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Transforming Liberal Arts Graduates to Advanced Manufacturing Careers: The First Cohort

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TRANSFORM: TRANSFORMing liberal arts careers to meet demand for advanced manufacturing workforce

Abstract

It is well recognized that a liberal arts degree (BA) equips graduates with many essential skills cited as critical for the current and future workforce. These include but are not limited to strong communication, critical thinking and problem solving skills in addition to being adaptable and innovative in a culturally diverse environment. Multiple employer surveys and educational standards stress the importance of the skills acquired through a liberal arts education and their value added to the preparation of technical career students such as engineers. However, it is also well recognized that BA graduates are more challenged securing employment after graduation than their counterparts in technical careers. Their prospects for meaningful employment in economic downturns are even less. Many of these graduates are either un- or mal-employed during recession times. Their compensation is often less than that of their technical counterparts. Many industries, including Advanced Manufacturing lack sufficient skilled labor to meet their labor needs.

This paper presents an innovative program (TRANSFORM) which seeks to address these two problems: lack of meaningful employment for BA graduates and the lack of a sufficient number of graduates with the essential technical skills to fill advanced manufacturing positions. TRANSFORM has been developed to equip BA graduates with skills essential for a financially stable career in advanced manufacturing. The central research question is how to accomplish this vision? The paper discusses a project currently funded by NSF that aims to answer this research question.

This paper presents the elements of the program: targeted advanced manufacturing positions, design and delivery of the TRANSFORMing curriculum and program, recruitment of the target audience (BA graduates), recruitment of industrial partners, internship opportunities, program logistics, student advising, and lessons learned.

Keywords: Advanced Manufacturing, Workforce Development, Mal-Employment, Flipped Classroom, Project Based Learning

Introduction

Over the past decade numerous reports have been issued regarding our regional and national manufacturing landscape. Many cite America's innovative strength to be directly tied to its manufacturing capabilities. Manufacturing is essential to address our current and emerging needs. It is especially critical for many local industries. Approximately 11% of our nation's workforce is employed in manufacturing. Based on the recent MIT report, *Strengthening the Innovation Ecosystem for Advanced Manufacturing PATHWAYS & OPPORTUNITIES for MASSACHUSETTS*, **(**2015)[1] the state has a diverse manufacturing base that encourages collaboration between industry groups. These local industries require a labor force having skills essential for their industry to support both the design and manufacturing of products. Employers have also cited the need for additional soft skills that support collaboration and creativity in the workplace.

Massachusetts in addition to many other states has a number of collaborative workforce efforts to address workforce challenges including but not limited to The Manufacturing Advancement Center Workforce Innovation Collaborative (MACWIC) as well as the Massachusetts Manufacturing Extension Partnership (MassMEP). Through these collaborations, much needed technical skills and training to support our manufacturing industries have been refined. The result was the development of a five-tiered training pyramid comprising of stackable consecutive training modules that is available to both secondary schools and Community Colleges. This curriculum however provides minimal information regarding the other essential skills industries required to foster innovation and compete in the global marketplace.

Massachusetts, with over 50% of its population holding a Bachelor's degree, **(**Andrew Sum, Ishwar Khatiwada 2013 [2]) (T. Frochlich, R. Serenbetz, A. Kent and A. E.M. Hess, 2014 [13]) boasts the highest percentage of college educated citizens in the United States. A considerable percentage of this population however acquired degrees in disciplines with little to no direct correlation to the current state labor market. (The Economic Value of College Majors, Georgetown University Center on Education and the Workforce, 2015 [6]) This talent pool is ideally poised to meet the expanding needs of the Massachusetts manufacturing industry.

