classroom learning with work experience. Employers provide the students with full-time paid positions relevant to their career while also mentoring the students. Typically, a student will co-op with the same employer for three alternating semesters beginning in their fifth semester of school. Students enter the workforce with one full year of engineering experience.

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At the University of Louisville J. B. Speed School of Engineering, the cooperative education program is an academically-focused program which provides students with progressive experiential learning opportunities that accelerate professional development and prepares students for successful careers in industry, research, or government. While students are gaining practical experience in their field, they acquire an understanding of the workplace, integrate theory and practice, and have the opportunity to further develop professional and interpersonal skills. The co-op program has been in place for over 90 years and is one of the reasons that the Speed School has been one of the top choices in the country for engineering graduates.

Key advantages of the University of Louisville co-op program include:

- *building the brand of the industry as a career of choice*—students who participate get to experience exciting engineering jobs while also getting paid competitive wages;
- *arming workers with common employability and workplace skills*—the engineering tasks performed daily provide important technical skills while “soft” skills are taught to the students by employers who actively mentor students;
- *building STEM foundational skills*—the co-op program is an accredited academic program that integrates classroom learning with work experience;
- *rebuilding the highly-skilled technical workforce*—each semester over 300 students develop skills required in the technical workforce; and
- *adapting to address new competencies required for new technologies and processes*—employers provide feedback directly to the Speed School which evaluates co-op performance.

Beyond co-op, the Speed School provides students with the guidance and skills to make a seamless transition from "co-op to company" as they approach graduation. By leveraging the cooperative education process, the school builds unique partnerships with employers throughout the region, North America, and the world, and provides employers searching for engineering talent with "one-stop shopping" that is responsive and easy to access.

For the student, the co-op program provides an opportunity to:

- obtain hands-on engineering experience as part of their formal education;
- become workforce ready; and
- defray college expenses: students are classified temporary, hourly employees, and earn about \$15-\$16 an hour.

For the employer, the co-op program provides the following benefits:

- access to a skilled, short-term, cost-effective workforce;
- opportunity to evaluate potential full-time employees; and
- reduced recruiting and training costs.

Scalability and Replicability

The Speed School of Engineering has 250 students engaged in "on-the-job" experiential education every semester. Each year, 550 students receive over 750 semesters of training with over 200 employers. Students work alternating semesters, starting at the end of their sophomore year. The mandatory aspect of this program is what sets the initiative apart from the majority of engineering programs in the nation. All graduating students enter the workforce with relevant experience and skills. Replication would require schools to implement three semesters of mandatory co-op experience.

Texas Tech University's Manufacturing-Centered Project-Based Framework: Revolutionizing Industrial Engineering Education

The Texas Tech University (TTU) Manufacturing-Centered Project Based Framework (MCPBF) is a pilot project in educational research of the Department of Industrial Engineering (IE) at TTU. The MCPBF aims to structurally change IE education. In this changeover, manufacturing is established as the focal point, thus exposing undergraduates in their middle years to real-world, industry-developed problems through project-based education in flipped classrooms. This framework is designed to provide students with authentic experiences to stimulate their creativity and curiosity, and enable them to gain meta-skills including leadership, communication, lifelong learning, entrepreneurship, and teamwork.

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The MCPBF stresses team-teaching in which instructors facilitate an industry-driven, project-based course with students, thus "breaking the office wall" of individualistic academic culture and promoting teamwork in teaching and research. Industry partners collaborate with the faculty on project design and serve as student mentors; the collaborating IE faculty are certified in active learning, flipped instruction, and team teaching.

The IE program at TTU integrates decision support systems and skills (presentation, teaming, business/economic skills) gained through course projects, senior projects, and an optional entrepreneurship certificate. Students

learn to recognize and understand problems, develop solutions, present to a client/customer, and then implement solutions using a suitable decision-support system.

The MCPBF program extends this integrated approach by inserting real-world problems suggested by industry partners into a hands-on and student-driven curriculum. The object is to produce engineers who can immediately be productive in an industrial or graduate school setting in ways that their traditionally-trained peers might not be. Additionally, since the program is student-driven, students learn to rely on and develop their intrinsic motivation, ability to learn, and professional skills such as communication and time management—skills needed in any professional setting.

Scalability and Replicability

The MCPBF averts costs for instructor training, student buy-in, and curricular development by employing services present at every research university and accessible to departments: a teaching/learning center to help train professors and design new curriculum, and social and educational scientists to help measure/calibrate change during the department evolution.

MCPBF plans to scale the program through:

- a pilot roll-out at TTU, in which training materials are developed and processes documented both for other departments and for research purposes on a publicly accessible website available to academic and industry peers for feedback;
- a limited release to three to five interested departments (at least one at another R1 similar to TTU, at least one at another R1 dissimilar in demographics and size to TTU, and at least one R2 either similar to dissimilar to TTU); and
- a roll-out to all interested departments.

This segmented scalability plan will help the MCPBF project designers discover missteps for correction, give others the opportunity to provide feedback, and help a limited number of other departments attempt to accomplish the same shift.

