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Closing the Advanced Manufacturing Talent Gap

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Abstract

Evidence exists that a thriving manufacturing sector increases the number of stable, well-paying jobs leading to the growth of the US economy. The manufacturing industry is the fifth largest employer in Massachusetts and benefits from the state's diversified economy, according to a recent Jobs For the Future (JFF) report. At the same time, several states in the US, including Massachusetts, are consistently reporting a skills gap that results in a shortage of a skilled workforce leading to thousands of unfilled positions in this sector. This paper describes an innovative approach that prepares college graduates to launch a second career in the growing advanced manufacturing sector while bringing together various stakeholders including higher education institutions, workforce investment boards and industry. The paper describes the range of services provided to students in the new manufacturing certificate programs at a community college in Massachusetts and opportunities that exist for additional collaboration.

Keywords: Advanced Manufacturing, Industry-Academia partnerships, NSF ATE, DOL TAACCCT, STEM Starter Academy, Skills Gap, Community College, Training

1 Introduction

In 2013, manufacturing represented a $2.08 trillion area of the U.S. economy—12.5 percent of gross domestic product—and accounted for 1 in 6 private sector jobs (Pew Charitable Trust, 2015). Evidence suggests that a thriving manufacturing sector increases the number of stable, well-paying jobs leading to a robust economy of a nation. Since 2012, in addition to the workforce training fund grants for manufacturing, the federal government has funded several national networks for

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manufacturing innovation (NNMI) that provide manufacturing research infrastructure to U.S. industry and academia for collaboration and link regional manufacturing innovation institutes. While reports differ in the estimated number of new manufacturing jobs created as a result of direct investments by the federal government, a recent US Congressional report (Levinson, 2015) noted that when manufacturing employment had recovered from its cyclical low in January 2010, manufacturers showed a preference for workers with academic-track associate degrees. A recent US policy that outlined the strategy for American innovation (National Economic Council and Office of Science and Technology, 2015) notes that 'technological innovation is the key source of economic growth for the United States' and 'coordinated and federal efforts can have large impacts on jobs and economic growth' in the nation and identifies a need to strengthen America's edge in both traditional and high-tech products as a priority area with a clear need to increase domestic production.

At the same time, the US manufacturing industry has consistently raised concerns about the "largest gap" in our educational system—it does not produce people with the technical knowledge, basic business skills, people skills, and problem solving abilities necessary to succeed in a modern manufacturing facility (Advanced Manufacturing Partnership Steering Committee, 2012). As a result, a number of vacancies in manufacturing are unfilled with nearly 82% of US manufacturers reporting moderate to serious gaps in the ability to find skilled manufacturing candidates.

At the other end of the spectrum, another cause of concern for the US labor market is the underutilization of the available workers, particularly those with recent college degrees. For example, in 2015, about 52.7% of youth workers aged 16-24 years in the US were employed in the month of July when the youth employment rate is expected to reach its highest in any given year. This signifies that nearly 47% of young people were not employed at this time. A recent Department of Labor report (Meyer, 2014) suggests that in 2014, high school graduates and those with an associate's degree or some college education accounted for disproportionate shares of the increased supply of underutilized labor. According to a recent New York Federal Bank study (Abel et al., 2014), only about 40 to 45% of recent college graduates majoring in communications, liberal arts, business, and social sciences were working in jobs that required a degree. This underutilization (or underemployment) of recent college graduates presents a challenge since it risks permanently lowering their estimated long-term earnings.

2 Opportunity and Industry Alignment

In an effort to provide an innovative solution to address the issues of underutilization of US labor workforce and the challenges faced by the manufacturing industry in finding skilled workforce, , MassBay Community College (MBCC), in collaboration with Northeastern University (NU) in Massachusetts, designed an advanced manufacturing program focused in technology and innovation.. The program has been supported by a National Science Foundation (NSF) Advanced Technological Education (ATE) collaborative grant award (NSF Project ID #1406741 and #1407160).

The program is an innovative, transformative, and fast track (12 month long) certificate for liberal arts (BA) college graduates interested in pursuing careers in advanced manufacturing. Our hypothesis is that BA graduates have already taken coursework that promoted critical thinking and communication skills. Therefore, the certificate program can focus on the technical training of the BA graduates at a reasonable cost, in a short timeframe. The certificate would introduce and prepare them for a second career in the growing advanced manufacturing industry. The certificate program would also identify how the college can address the problem of underemployment in the region.