Employment of liberal arts graduates

TRANSFORM has focused its efforts on this critical component of the manufacturing industry, access to a well-trained and innovative talent pool that could fill the current and expanding labor shortage in this industry. We have approached this problem with a solution that addresses an equally challenging problem, the mal-employment of many individuals with a college degree in a non-technical field. (Neeta P. Fogg and Paul E. Harrington**,** 2011[3]**)** Our original premise was to identify recent liberal arts graduates seeking additional training and job placement in technical positions of high demand in our region. This model has been expanded upon as we sought out our target population and subsequently identified other's seeking the training and skill sets the TRANSFORM program proposed to provide. Mass Bay, as with other similar institutions was seeing a rise of college educated students interested in programming at their institutions. This population might be recent graduates in addition to those now unemployed. (Krupnik, 2015 [15]) As noted previously, Massachusetts has the highest population of college educated citizens in the country, close to double the national average. Many well-paying jobs however in this state may not have required this level of education, but rather specific technical skills. In more recent years the average salary for Associate Degree graduates of technical programs exceeded that of a liberal arts graduate with a Bachelor's Degree.

Many Liberal Arts graduates during the most recent economic downturn experience a sharp increase in mal-employment. "From 2000 to 2010, mal-employment rose by 9.3 percentage points for college graduates between the ages of 20 and 24. (Foroohar, 2013 [8]) Nearly 4 out of 10 young people in that group are now underemployed, and humanities and liberal-arts graduates fared the worst as a group." Over the past decade considerable attention has been given to expanding our STEM Pipeline. In such reports as "A Nation at Risk" (Commission on Excellence in Education 1983 [4]) and through the "President's Innovation Agenda" (Executive Office of the President, 2010 [5]) strengthening and expansion of STEM curriculum in K12 in addition to increasing informal program opportunities in STEM have become commonplace. These efforts however, fail to address much of our current young educated labor force, many of

whom did not “hear” the messaging regarding the opportunities that Advanced Manufacturing and other industries might hold for them. (K. Baron, 2013 [14)] Through TRANSFORM we are creating bridges between populations in need of essential technical skills with customized, industry informed technical training. TRANSFORM also embeds the mindset that lifelong learning and skill development are essential to personal and collective economic viability.

Technical workforce required soft skills

In a National Survey of Business and Non Profit Leaders (It Takes More than a Major: Employer Priorities for College Learning and Student Success) (AACU 2013 [7]), employers outlined a number of essential skills they sought from their employees. These skills moved well beyond the boundaries of traditional majors, technical and otherwise. They referenced a capacity to communicate clearly, think critically in addition to the ability to solve complex problems as more important than the specific course of study at the undergraduate level. An overwhelming majority cited these skills as crucial to the workforce.

Our target population already possesses many of these essential soft skills; however they lack the necessary technical knowledge and the opportunity to apply that knowledge in a “real world setting”. “The United States system of higher education has long been the envy of other nations because of its success in allowing individuals to access it. But as our data and analysis have shown, it is not enough to educate young people; we must also prepare them, and help them find the most appropriate labor-market outlets for their educational background and skills.”

TRANSFORM is ideally positioned to identify labor markets such as Advanced Manufacturing in need of essential skills, recruit and train a labor pool in need of these skills and competencies, and break down the traditional mindset of only one pathway from education to the technical workforce.

Cost effective program model

Through TRANSFORM, we have partnered with industry to develop an Advanced Manufacturing curriculum specifically addressing the technical skills gap liberal arts majors might have, being mindful of the skills they already hold. Building on current workforce training guidelines and through review of existing associate level course content we have developed a yearlong intensive program of study and workplace skill development offered at a price point palatable to those struggling with current student loan debt. The program integrates required courses with career planning and support, followed by a paid internship with a partner company, completed by final reflection and placement. The net cash outlay for a participant is $4,400 with the opportunity to earn the equivalent or more during the paid internship. We have developed two tracks for the program, one in Innovation and one in Technology. Each track shares several foundational courses and has been designed to meet the diverse needs and prior skills of our target population.

Courses/core curriculum

Manufacturing certificate programs are offered at MassBay Community College and are part of the engineering department offerings. The college is an open access institution and the

certificate programs do not have prerequisite requirements. Tables 1 and 2 show the program courses.