University of Pittsburgh Manufacturing Accelerator Program: Linking Artists and Artisans to Manufacturing Production Processes

The University of Pittsburgh (UP) Swanson School of Engineering announced their receipt of an Economic Development Administration's 2016 Regional Innovation Strategies award in November 2016. The university is establishing a Manufacturing Accelerator Program (MAP) (also known as a Lean Assembly Cell Accelerator) for the creative arts and maker movement. The project strategically focuses on serving entrepreneurial and innovative artisans, craftspeople, and designers throughout the ten-county footprint of southwestern Pennsylvania, with the Homewood neighborhood of Pittsburgh and the location of the MAP as the focal point. The goal is to jumpstart commercial activity in one of Pittsburgh's most severely neglected and underserved neighborhoods through education and training, career, and entrepreneurial support. MAP will be operated by the Manufacturing Assistance Center (MAC) within Pitt's Swanson School of Engineering and the Institute for Entrepreneurial Excellence along with local partners, Catalyst Connection and Innovation Works.

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The MAP aims to adapt cellular manufacturing for and provide entrepreneurial resources to the artistic sector in the Pittsburgh region, a community underserved relative to the heavily-supported technology sector. By connecting the world of work and the world of learning, the MAP will help artists leverage their design skills to scale their production and create thriving businesses. Consulting services will be available on site for the small business owners to gain insight into how to grow their businesses, market their products, and deal with day-to-day business concerns. If products become in demand, the entrepreneurs will be able to scale their business beyond the size of the lean assembly cell through the resources offered through UP's economic development partners, Catalyst Connection and Innovation Works, and UP's Institute for Entrepreneurial Excellence.

Scalability and Replicability

As the maker movement continues to flourish throughout the United States, the UP model will likely be replicated in other cities with a particular focus on creating a base in disadvantaged communities that can benefit from the commercial activity.

American Institute of Manufacturing Photonics Academy: Future Leaders Program, Master's in Manufacturing in Integrated Photonics, and Education and Practice Factory

The American Institute of Manufacturing (AIM) Photonics Academy is funded by the Federal Government as well as Massachusetts, California, Arizona, and New York to accelerate domestic capabilities and leadership in the emerging field of integrated photonics (putting light technology into chips and onto circuit boards). AIM Photonics Academy offers a comprehensive program that creates opportunities for industry networking through national meetings, workshops, workforce development, and industry-university partnerships. To spur workforce development, AIM Photonics Academy has developed a Future Leaders Program, an eight-week summer internship at a major university, to help train and recruit undergraduate students into the photonics industry and graduate programs. In further support of an education infrastructure, AIM Photonics Academy has created a new graduate program in advanced manufacturing and the design of integrated photonics. The program is offered by the Massachusetts Institute of Technology (MIT), and structured to be delivered over a period of one year.

The AIM Photonics Academy represents a collaboration of university partners across the country, with physical headquarters at MIT and the University of California at Santa Barbara (UCSB) (West Coast Headquarters). AIM Photonics Academy is sponsoring 11 rising seniors for eight weeks in summer 2017 across four states: California (UCSB), New York (SUNY Poly), Arizona (UA), and Massachusetts (MIT). Each student will be connected with an AIM research project, a faculty mentor, and an industry mentor. The goal of the program is to interest students both in graduate studies and careers in integrated photonics, and is open to all undergraduate students majoring in science, mathematics, or engineering.

This fall, there will be 6 students in the first year of the Master's in Manufacturing in Integrated Photonics program at MIT, with the goal of expanding in future years.

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The “Education and Practice Factory” experience will allow masters students and others to have hands-on experience in integrated photonics tied to the work they’re doing in the classroom. This on-campus factory will provide a place for students and professionals to practice the real-time operation of a volume production system as part of their education and training. The Education and Practice Factory curriculum will be coordinated with outside companies that collaborate in the use of the factory for new product introduction and process innovation. The initial factory capability includes equipment necessary for chip packaging, inspection, and testing, all of which are required functions for the AIM Photonics industries. At least 50 industry professionals will be using the Education & Practice Factory during summer 2017 to work on projects, and other companies are being invited to participate in the future. The Education and Practice Factory also will work closely with the Department of Commerce’s Manufacturing Extension Partnership Program, small and medium enterprises (SMEs), and community colleges on supporting certification programs and the teaching of integrated photonics.

Scalability and Replicability

The AIM Photonics Academy has a number of industry and college/university partners with varying levels of financial or other commitment. The academy network allows for continued collaboration across the network to build educational programs, such as the AIM Future Leaders summer program. The initial Future Leaders program has required seed funding of \$125,000 per year for the first two years; the academy expects to raise all necessary future funding from industry partners. As for the master’s degree, MIT plans to offer more specialization tracks beyond photonics that are tied to other specialized manufacturing institutes so that its students are better prepared and gain industry contacts in the most exciting areas of advanced manufacturing. AIM Academy plans to make course content available online and sharable, and it has inaugurated discussions among partner institutions about launching a similar Master of Engineering program in integrated photonics manufacturing. The practice factory concept is also replicable; the state of Massachusetts is supporting the lab at MIT as a model that can be replicated in Central and Western Massachusetts.