2.1 TRANSFORM Curricula

This project, referred to as TRANSFORM, aims to transform the students seeking skills and support for a career transition to the advanced manufacturing sector. Developed in 2015, the program offers two 12-month fast track certificate programs: Manufacturing Technology and Manufacturing Innovation. TRANSFORM is informed by the labor market needs in Massachusetts and builds on students' strong liberal arts foundation from their previous college education. TRANSFORM coursework provides a broad introduction to advanced manufacturing and design processes, quality control and sustainable manufacturing, as well as exposure to modern equipment and techniques used by the modern manufacturing industry. Both certificate programs feature a credit-bearing experiential learning component that provides students with practical training and experience necessary to apply for jobs in the manufacturing industry.

2.2 Who Are We Serving: Manufacturing Industry in Massachusetts

The manufacturing industry in Massachusetts is diverse representing a broad spectrum of companies (Massachusetts Institute of Technology's (MIT) Industrial Performance Center, 2015a). These companies manufacture a variety of products including traditional fabricated metal products, industrial machinery, scientific instruments, electrical equipment, communication equipment or medical devices. The growing advanced manufacturing sector in Massachusetts includes several companies that are technology-driven, such as those who manufacture robots. There are also a significant number of companies that produce equipment and instruments for the life sciences industry.

Recognizing the potential of the life sciences industry to create large numbers of jobs, Massachusetts state government has continued to invest in research and development and in manufacturing by offering planning grants, major capital project grants, equipment and supply grants to community colleges and high schools. For example, in 2014, via its Massachusetts Life Sciences Center (MLSC), the state awarded several grants to cities, university based research and innovation centers, community colleges and high schools totaling more than $50.5 million (Massachusetts Life Sciences Center, 2014).

A recent study (MIT Industrial Performance Center, 2015b) reported that approximately 97% of all manufacturing establishments in Massachusetts are small or medium manufacturing enterprises (SMEs) and about 92% have fewer than 100 employees. It also found that the manufacturing industry in Massachusetts is characterized by a focus on quality and small-batch niche production, rather than large-volume mass production; developing products that require high proprietary content or regulatory reviews. The study further notes that the state's efforts to date revolve around workforce training and lean practice. While applauding these efforts, the study suggests that with the rise of new technologies, such as additive manufacturing, program support should be expanded to include centers, either existing or yet to be formed, that provide technological and engineering services to SMEs engaged in product and process innovation.

2.3 Alignment with Employer Needs

Noting the diversity in the manufacturing sector in Massachusetts, and the absence of a single dominating industry or employer, the TRANSFORM curriculum was designed to serve the ongoing needs of the manufacturing industry in Massachusetts without a focus on a specific employer or industry. The courses are designed to provide a broad knowledge of the manufacturing field enhanced by a hands-on introduction to design and manufacturing processes, tools and equipment.

Figure 1 describes the TRANSFORM vision that is based on three pillars for student development: Technical expertise, Innovation and Career Preparedness. It was expected that some competencies would be developed through participation in credit-bearing coursework, while others were expected to be acquired from regular interactions with staff, faculty and industry partners, other stakeholders in the state, or through experiential learning.

With its focus on credit-bearing courses in design and product innovation and electives, the TRANSFORM curricula is distinct from the training offered by the Manufacturing Advancement Center Workforce Development Collaborative (MACWIC). Sample electives are introduction to business, robotics, supply chain management, and lean six sigma. TRANSFORM certificate programs also feature a broad introduction to advanced manufacturing tools and processes. The graduates of this certificate program are prepared to fill entry-level technician jobs or jobs in the manufacturing industry that require an understanding of the manufacturing environment.