Table 1. Curriculum design for manufacturing technology track with advising notes

Course Title	Course # Credit Hrs	Semester Offered	Prerequisites
Semester 1			
Engineering Design with CAD I*	MN130 (4)	Fall/Spr/Sum	Recommended: A working knowledge of Word, Excel & WWW
Manufacturing Technology Fundamentals*	MN131A (1)	Sum	
Geometric Dimensioning & Tolerancing*	MN131B (1)	Sum	Co-Requisite: MN130 Engineering Design I
Statistical Process Control and Quality Assurance*	MN131C (1)	Sum	Co-Requisite: MN130 Engineering Design I
Career Readiness and e-Portfolio*	MN100 (1)	Sum	
Making it Happen with Code****	CS101A (1)	Sum	
Making it Happen with Artifacts****	CS101B (1)	Sum	Prerequisite: CS 101A Making it Happen with Code
Making it Happen with Robots****	CS101C (1)	Sum	Prerequisite: CS 101A Making it Happen with Code
Making it Happen with Data****	CS101D (1)	Sum	Prerequisite: CS 101A Making it Happen with Code
Credits	**(12)**		
Semester 2			
Supply Chain Management****	MN205 (4)	Fall	
Reverse Engineering, 3D Scanning & 3D Printing*	MN132A (1)	Fall	
Numerical Control Machining*	MN132B (2)	Fall	Prerequisite: MN 131A Manufacturing Technology Fund.
Sustainability & Lifecycle Management*	MN132C (1)	Fall	
Program Elective; See list of program electives below	(4)	Fall	
Credits	**(12)**		
Semester 3			
Co-Op Dialogue**	MN201 (1)	Fall/Spr/Sum	
Total Credits Required	**(25)**		

hybrid course, ** online course, * face-to-face course*

Advising Notes:

1. Prior to Semester 1, students should be sure they have applied & been accepted to this program
2. Co-Requisites must be taken before or during the same semester
3. In order to graduate in one year, students must register for all courses in each semester.
4. During Semester 2, students should meet with College & Career Navigator and the Program Coordinator for the Co-Op Experience

Table 2 Elective courses for manufacturing technology track

COURSE #	COURSE TITLE	CREDITS
	Engineering	
EL101	Fundamentals of Electronics	4
MN 121	Mechanical Detailing	4
MN 125	Engineering Computation with Application Software	4
MN 140	Project Management	4
MN 251	Electro-Mechanical Design	4
MN 261	Animation Materials 3D Modeling	4
MN 272	Designing Plastic Parts	4
MN 135	Engineering Design with CAD II	4
	Computer Science	
CS 108	Web Page Development I	1
CS 109	Web Page Development II	1
CS 126	Digital Imaging	3
CS 140	Interactive Multimedia	3
CS 176	Web Design	4
	Business	
BU 100	Introduction to Business	3
AC 101	Financial Accounting I	4
MG 101	Principles of Management	3
MK 103	Principles of Marketing	3
MK 213	Principles of Sales	3
MG 210	Entrepreneurship	3
OA 201	Business Communications	3
	Manufacturing	
MN 133 A	New Product Development	2
MN 133 B	Lean Six Sigma Fundamentals	2

The 25 credit Manufacturing Technology Certificate program (see Table 1 for detailed curriculum with advising notes) can be completed within one year of full time study (12 credits in semesters 1 and 2) with an Internship and a 1 credit CO-OP Dialogue course in semester 3. Many courses are offered in modular and hybrid formats with evening/weekend on campus sessions. The program introduces students to the manufacturing industry and some of its typical tools through a series of required coursework and the internship component. Students are taught using a flipped classroom model, (F-L-I-P, 2014 [12]) hands on activities, project based learning, and team projects using online simulations and course materials.

The manufacturing industry in Massachusetts is incredibly diverse, with sectors spanning from electronics, battery makers, and injection molding to the pharmaceutical and food industries. The skillset required by each sector is varied. To accommodate each industry's need for a diverse skillset, students are offered an elective course that can be selected based on their interest (See table 2 for a list of electives).