Pennsylvania College of Technology: Meeting Hands-On and Classroom Training Needs for the Mechatronics Registered Apprenticeship Program

Pennsylvania College of Technology (Penn College) through its Workforce Development & Continuing Education office, offers the Mechatronics Apprenticeship Series, a training program satisfying the classroom requirements of the U.S. Department of Labor (USDOL) and Pennsylvania Department of Labor (PADOL) Mechatronics Apprenticeship. The competencies covered by Penn College’s classroom training are fully aligned with the Association for Packaging and Processing Technologies (PMMI) standards which were approved by the USDOL as the foundation for mechatronics apprenticeships around the country in 2015. In order to demonstrate proof of competencies, apprenticeship candidates must successfully pass the PMMI certifications in each category. The categories of training can be delivered in any order.

Penn College became an affiliate of The Pennsylvania State University in 1989, after establishing a national reputation for education supporting workforce development, first as a technical institute and later as a community college. The PMMI training course, offered by Penn College, delivers 144 hours of instruction a year for four years. It is broken down into the four categories of mechatronics designated by the USDOL: Industrial Electricity, Mechanical Components, Fluid Power and Programmable Logic Controllers (PLC). Investment in apprenticeship programs pays off for completers of programs like this.

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Several features differentiate this program from traditional training classes. Penn College built the training program to be competency-based; it incorporates features designed to minimize production disruption. The competency-based structure begins with a baseline assessment, which gauges the initial strengths and weaknesses of the program participants. Training is then individually targeted; trainers provide instruction in areas of need while allowing individual employees to remain on the production floor during training topics in areas in which they have already demonstrated sufficient mastery.

A blended delivery model for training results in convenience for the companies. On-site training is combined with remote, instructor-led training which minimizes employee travel time. Penn College's portable training equipment allows for hands-on training in areas such as Programmable Logic Controllers (PLC) without the need for employees to travel to campus labs or take up valuable time on existing equipment onsite at the employer location. The inclusion of advanced remote instruction technology makes it considerably easier for groups of companies to form a training consortium, further minimizing the cost to each.

One application of the consortium approach has resulted in a first-of-its-kind apprenticeship training for a combination of union and non-union manufacturers. Autoneum North America, Inc. was one of the companies to participate in the training consortium. With 700 employees in Central Pennsylvania, Autoneum is the global technology leader in acoustic and thermal management solutions for motor vehicles. The company is a partner for the major light vehicle and heavy truck manufacturers around the world, and it has a goal is to promote and advance apprenticeship programs. SEKISUI SPI and one other manufacturer rounded out the consortium. At the discretion of the employers, not all of the participants were registered with the state, but more than half are completing all required elements of the approved program. Regardless of registration status, all participants were held to the same high standards for the classroom training.

The program will run for four years with a new category of training delivered each year during the months of August through May. Each company participating is responsible for documenting classroom training and on the job training experience for their employees that aligns with the competencies required by the registered apprenticeship program.

The Mechanical Components portion of the first training session concluded in May 2017. Six of the 42 participants displayed sufficiently high levels of proficiency across all competency areas in the baseline assessment to place out of requiring a final assessment. Scoring for those taking both the baseline and final assessments averaged an impressive 11.5 point increase. Over 90 percent (38/42) of the participants displayed sufficient mastery in the overall assessment process to proceed to the second year. A short, targeted remediation training course has been developed for the few falling short of the standard in order to provide maximum opportunity to advance.

Scalability and Replicability

Penn College's Mechatronics Apprenticeship Series is easily replicated by individual companies and/or consortia in nearly any location and is replicable across multiple industry sectors. Because the training program is competency based, it can be applied to varied apprenticeship programs, and it can be seamlessly delivered to both large and small groups of employees. The curriculum itself is scalable both up and down because it is modular, allowing for added training components (e.g., robotics, welding, OSHA) to be attached, and allowing companies to choose individual components for targeted training application.

University of Cincinnati Simulation Technology Centers: Partnered with Industry for Career Training and Research

The University of Cincinnati's College of Engineering and Applied Science (CEAS) houses two industry-specific simulation centers that represent innovative partnerships with industry to stimulate research and product development and train students in advanced manufacturing technologies. The recently formed Siemens PLM Simulation Technology Center allows for simulation and modelling using Siemens product lifecycle management (PLM) software. The center not only is a hub for developing and applying new methodologies and technologies for all aspects of PLM, but also is part of a talent development program where co-op students will be placed on software development projects in Siemens' PLM Software Office in Milford, Ohio. The Procter and Gamble (P&G) UC Simulation Center for over eight years has been a true experiential learning center, where students further their education by working directly on industry problems alongside researchers from P&G who are responsible for creating innovations to propel the business forward. At the Center, UC's faculty and students deploy modeling and simulation capabilities across actual projects in the Research and Development and Product Supply units of P&G. Both simulation centers are located on the University of Cincinnati campus.

Siemens PLM Simulation Technology Center. In September 2016, Siemens and the University of Cincinnati announced a partnership to establish an innovative simulation and modeling center enabled with Siemens product lifecycle management (PLM) software. Through this close collaboration, a transformational change in undergraduate engineering and applied science curricula is expected. Siemens has provided the PLM software and pledged up to \$1M to establish the center.

To prepare students for work in the center, Computer Aided Design (CAD), Digital Design and Manufacturing and Computer Aided Engineering (CAE) will be systematically integrated in engineering education, beginning with early year courses and extending to multi-year projects with global multi-disciplinary teams in upper-level courses.