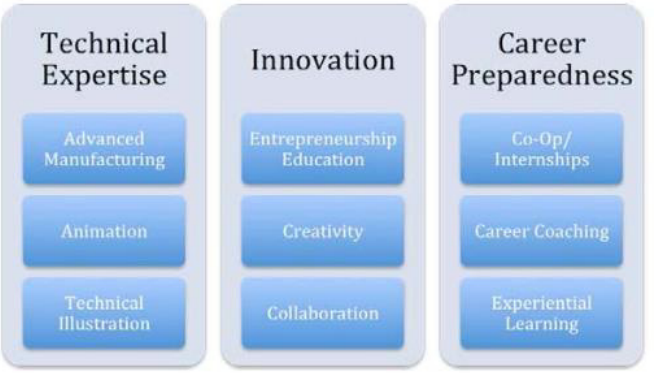

Figure 1 TRANSFORM Vision

The curricular framework was shared with industry partners for initial feedback. The project team also sought feedback from industry at two industry breakfasts hosted by the college as well as informally through on-going communication and employer outreach. A recommendation from the project's industry partners has been the inclusion of Computer Numerical Control (CNC) training since the certificates offer an introduction to CNC programming. While the project team recognizes that there is a growing high demand for CNC operators and machinists in Massachusetts, the team did not proceed with this training due to the high cost of initial capital investments, projected high maintenance, personnel costs and expenditures during the life span of the equipment. In addition, the certificate programs are designed to benefit a broad range of OMEs and SMEs and the team decided that students would be better served if they received additional training on specific equipment by individual employers.

3 From Idea to Implementation

For the past several years, MBCC has offered a Computer-Aided Design (CAD) Certificate and a two-year career track Engineering Design Associate Degree program. The new manufacturing certificate ('Manufacturing Technology' and 'Manufacturing Innovation') programs were founded on the strength of the existing programs in CAD and Engineering Design and share laboratory space and faculty.

The manufacturing certificate programs are funded by two NSF ATE collaborative research awards (NSF Project ID #1406741 and #1407160). A team of collaborators from MBCC and NU began designing the two certificate programs in fall 2014. These programs feature several modular, one-credit courses that allow for multiple entry points for students. Both programs share a set of core or foundational courses. These courses provide students with introduction to manufacturing processes, engineering design, and modern tools and equipment such as 3D printers and scanners. Additionally, the technology curriculum features a modular "Making it Happen with" coursework that sequentially provides students with hands-on introduction to various computing concepts like coding, artifacts, robots and data. Students are also introduced to manufacturing technologies as well as CNC programming, Geometric Dimensioning and Tolerancing, and Statistical Process Control and Quality Assurance through the coursework. The Business side of the manufacturing operations is stressed through introductory coursework on supply chain management as well as sustainability and lifecycle management. The manufacturing innovation certificate offers some introductory business courses, as well as, including an an Entrepreneurship course. Northeastern University provided curriculum outline and resources for developing new coursework at MBCC in Supply Chain Management and Manufacturing Technology.

The curriculum was developed in accordance with MBCC's faculty governance policies and was approved and voted on by MBCC's Board of Trustees in spring 2015. The two short (less than 30-credits) certificate programs were then sent to the Massachusetts Department of Higher Education (DHE) for final approval. One of the early decisions was to ensure that the certificates were approved for the ITA/Section 30 population that typically brings their own funding to be trained.

MBCC offered its first set of courses in summer 2015 for its first cohort of TRANSFORM students. Although students were able to enroll in either the Technology or Innovation track, all students chose the Manufacturing Technology option.

The team began holding regular information sessions for prospective students in early March 2015. The initial sessions were attended by prospective students who learned about the program through referrals from friends or relatives, emails to the campus community, or simply by searching on the Internet. MBCC's marketing department assisted by creating a TRANSFORM web page and linking the front page to the project website. The team used social media platforms such as LinkedIn, Twitter and Facebook to reach prospective students. The team reached out to departments at four-year schools including Northeastern and local colleges/universities, alumni organizations including those at MBCC. The team also reached out to other places such as coffee shops, libraries and manufacturing companies with entry-level workers who might benefit from this training.

From the beginning, it was clear that this would be a marketing-intensive process and the team would need to combine resources to make these programs accessible for interested students and to meet the needs of enrolled students and employers. The decision to collaborate with allied project teams was made consciously to address these concerns. One such example was the decision to make the certificates available as an online hybrid program. The college has adopted a standard for all online and online course delivery that requires instructors to undergo training and in turn provide them with a stipend per credit for development of the curricula.

To make this program flexible and attractive to students with busy schedules, the team decided to offer the course in an online hybrid format consisting of an online lecture component and an in-class meeting for laboratory or group work. Coupled with significant faculty interest and expertise in development of the online curriculum, it was not difficult to implement, but since this decision was made after the ATE project was awarded, the college's online program budgets could not be altered easily to offer the faculty stipends for the online course delivery.