Our first cohort of 10 students has a diverse academic and professional background as well as age, sex, and ethnicity. 4 students have bachelor's degrees with 2 in business and 2 technical. 3 have associates degrees in relevant technical disciplines. 3 have a high school diploma or an equivalent with 2 students having previous technical work experience and 1 from a performing arts background. For 2 of the students, English is not their first language. The cohort consists of 7 males and 3 females.

All students in our first cohort are driven and goal oriented, show initiative, have overall good study habits and for the most part take responsibility for their own learning. Students are moving through the program together, participating in team projects and have been able to form a natural cohort. Observing them in and outside of class, it is easy to see that they are willing to lend a helping hand to their classmates and encourage each other to excel. Students who come to the program with some technical background, more often take a leading role in projects and offer assistance to others.

A diverse student population with varied educational backgrounds is not new to a community college setting. The college has assistance in place to help students in subjects that might present a struggle. Peer and professional tutors are available through the academic achievement center to assist with technical subjects as well as writing and math. The college caters to working adults by offering courses after typical working hours, on weekends and online. Faculty members teaching online curriculum have undergone training and use universal course design techniques (S. Burgstahler, 2006 [16)] to cater to all learning styles.

Student advising starts prior to entering the program. Students meet with a designated College and Career Navigator who is the first point of contact for each student participating in this certificate program. The College and Career Navigator assists with the application process and remains a point of contact throughout the program.

Academic advising is performed by program faculty. An academic map shown in Table 1 is used to aid with the advising process. The map includes the list of courses and electives as well

as notes on prerequisites and the semester when each course is typically offered. The block schedule shown in Figure 1 informs students of the course modality and when the courses meet in the upcoming semester. This helps both students and college staff who might not be familiar with the program in selecting appropriate courses that meet the individual's schedule. Having a block schedule in place for this program assures that all students are moving through the program as a cohesive cohort and can complete the program in a timely manner. A block schedule with the summer, fall, or spring semester start was developed to provide flexibility and allow students to start the program in any semester (summer, fall, or spring).

An advising event held every semester provides another opportunity for students to interact with engineering and manufacturing faculty as well as students currently enrolled in this and other programs. MassBay Community College has a set registration and advising period that usually starts in the ninth week of a traditional semester. During that time, students at the college are encouraged to meet with their advisers individually and register for courses they plan to take in the upcoming semester. The advising event allows students to learn about the course content for various courses in their respective programs, and get advice on which courses would fit their needs. Advising curriculum sheets, block schedules, and advising events are part of the intrusive advising process to ensure that students are progressing through the program in a timely manner and identify any issues early on.

Figure 1. Sample Block schedule for full time students starting the certificate in the summer

Advanced Manufacturing-Manufacturing Technology Option

Block Schedule for summer

Course Title	Course #	Day(s) of the Week	Time(s)
Engineering Design with Cad 1	MN130	Mon, Weds Lab Online Class	Lab: 10 a.m. – 12 p.m. 5/26 – 7/3
Manufacturing Technology Fundamentals	MN 131A	Weds Lab Online Class	Lab: 5 p.m. – 7 p.m. 7/6-7/17
Geometric Dimensioning & Tolerancing	MN131B	Weds Lab Online Class	Lab: 5 p.m. – 7 p.m. 7/20-7/31
Statistical Process Control & Quality Assurance	MN131C	Weds Lab Online Class	Lab 5 p.m. – 7 p.m. 8/3-8/14
Career Readiness and E-portfolio	MN100	Weds Lab Online Class	Lab 4 p.m. – 4:50 p.m. 7/6 – 8/14
Making it Happen with Code	CS 101A	Tues, Thurs	4 p.m. – 8:10 p.m. 7/7 -7/14
Making it Happen w/Artifacts	CS 101B	Tues, Thurs	4 p.m. -8:10 p.m. 7/16-7/13
Making it Happen with Robots	CS 101C	Tues, Thurs	4 p.m. – 8:10 p.m. 7/28-8/4
Making it Happen with Data	CS 101D	Tues, Thurs	4 p.m. – 8:10 p.m. 8/6-8/11