P&G UC Simulation Center. The P&G UC Simulation Center brings together Procter and Gamble's status as the world's largest consumer goods company with the University of Cincinnati's expertise in structural mechanics and dynamics, computational fluid dynamics, and other modeling disciplines in engineering and science.

The P&G UC Simulation Center began in 2008 as a reapplication of the Champaign Simulation Center that Caterpillar launched with the University of Illinois. The physical location of the P&G UC Center is on the edge of the university's campus rather than at the P&G facilities, which allows easy access for students and faculty to work on projects during any open schedule opportunities.

To date, over 100 projects have gone through the P&G UC Simulation Center, which has resulted in over \$12M in direct funding from P&G. Numerous publications and conference presentations have also resulted from work at the Simulation Center. Students who work at the center have contributed to meaningful innovations at P&G, leading to intellectual property development and measurable business benefits for the company. As of late 2016,

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P&G has hired 15 new employees from the nearly 200 UC students who have worked at the P&G UC Simulation Center.

P&G has continually increased funding to the Simulation Center as a result of successful projects. During 2016, the number of students supported by the P&G grant reached 70. P&G estimates that this partnership has provided them with greater than a seven-fold return on their investment. In this partnership, P&G has exclusive rights to the intellectual properties developed in the course of the project work, but UC faculty and students retain the ownership of prior technology used for the project, as well as for applications outside of P&G interests.

Both P&G and UC made it an early priority to identify highly committed leaders from both sides who would work collaboratively to share risk and benefit, think outside the box, and follow-through on commitments. Ultimately, success has been achieved through very deliberate setups, including deployment of full-time managers from UC and P&G, clear support from both upper managements, and commitment on both sides to stay focused on the goal and think creatively to address the challenges that might arise. Their best practices for leveraging external resources to drive discontinuous, sustainable innovation and productivity provided a success model upon which to build.

Scalability and Replicability

The long-term success of the P&G UC Simulation Center and the potential of the Siemens PLM Simulation Center demonstrate how initiatives such as these can develop global innovation partnerships that create a win-win-win for both partners and the consumer. The Siemens PLM Center and Siemens's commitment to talent development promise to deliver highly trained employees for the PLM software group, while improving and generating new products. P&G's commitment to expanding the center and increased grant support have allowed the program to grow and engage more students in new technologies and to hire several of them directly into P&G and other companies. Both programs extend the simulation center concept developed in Illinois and provide models for potential replication at other university sites with engineering and technology programs.

The New Jersey Innovation Institute: Promoting Advanced Technologies Development, Start-up Companies, and Business Services for Advanced Manufacturing

Created in 2014, the New Jersey Innovation Institute (NJII) is a New Jersey Institute of Technology (NJIT) corporation that applies the intellectual and technological resources of New Jersey's science and technology university to address challenges identified by private and public sector partners. NJII builds upon NJIT's rich history and links New Jersey's private, public and academic sectors in pursuit of economic development and the next generation of technological advances. NJII advances education and workforce development by serving as a source of employment and internships for students in the technical and scientific enterprises that are the focus of NJII operations and Innovation Laboratories (iLabs). Designed to serve as a market-facing intermediary organization, NJII acts as a pivotal link between New Jersey research universities and industry.

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NJII works with businesses to align stakeholders to solve grand challenges across commercial sectors, and provide access to world-class intellectual and technological resources, including undergraduate and graduate students in a variety of STEM fields. Opportunities for employment bring students and interns into work settings

that support highly relevant experiential learning. NJII's iLabs are strategically organized to serve market verticals and follow industry-led agendas.

Students are employed across NJII's various iLabs, coreLabs, and core functions. NJII's five iLabs focus on the following industry sectors: Healthcare Delivery Systems, Biotechnology and Pharmaceutical Production, Civil Infrastructure, Defense and Homeland Security, Financial Services, Technology and Enterprise Development, Cluster and Economic Development, Data Analytics, and Advanced Manufacturing.

Since 2011, over 50 NJIT students have been employed directly by the Healthcare Delivery Systems iLab and through contractors hired with iLab funds. Dozens of students are hired in the Biotechnology and Pharmaceutical Production iLab to work on applied research and in technology development roles. A total of 302 students have been employed at NJII (iLabs and coreLabs) and/or Enterprise Development Center-hosted companies.

Also, NJII enjoys 8 pre-competitive industry partnerships and 7 regional economic/workforce development collaborations.

Scalability and Replicability

NJII scales its activities through its interconnectedness, and by providing opportunities for professional experience to large numbers of undergraduate and postgraduate students who are better prepared for employment in advanced technology industries. Because NJII hosts deep, sustained institutional relationships with industry partners premised on a value proposition offering access to talent, technology and opportunity, NJII can sponsor multiple innovation platforms in the form of test sites, technology test beds, intelligence platforms, pilot scale up facilities, and other physical assets that allow academic, industry, and government partners to intersect in productive ways. NJII also supports and enhances NJIT's ability to have both proximity to and leadership in meaningful interactions with industry and technical professionals on practical economic topics.