In this regard, MBCC has been able to expand the enrollment efforts for the manufacturing certificate programs when it received a Department of Labor (DOL) TAACCCT –Guided Pathways to Success in Science, Technology, Engineering and Mathematics (GPSTEM) award and a STEM Starter Academy (SSA) award from the DHE. The three projects at the college are structurally linked and

functionally similar. This has allowed the college to coordinate and expand its project activities. These activities include informing and enrolling students as well as conducting industry outreach and developing relationships with manufacturing employers. MBCC team, led by the Principal Investigators (PIs), was able to successfully address this additional fiscal need as well as supplement operational and organizational needs such as enrollment efforts.

For example, MBCC's SSA grant allowed it to fund the training and online hybrid delivery of the coursework, while its GPSTEM grant allowed it to create two new positions: GPSTEM Director and a College and Career Navigator. The new positions played a major role in attracting new students to the certificate programs. The GPSTEM Director plays an important role in sharing the best practices learned from the state's 15 community colleges and is an important link to the state's one-stop centers that serve its unemployed population. These centers assist job seekers by linking them to employers and to a variety of job assistance services including career counseling, workshops and short-term training, and providing resume and cover letter assistance.

Employment & Training Resources (ETR) is one of the sixteen One-Stop Career Centers in Massachusetts that serves the Metro South/West metropolitan Boston region in Massachusetts where MBCC is located. ETR is a joint venture of the Metro South/West Employment & Training Administration and the Massachusetts Department of Labor and Workforce Development. It is chartered by Partnerships for a Skilled Workforce (PSW). MBCC's GPSTEM Director, working in collaboration with the College's ATE PI, established a Memorandum of Agreement (MOA) that outlines an agreement between MBCC, PSW and ETR. The memorandum aims to accelerate progress for low-skilled workers, unemployed persons, and career changers and reduce time to completion of industry-recognized credentials, certificates and degrees. Per this agreement, MBCC serves the individuals seeking services from the ETR by holding regular information sessions and workshops to inform a variety of career and professional training options that the college offers including the academic and non-academic support services, as well as career and other advising provided by the college.

The College and Career Navigator plays an active role in recruitment and enrollment of Trade Adjustment Assistance (TAA) and other dislocated workers, guiding their decisions about career pathways and related courses, as well as connecting them to the college's Career Services. The GPSTEM staff's role is to enhance student services including career advising, academic support, internship opportunities, and creating partnerships to industry, to support TAA and other program participants. Enrollment activities were significantly enhanced beginning in May when the college's GPSTEM team began holding routine TRANSFORM information sessions at the regional one stop career centers in Massachusetts for the population it serves. In 2015, the GPSTEM team hosted 15 information sessions for TRANSFORM.

The prospective candidates attending information sessions from the One Stop Centers are often eligible for training funds distributed throughout the state. Though funding eligibility is determined for each individual, on an as needed basis by the one stop career center staff, MBCC finds value in informing the underemployed and unemployed individuals in the Commonwealth about the TRANSFORM program. The multiple training funds identified are dependent upon a variety of factors including where a client has lost employment, if a client needs to re-evaluate career prospects to find in-demand employment opportunities or have access to education to provide employment with a sustainable wage. The TAA fund is a federally funded program that assists workers who have lost their jobs as a result of foreign trade to quickly rejoin the workforce. The program provides up to two years of training funds to attain competitive and marketable skills for fields that are in demand. Workforce Investment Act and Individual Training account funds (WIA/Title-I ITA) are distributed to individuals who need occupational skills training in order to successfully re-enter the workforce.

A prospective candidate could be a one stop center client who has lost employment and needs to change careers, needs to enhance skills to obtain employment, is economically disadvantaged, or part of the at-risk youth program designated for the 17-21 year old population. Though Section 30 is not a

source of funding for students to attend training, it is attractive to the prospective student who is unemployed to begin training and continue to receive unemployment benefits. Section 30 approval allows unemployment insurance (UI) claimants to collect benefits while enrolled in full-time, approved training. The Department of Unemployment Assistance (DUA) waives the usual requirement to look for employment while attending training to allow students the time to develop marketable skills and then find suitable employment. Again, funding for training and eligibility is dependent on many variables for each individual seeking both funding and section 30. MBCC has discovered that prospective students seeking training funds often need guidance in the process which is provided by the College and Career Navigator.