Block Schedule for fall

Course Title	Course #	Day(s) of the Week	Time(s)
Supply Chain Management	MN205		9 a.m. – 1:10 p.m.
Reverse Engineering, 3D Scanning and 3D Printing	MN132A		Lab 5 p.m. – 7 p.m. 9/8-12/23
Numerical Control Machining	MN132B		Lab 5 p.m. – 7 p.m. 10/6-11/20
Sustainability & Lifecycle Management	MN132C		Lab 5 p.m. – 7 p.m. 11/23-12/17
Program Elective			

Block Schedule for spring

Co-Op Dialogue	MN201		

Students participating in the TRANSFORM program are able to utilize existing support structures as well as benefit from modular curriculum allowing flexibility with short targeted courses. Studies show (C.T. Medrano, M. Ube, I. Plaza, A. Blesa, 2004 [11]) that students new to a subject matter learn better when they understand the relevance of what they are learning, have some flexibility in selecting projects that are of interest to them and can use their prior experiences to gain new knowledge and skills.

With that in mind, students are taught using a flipped classroom model, hands on activities, project based learning, and team projects using online simulations and course materials. The hybrid, flipped classroom model allows students to learn at their own pace. Students review course materials online, bringing questions, problems, and project discussions to the classroom. This allows the instructor to address individual questions and misconceptions and gives time for students to work on team projects.

Project Based Learning is an effective way of introducing students to technical concepts while also getting them interested in what they are learning**.** (J. Lillieskold and S. Ostuland, 2008 [10]).It allows students to see the big picture while applying newly acquired concepts at every stage of their chosen project.

Students participate in small classes (22 - 25 students) taught by both full time and adjunct college faculty. Faculty are accessible outside of class via office hours and email. In addition, personal interaction in a small classroom allows faculty to get to know the students in various settings helping the faculty adjust to each student's needs and advise accordingly. Students receive almost personalized faculty attention in and outside the classroom, and form relationships with faculty and peers.

Currently there are four instructors who have been teaching program specific courses and all use some aspects of the above mentioned teaching methodology in their courses. Three of the four

instructors have been teaching at MassBay for over 5 years and one is new to the college . Two of the instructors have incorporated a long term project into the program's courses.

Participation in the TRANSFORM courses requires independence, good study and communication habits, and critical thinking skills. At the end of the second semester working with this cohort all instructors informally reported that they are impressed with the students' attitude, level of preparation and submitted work.

In informal conversations with students, most students enjoyed the independence of the hybrid course environment, allowing them the necessary time to learn new topics and skimming through topics that they were already familiar with. Students preferred working on long term projects where they were involved in a project from concept to prototype creation.

In addition to the structured curriculum, students in this cohort were introduced to the industry through company tours. One student had the opportunity to spend a day job shadowing those in a career track of interest. For those new to the industry, these tours provided additional exposure and industry understanding. To date, our first cohort of 10 students enrolled in the program have progressed through the coursework as expected: as our first cohort has not yet completed their studies, we are unable to report on post-graduation results.

Role of industry

The industry has been included throughout all stages of development and implementation of the TRANSFORM program. An initial meeting with industry professionals was utilized to gain insights and feedback on the proposed curriculum. Subsequent meetings were held to begin the internship phase of our program and to solicit paid internships for TRANSFORM students. Throughout this process we have strengthened our relationship with partners, in addition to utilizing their input to make modifications to our program design and internship placement process.

Preparing for Employment

As part of the curriculum, students participate in two 1 credit courses; Career Readiness and e-Portfolio and CO-OP Dialogue. The courses are designed to assist students with preparing for an internship/job search and sharing their internship experiences.

The Career Readiness and ePortfolio hybrid course is offered during the first semester and assists students with understanding industry diversity and the types of jobs within the manufacturing industry. As part of the course, students build an ePortfolio, update their resume, Linked In profile, and practice their interviewing skills. The ePortfolio started in this course, is designed to help students organize their work from various courses and reflect on their progress in the program.