MechaFORCE – Registered Internships in Manufacturing: Training in Mechatronics Hosted by the New Jersey Institute of Technology

MechaFORCE Registered Internships in Manufacturing (M-RIM) is a career and educational pathway program commissioned by industry and coordinated by the New Jersey Institute of Technology (NJIT) to ready high school and college students for professional careers in New Jersey's small to medium-sized manufacturing firms. Through its scalability and flexible approach, M-RIM enables high schools and both the academic and continuing education units of two- and four-year colleges throughout the state to offer learners the opportunity to acquire industry-valued skills, credentials and degrees in modern manufacturing. Simultaneously, M-RIM provides companies with a new source from which to choose appropriately trained talent.

M-RIM is offered through MechaFORCE (MFP), an industry-led program designed to help people and companies reach their full potential through skills training. MFP partners with industry to support educational institutions in offering credentials and degrees to learners of any age or background. Using modest funding contributed by a coalition of manufacturers, the M-

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RIM team links and leverages existing programs and initiatives, already available, and packages them in a navigable, customized way based upon manufacturers' needs and requirements.

Currently M-RIM is working with 8 apprenticeships, 10 companies, 10 CTE schools, 8 two-year community colleges, and a couple four-year institutions. There are a number of other small and medium-sized manufacturing firms interested in the program and M-RIM hopes to expand the network and increase the number of apprenticeships once additional funding has been received.

Scalability and Replicability

Many manufacturers are doing their own training to gain experienced workers. The M-RIM program is a more formal approach which includes on the job learning coupled with classroom teaching. It is not only an efficient and transferable program, but Registered Interns gain national accreditation while interning, which builds employee loyalty. M-RIM can act as the sponsor for small manufacturers, helping them by: developing agreements between manufacturers and the RIs that describe on the job learning and salary increases; identifying classes at local schools that meet the Apprenticeship USA requirements, and assisting in the periodic reporting to Apprenticeship USA. The M-RIM Program, as sponsor of Registered Interns, will help increase the engagement of many manufacturers that are interested in including apprenticeships in their workforce development strategies but don't have the resources to accomplish this.

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Penn State Center for Innovative Materials Process through Direct Digital Deposition (CIMP-3D): A State-of-the-Art Practicum for Industry on 3D Manufacturing with Metallic Materials

The Penn State Center for Innovative Materials for Direct Digital Deposition (CIMP-3D) Industry Practicum, titled an Introduction to Additive Manufacturing with Metallic Materials, offers intensive hands-on training for industry focusing on additive manufacturing (AM) of metallic materials. As the Defense Advanced Research Projects Agency (DARPA)'s Manufacturing Demonstration Facility for Additive Manufacturing, CIMP-3D provides tours to more than 1000 employees per year from companies across industry sectors. CIMP-3D's Industry Practicum was the first-of-its-kind in metal AM and specifically targeted industry practitioners. It runs 4-5 days and has been offered at least twice each summer for the past four years, attracting over 250 industry participants from more than a dozen different companies and organizations to date, with little to no advertising. CIMP-3D is one of many additive manufacturing demonstration facilities emerging at or near universities around the country.

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Penn State's CIMP-3D Industry Practicum leverages the university's research efforts, industry connections, and the CIMP-3D's status as a Manufacturing Demonstration Facility to create attractive industry training around new competencies for additive manufacturing. The 8,000 square-foot facility includes several additive manufacturing (AM) systems capable of full consolidation of polymeric, metallic, and ceramic material systems,

as well as a state-of-the-art design studio and prototyping laboratory which includes a host of characterization techniques.

The CIMP-3D Practicum specifically was designed to help companies educate and retrain their workforce (design, engineering, manufacturing, and quality control) in AM with metals technologies. The CIMP is also promoting careers in AM, and introducing the research opportunities and ongoing challenges in AM with metals.

Scalability and Replicability

The CIMP-3D Practicum model is transferable to other universities that have comparable AM equipment and resources, and the effort could be scaled using regional clusters coordinated nationally.

Other examples of CIMP facilities include the Additive Manufacturing Competency Center (AMCC) at the University of Louisville, the Oak Ridge Manufacturing Demonstration Facility (MDF) near the University of Tennessee-Knoxville, and the Innovation Factory at America Makes (the National Additive Manufacturing Innovation Institute, which is operated in collaboration with Youngstown State University). These additive manufacturing demonstration facilities provide network for additive manufacturing capabilities within a region, and they could be leveraged to scale and replicate the CIMP-3D hands-on industry course. Coordination and collaboration among these facilities and related “centers of excellence” in additive manufacturing could promote scalability and replicability across the country, leveraging the significant investments that are required for metal-based additive manufacturing.

Penn State’s CIMP-3D program has also contacted several professional societies and non-profit organizations to identify ways to scale up training material online to expand the reach of the practicum while still providing access to the hands-on labs that are so vital to understanding what additive manufacturing can and cannot do. Online offerings would help reduce some of the resources needed to offer the practicum, and enable more effective use of lab time for hands-on demonstrations with staff and practitioners.

CHAPTER 5

PROMISING PRACTICES *for* Involving Manufacturers in Education Reform



The Key to Successful Solutions

Much of the conversation on workforce development for advanced manufacturing focuses on ways that educational institutions can change their programming to meet job requirements for a highly-trained technical workforce. Institutions are encouraged to engage industry advisors, allow for flexible student scheduling, modify courses to include practical experience in modern manufacturing, and accommodate new populations not sufficiently served by colleges, universities, or even high schools. Leadership to make these changes is often focused on educational institutions as well. This focus ignores the potential of industry leaders and support personnel to lead educational change, and take a more prominent role in designing and supporting programs that result in workers ready for the job on day one.