The current TRANSFORM student population consists of eight (8) male and three (3) female participants. Of these seven (7) are recent college graduates with at least a two-year associate degree. Of these, four (4) students were unemployed before they enrolled in the program and heard about the program through their regional one stop centers and seven (7) students reported learning about the program from MBCC faculty/staff, their relatives, a newspaper ad, or social media.

4 Services

The team's unique structural organization and alignment of goals has allowed it to function effectively and to access resources to provide TRANSFORM students with academic advising. The team also provides special training sessions, workshops for resume and portfolio preparation, interview skills, as well as placement into internships and co-ops. The SSA Coordinator who is also the Director of the STEM Mentor Program at the college, connected the students to professional mentors in the field, pairing each student in a one-on-one relationship with a STEM professional. The Director has identified that 37% of the TRANSFORM students are in the STEM Mentor Program and one student is on a waiting list to join the program when space becomes available. SSA staff worked closely with Career Services to develop career development workshops and to facilitate individual review of students' job/internship application materials.

Workshops on resume, interviewing, LinkedIn as well as individual mock-interviews conducted by employers were offered during the course of the year. In addition, nine (9) students participated in a Manufacturing Internship Program event where students had the opportunity to "speed interview" with multiple employers for internship placements. SSA staff also met individually with the students to assist them with identifying and applying for internships and conducted extensive outreach with manufacturing employers to create internship opportunities for the students.

Similarly, the GPSTEM Director and SSA Coordinator have arranged manufacturing site visits for students that have exposed them to manufacturing facilities and provided informal networking opportunities. The SSA Coordinator took eight (8) TRANSFORM students to the Genzyme manufacturing facility in Framingham in November. The GPSTEM Director and Career Navigator have offered the students group and individual sessions for resume writing, feedback and review. The GPSTEM Director also took the students to visit the manufacturing site of MicroGroup, Inc. Working in collaboration with the ATE PI and Co-PIs, the GPSTEM Director and SSA Coordinator and STEM Mentor Program Director, the team established various points of connections with industry (Human Resources, CEOs and managers of SMEs), and routinely follow up with their contacts at the companies for placing interns, and manage information and communication flow.

5 Initial Results and Feedback

Of the first cohort, 80% of the students have or will have completed their core coursework by the end of the spring 2016 semester. In addition to coursework, the internship or co-op experience is a

major component of the certificate programs. By January of 2016, every student from the first cohort of TRANSFORM students has interviewed with at least one Massachusetts based manufacturing company. Also, 40% of these students were placed in or completed an internship. Nearly all TRANSFORM students attended both on-campus interviews as well as interviews at employer sites. Some companies such as the MicroGroup offered students a tour of their facility before they interviewed students for internships. Titles of the successful internships to date include: 3D CAD designer, SolidWorks/CAD designer, Precision Technology and Machining (technician), and Production Operator. A student who completed his internship as a Production Operator has continued part-time work with the same employer.

Upon completion of the internship, site supervisors (employers) are asked to complete a comprehensive evaluation form for the intern. This form completes one feedback loop: from employer to the college and is expected to provide an honest, useful and constructive assessment of the student. One employer writes, "Adam* was a good worker, polite, dependable, and earned respect from other employees. Adam was able to take constructive criticism well, learn from it, and apply it to the next project", and "Adam was able to function with little supervision and accomplished the tasks assigned to him". The supervisor further reported that while the candidate's 'ability to write using language appropriate to major' is still developing, the candidate was able to demonstrate competence in thinking 'critically and analytically about discipline issues and providing alternative solutions to problems'. This student, 'Adam', on the other hand, described his experience working for the company as, "working for (my internship employer) will dramatically help my future, as it has provided me with good connections in a growing field. This time has also helped to better my skills in many manufacturing/engineering disciplines, and office dynamics".

At the same time, the project is offering some interesting insights into the manufacturing industry in the state. The project team found that most employers who attended the two industry breakfast meetings at MBCC's campus were referred by various stakeholders such as MassDevelopment (Commonwealth's economic development and finance agency). These employers were genuinely interested in learning about the certificates and training and helped the team by providing feedback on the curriculum or by offering internships and site visits. Nearly all employers who attended the meetings at the college expressed the need to train a new manufacturing workforce in light of a workforce that is fast-approaching retirement age. In addition, these companies strongly supported TRANSFORM's vision to train non-technical, underemployed college educated populations.