For the first cohort, this course coincided with the internship search. This had proven to be a challenge as some of the necessary work was not completed in time for interviews. The most challenging aspect of this course for the entire first cohort has been the reflective writing component for the ePortfolio pages. The following guest speakers were invited to assist students with various parts of the course:

- A member of the MassBay English faculty, who provided an additional perspective on reflective writing in ePortfolios
- The Career Services director, who presented a workshop on resume writing and interviewing
- The GPSTEM College and Career Navigator who assisted students with mock interviews

Overall, one student summed up the course by stating: “I hate doing this and would never have done this on my own. Thank you for including this course in the curriculum”.

In conjunction with an internship in Semester 3, students participate in a CO-OP Dialogue online course. This course is designed to help students reflect on their learning experience while on the job, as well as share that experience with their peers. Students continue learning from their peers about the industry diversity and various opportunities that exist, as well as provide feedback on their internship experience.

Employment

Two students had completed an internship to date. The students shared their experience with each other in a bi-weekly blog and uploaded a presentation on their experience at the end of the semester. As the number of internships increase, student reflections collected in this course can be a great repository of manufacturing industry positions. This will help future student cohorts in understanding the industry and job requirements.

Lessons learned

Our first 6 students who started the program in summer 2015, completed Semester 1 and 2 requirements with 2 courses remaining (an elective and a CO-OP Dialogue). 4 additional students who started the program in the fall have also completed most requirements for semester 2 and a career readiness course. The modular and stackable curriculum allowed students to join the program in the middle of the semester and continue through the program. Project based and active learning components helped students gain interest and succeed in technical courses.

There are 2 certificate tracks offered; Manufacturing Innovation and Manufacturing Technology. Manufacturing Innovation catered to those interested in opening a small business or working in operational positions. Manufacturing Technology, a more technical track, is presented in this paper. All students in the first cohort selected to pursue the Manufacturing Technology track. Based on conversations with students and employers, this choice was driven by economic reasons. All students enrolled in the program were interested in job opportunities in the manufacturing sector. A more technical curriculum seemed to appeal to potential employers.

This program was designed with a summer start in the hope that it would be easier to place students in internships during the spring semester, rather than the summer when other college students are also searching for internships. A typical summer at MassBay Community College includes 2 six week sessions. Unlike a traditional 15 week semester, courses in the summer are

highly accelerated. Some students participating in accelerated summer courses struggled with the volume of new, technical material in a short amount of time.

With our first cohort, it was challenging to recruit students interested in starting the program in the summer. Spring internship placement has also been a challenge. Extending summer courses from 6 to 10 weeks or moving the program to a traditional Fall/Spring schedule should help with retaining and processing new material without hindering internship possibilities.

As this is a new program, we are still working on establishing relationships with relevant manufacturing companies in the area. Most companies we have been working with are small and for the most part do not have structures in place to mentor an intern. Based on one employer's observation, the program is new and needs time to "get the word out". On the other hand, smaller manufacturing employers need a better understanding of an internship mentoring process and have structures in place to be able to support an intern.

An additional challenge that our students face when applying for internships, is the lack of technical background on their resumes. At the start of the application process, companies are provided access to student resumes. One employer had commented that the resumes lacked technical background. The employer then had a chance to see and discuss students' class project after which he was eager to interview the students. At the suggestion of another employer, we will now hold off on offering employers student resumes prior to the initial meeting with the students.

Conclusion

In this paper we have shared our experience and learning with the first cohort of students enrolled in the Manufacturing Technology Curriculum at MassBay Community College. The 25 credit certificate program has been designed to be completed within one year of full time study. The goal of the program is to prepare non-technical BA graduates to enter manufacturing industry careers. At this stage, the important conclusions and lessons learned are:

(1) Identification and recruitment of applicants that fit our intended profile requires extensive time and additional advertising efforts;
(2) Curriculum must be flexible and infused with project based, active learning components to ensure that students remain interested and receive hands on experience;
(3) Employers must also be informed about the skills TRANSFORM students are gaining in the classroom;
(4) Employers should be encouraged to share best practices in mentoring ours and other student interns;
(5) Lessons learned can be applied to other technical fields of study and other geographic locations.

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