The programs presented in this section have the distinctive feature of engaging manufacturers as equal partners—and, in some cases, lead partners—in educational change. The approaches feature: tight relationships between manufacturers and community colleges that allow students to get credit for learning skills on the job; manufacturer-led skill programs that promise certifications honored by industry; and employers' "skin in the game" in the form of compensation for student workers, provision of equipment and supplies, and availability of modern training facilities suitable for student learners. All of these approaches result in producing trained workers with hope—and often guarantee—of employment.

Kentucky FAME: Building a Skilled Manufacturing Workforce through an Employer-Educator Partnership

The Kentucky Federation for Advanced Manufacturing Education (KY FAME) is a statewide network of partnerships between regional manufacturers and local community colleges whose purpose is to implement dual-track, apprenticeship-style training that will create a pipeline of highly skilled workers. The primary method to achieve this goal is through partnerships with local educational institutions to offer the Advanced Manufacturing Technician Program (AMT). KY FAME develops a pipeline of skilled advanced manufacturing technicians through on-the-job application of a process that combines technical skills, personal behaviors and core manufacturing exercises. The program also serves to improve the image of the manufacturing industry and promote manufacturing-related career pathway opportunities for Kentucky residents.

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KY FAME is a collection of manufacturing-led regional chapters including almost 100 companies across Kentucky, such as 3M Manufacturing, Bosch AS, GE, Hahn Automation, L'Oréal, and Toyota. Companies recruit three groups of students for the KY FAME program:

- high-achieving high school students with an interest and background in science, technology, engineering and math;
- veterans with technical backgrounds; and
- current or displaced workers interested in advancing their skills.

Over the course of five consecutive semesters, selected program participants complete a 40-hour work week plus course homework. The work week includes: 16 hours of instruction and labs over two days on campus in a simulated manufacturing setting at a KY Community and Technical College System (KCTCS) location; and 24 hours of hands-on apprenticeship-style training with mentors at an AMT partner company.

Students from the KY FAME program leave the program with:

- common employability skills for success in business,
- pathways to high demand technical jobs,
- associate degrees in Applied Science in Industrial Maintenance Technology—Advanced Manufacturing Technician Track (AMT),
- industry-recognized certifications,
- 1,800 hours of on-the-job training,
- little to no school debt, and
- an opportunity for full-time employment with the KY FAME sponsoring employer.

In the 2016 fall semester, KY FAME had 317 students enrolled statewide, sponsored by 103 employers at 12 KCTCS partner colleges and two postsecondary university partners. Approximately 650 students will be enrolled in KY FAME endorsed programs in Fall 2017. There are a total of 232 AMT graduates, and the on-time graduation rate for AMT students is 89 percent.

After receiving their associate degree, some students choose to further their education and pursue a bachelor's degree, either right away, or after having worked a few years. Through a partnership with Northwood University, students can apply their AMT credits toward the Manufacturing Management Bachelor of Business

Administration degree. Students also have the advantage of hands-on skills training should they choose to work toward a degree in engineering at the University of Kentucky or another state university.

Scalability and Replicability

Using the KY FAME model, Toyota has established similar programs in its plant communities in Alabama, Indiana, Kentucky, Mississippi, Missouri, Tennessee, Texas, and West Virginia. The program is successful because it is an employer-educator partnership lead by local employers. Through industry leadership, a program like KY FAME is sustainable and replicable.

Alabama Robotics Technology Park: A Collaboration of State Government, Education, and Manufacturers to Train for the Robotics Industry

The Alabama Robotics Technology Park (RTP) is a modern facility offering robotics training through the collaborative efforts of multiple industries, state government, and community colleges. Currently housing three operational phases, the park operates a Robotics Maintenance Training Center, offering several training programs and an advanced robotics training line which demonstrates how several different machines can be combined into a continuous assembly line, and an Advanced Research and Technology Center, where clients who have funding to conduct research are encouraged to involve co-op students in developing new robotics technologies. The park recently opened an Integration, Entrepreneurial, and Paint Dispense Training Center, which will offer training in paint dispense techniques and encourage research and development in this area. The RTP also operates a mobile robotics unit which visits schools and demonstrates equipment to interest students in robotics careers.

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The Alabama Robotics Technology Park (RTP) represents a collaboration among the state of Alabama, the Alabama Community College System, Alabama Industrial Development Training (AIDT), and robotics industry leaders across the nation. The RTP consists of three individual training facilities, each targeted to a specific industry need. The three buildings have an investment of approximately \$73 million, including robotics equipment. The park's parent company, AIDT, is a division of the Alabama Department of Commerce that was established to recruit and train a skilled workforce; it provides job-specific pre-employment and on-the-job training for any and all manufacturers.

The Alabama RTP has three operational phases: the Robotics Maintenance Training Center, the Advanced Research and Technology Center, and the Integration/Entrepreneurial and Paint Dispense Training Center. Businesses and start-ups apply to use these facilities. Currently, dozens of industry clients use the facilities and there are 8 educational partners.