Most companies served by the TRANSFORM program to date are small to medium-sized enterprises. They represent a number of subsectors, and produce high quality products to serve the region's needs. They are also agile and lean, but their size, which makes them attractive and versatile on the one hand, may be preventing them from participating on a fundamentally transformative scale to train new interns on site. One employer who offered an early internship explained his reason for not offering another internship, "I am looking for someone full-time, ideally someone to partner with me, not really an intern". After initial interest in offering internships, another employer indicated that the owner of the company was forced to take a break from operations due to personal reasons and she would not be able to supervise a new intern in his absence.

A comprehensive evaluation effort with responses collected from students and employers who participated (attended or provided internships) is currently underway and is expected to yield additional useful insights about this student population as well as the manufacturing sector in the state. At this time, it appears that the TRANSFORM students are gaining fundamental and important skills to prepare them for careers in manufacturing, but will need time and additional opportunities to develop expertise or gain in-depth knowledge in industry specific areas.

* Name changed to protect privacy.

6 Opportunities

This collaboration between a community college and a private research university in Massachusetts has developed two new certificate programs in manufacturing and within a year has created new retraining and experiential learning opportunities for underemployed college graduates. The structures that existed in the community college were fully utilized to maximize the potential for student success and the work opportunities available for them. The program is currently dependent on state and federal funds but has the potential to scale up. Additional opportunities for collaboration exist for continuous stakeholder engagement and for sharing resources.

Several immediate opportunities exist for ensuring continuous stakeholder engagement. **First**, the manufacturing programs will be strengthened by the formation of a permanent advisory board for community college manufacturing students. While it might not be sustainable to create an advisory board with industry representatives for each program in a department in the long-term, small cohesive units (departments, divisions) within the community college will benefit from a joint advisory board that provides continuous engagement with the industry. The community college advisory board members can continue to guide the curriculum and student development.

Second, individual members of the project team have worked with other stakeholders in the state and have supported various manufacturing initiatives to form regional or national manufacturing networks. However, this interaction is usually limited to providing education and training. It does not provide community colleges with substantive opportunities for representation on regional manufacturing networks to contribute to the ongoing dialogue with various stakeholders including state government, industry and research universities. There is a need for community colleges to be represented on regional manufacturing networks.

Third, small and medium sized manufacturing enterprises can greatly benefit from their regional community colleges. They can receive customized training for their employees including technicians and executive staff. A request for employee training and professional development was brought up several times during the industry breakfast meetings. Employers repeatedly expressed the need for the development of soft skills such as writing, problem-solving and communication.

Fourth, sharing lessons learned from TRANFORM with industry and the State Board of Higher Education will inform employment practices in manufacturing and other industries. Massachusetts, as with many other states, is expanding recommendations for student internships. This project will help inform student and industry preparation and capacity to take these efforts to scale in our state.

Finally, the high initial capital costs and long-term costs such as maintenance and personnel associated with manufacturing programs discourages educational institutions from offering specific training on certain industry standard equipment such as CNC machines. Colleges and industry or maker-spaces in the region could share their resources such as, space and equipment, which would reduce the costs of training and professional development for the region's workforce.

7 Conclusions

In fall 2014, MassBay Community College in collaboration with Northeastern University designed an innovative transformative program for liberal arts college graduates interested in pursuing careers in advanced manufacturing. This project, referred to as TRANSFORM is providing a broad introduction to advanced manufacturing and design processes and exposure to modern equipment and techniques used by the modern manufacturing industry. Leveraging various resources available at the MBCC, these students are provided a range of services including professional mentoring, assistance with career development, and support to launch a career in advanced manufacturing. It also outlines the opportunities that exist for additional collaboration with industry and other stakeholders. At this

time, the TRANSFORM students have developed important skills in specific disciplinary areas during the short-duration certificate programs. These skills are further honed and expanded upon by the experiential component of the program that is providing students with direct experience in the manufacturing industry. Follow-up with initial and subsequent cohorts will be necessary to determine the ultimate career paths of the students who have benefitted from the education and training these programs have provided.

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