Clients of the Alabama RTP can employ or admit interns or co-op students from colleges and universities, train staff at no cost to the RTP client, have access to vendor-specific training classes and certifications, use the Paint Dispense entity equipment for research and testing, and lease the Integration/Entrepreneurial offices, workroom, and high-bay floor space at no cost (except set up and utilities).

Scalability and Replicability

The Alabama RTP accommodates a revolving set of clients, and has opportunity to help and improve an ever-increasing number of businesses in their quest to upgrade manufacturing technologies through the use of robotics and a skilled workforce. The RTP also provides a replicable model that demonstrates how a contracted workforce training entity can collaborate with partners in economic development agencies, education, and industry to outfit and staff one or more training facilities to advance robotics or other new technologies for advanced manufacturing.

RIGHT SKILLS NOW for Manufacturing: Fast-Track Training for Manufacturing Jobs

RIGHT SKILLS NOW for Manufacturing is an accelerated program designed to support the National Association of Manufacturers (NAM) Endorsed Manufacturing Skills Certification System which includes nationally portable, industry-recognized certifications that are combined with for-credit education programs. These education pathways are directly aligned to career pathways in manufacturing, so students progressing through the programs earn college credit towards a degree, one or more national certifications with labor market value, and the hands-on technical experience to be successful on the job from day one. RIGHT SKILLS NOW fast-tracks and focuses career training in core employability and technical skills by “chunking” relevant curriculum that leads to interim credentials in critical machining skills. While the initial model focuses on machining skills, for which there is immediate demand, the program can accelerate skills development in other foundational skills areas for advanced manufacturing like production or welding.

RIGHT SKILLS NOW was developed by the National Institute of Metalworking Skills (NIMS), which worked with the President’s Jobs Council to tailor the national manufacturing certification system into a nationally replicable fast-track solution to deliver just-in-time talent to small manufacturers. This accelerated program allows individuals to earn college credit and national industry certifications in 16 weeks, preparing them for immediate employment in high-quality manufacturing jobs and giving them a solid foundation to advance in higher education and careers.

RIGHT SKILLS NOW is deployed at two Minnesota colleges, Dunwoody College of Technology and South Central Community College, as well as in Ohio, where it has been adopted by MAGNET, the Manufacturing Advocacy and Growth Network, an Ohio MEP Affiliate. Other partners include ACT, the certifying body for the National Career Readiness Certificate which is the foundational credential signaling attainment of critical employability skills.

South Central College and Dunwoody College of Engineering in Minnesota jointly offer a curriculum developed by surveying manufacturing companies that have hired their graduates. MAGNET, the Manufacturing Advocacy and Growth Network, an Ohio MEP Affiliate, worked with Cuyahoga Community College and company trainers to identify learning outcomes and build the curriculum content and delivery structure for the program.

Thus far, through Cuyahoga Community college, Lorain County Community College, and Stark State College, there have been 23 cohorts with 154 students completing training, 114 placed in jobs, with a 74 percent placement rate (immediately following program/internship).

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Scalability and Replicability

Due to initial success, MAGNET has replicated the RIGHT SKILLS NOW model with a group of smaller employers and with two other community colleges. Essential features of the model to replicate include:

- Securing company commitment to participate in job task analysis, provide curriculum input, and offer paid internships for successful training completers;
- Convening subject matter experts from participating companies;
- Conducting a job task analysis process to identify and prioritize common skills needed for the job;
- Engaging the education partner to identify the courses that would result in the necessary skills;
- Identifying the industry certifications that would validate the learning outcomes;
- Designing the program to meet these criteria;
- Reviewing the program design with the participating companies; and
- Clearly identifying enrollment criteria to ensure that the students have the necessary basic skills and are prepared to participate in a fast-track training program.

In the Ohio MAGNET program, the process and outcomes validated the potential for schools and colleges to work with companies to design and deliver solutions to workforce challenges. It also demonstrated the value of a workforce intermediary like MAGNET in facilitating the process.

Mercedes-Benz U.S. International, Inc.: The Bill Taylor Institute Automotive Systems Program, Mechatronics Program, and Co-op Program

Mercedes-Benz U.S. International, Inc. (MBUSI) offers several career training programs, three of which are associated directly with local colleges in Alabama and take place at the Bill Taylor Institute, MBUSI's training facility: an Automotive Systems Program, a Mechatronics Program, and a co-op program featuring several career tracks at MBUSI. All three programs require students to be able to work at MBUSI's facilities in Vance, Alabama, and offer paid internships and potential employment. The Bill Taylor Institute in Vance is a state-of-the-art training program for individuals who wish to learn to work on Mercedes-Benz and other luxury automobiles. Individuals receive the on the job, hands-on experience, and all necessary instruction to successfully complete their program, creating a seamless transition from classroom to workplace.

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The Automotive Systems associate degree program includes 61 credit hours of instruction from both Shelton State Community College and the University of West Alabama. The top students in the graduating class can earn a position with MBUSI, and 64 prior students who have successfully completed the program are now working full time with MBUSI.

The Industrial Mechatronics program is a training partnership between MBUSI, Shelton State Community College, and AIDT (Alabama's Workforce Training Agency). The Mechatronics Program includes 7 terms of instruction at Shelton State Community College and an additional 18 months of training at MBUSI. Students can earn an Associates of Applied Science degree in Industrial Electronics and a short certificate in Industrial Maintenance.

The MBUSI Co-op Program gives students the opportunity to gain real world working experience in an international environment. As a Co-op student, individuals are placed in many different departments within the manufacturing organization to gain a variety of experience.

Scalability and Replicability

The Mercedes-Benz training programs provide a model for instituting multiple industry training programs in conjunction with local colleges. They have the advantage of allowing students to complete an education while working and guaranteeing employment to top graduates.

University of Tennessee Center for Industrial Services: Leadership and Supervision Program for Managers

The University of Tennessee Center for Industrial Services (UT CIS) offers a highly individualized, practical course in leadership that is well-suited for new and experienced managers in modern manufacturing settings. This program helps participants learn how to be effective leaders and to explore leadership and management on-the-job. Program participants are taught by industry leaders, experienced coaches, and management professionals who cover topics such the fundamentals of leadership, communication, coaching for improved performance, problem solving, resolving conflicts, health and safety in the workplace, principles of lean manufacturing, and more. The program was initially developed as a pilot for Delta Faucet, whose staff collaborated to develop the curriculum, and it is taught in three sessions of 2.5 days each.

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Two cohorts have graduated from the program. Caterpillar participated in the program in 2016 and the program will be expanded in 2017 to include manufacturers statewide.

The curriculum opens with theoretical and practical applications involving leadership and communication and ends with proven management practices and tools designed to benefit their company as a whole. The program also provides participants a baseline in continuing improvement practices, industrial health and safety practices, human resource issues, and organizational problem solving. The program ends with individual and group assignments that help learners reflect on how they can use their new knowledge and tools in their current leadership positions. Participants in the program spend a lot of time together as a cohort and work as a group and individually throughout the sessions, building trust with their co-workers as well as the instructors, and increasing the chances of successful transfer of the program learnings to the workplace.

Scalability and Replicability

This UT CIS Leadership and Supervision Program introduces an innovative and disruptive process that has produced real results toward aligning educational and training outcomes with the competencies that Tennessee's regional manufacturing workforce needs. The program has already been proven to be replicable, scalable, and sustainable in various manufacturing settings across Tennessee and in a very short period. Since launching the pilot project in collaboration with Delta Faucet in 2015, the program has been customized and delivered for manufacturers in other industry clusters including the automotive and heavy machinery supply chains.

Central Piedmont Community College: Customized Training for Major Expansion of the Siemens Charlotte Energy Hub Manufacturing Plant in Charlotte, N.C.

Central Piedmont Community College (CPCC) for the past six years has worked with the Siemens Charlotte Energy Hub (SCEH) and Charlotte Works in an innovative partnership to meet a concentrated demand for skilled workers required for a major plant expansion for the SCEH. The expansion has involved a multi-year, multi-phased, and multi-million dollar training effort engaging public, private, state, and local partners. The training has focused on middle-skill level workers for technical, STEM-focused, and other related jobs. The partnership credits its success to: engaged communication aimed toward recruiting and training talent, application of the CPCC Advanced Manufacturing Strategic Framework for developing key curricular components, and attention to all components that drive results—classes (some 1,500), apprenticeships, curriculum development, and an advanced, agile infrastructure for workforce development.

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The SCEH is the Siemens Company's worldwide hub for fossil power generation equipment manufacturing and service, and has manufactured and serviced generators and steam turbines for the power generation market for decades. In November 2011 the facility was expanded to add gas turbine production and service, and was designed based on LEAN manufacturing principles and U.S. LEED Gold building standards, making it the most advanced gas turbine production plant in the world.

With the expansion, Siemens needed highly trained machinists, mechanics, and welders, as well as those in engineering occupations that involved STEM background. This brought together the three partners along with the N.C. Community College system.

CPCC applied their Advanced Manufacturing Strategic Framework, a flexible system that addresses 1) core skills, 2) industry and sector-specific applied skills, and 3) the need for highly customized employer-specific skills. Charlotte Works has contributed to the partnership by providing a website portal for job-seekers to apply online and to find assessment and training information. Siemens' local training manager, supervisors, and others set extensive training schedules with college coordinators and staff.

Siemens also started an apprenticeship program where apprentices attend classes at CPCC for their associate degree in mechatronics, and also work at the Siemens Charlotte Energy Hub to apply the skills they are learning in the classroom.

As of February 2017, CPCC has provided 2,083 classes representing nearly 21,000 hours of training, and added employees at Siemens is reaching numbers beyond the projected 800 new hires. CPCC has expanded the apprenticeship program, graduating 11 apprentices with two-year degrees in either Mechatronics Engineering Technology or Computer Integrated Machining Technology. As of spring 2017, Siemens has employed 15 apprentices.

Siemens claims the partnership has allowed the company to customize the training for its workforce, a critical factor in its ability to quickly staff the new gas turbine facility.

Scalability and Replicability

With clear objectives, willing partners, and associated best practices, the model is both scalable and replicable. Key criteria for successful replication include completing the following steps:

- Effectively engage training and education stakeholders and institutions, including funding and resources;
 - Identify skill sets required and appropriate assessment methods;
 - Identify and select qualified candidates from which to hire and train;
 - Train expert instructors and develop curriculum in a global learning exchange; and
 - Deliver targeted training.
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