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Government Policy and Manufacturing Education

Introduction

It is becoming increasingly apparent that as United States policymakers try to improve the economy, manufacturing must play a central role. Unfortunately, over the last few decades there has been little effort to sustain existing educational manufacturing programs at all levels. This trend has been fueled by economic policies that emphasized a service-based economy over a manufacturing-based economy and was supported by the notion that these policies were not only inevitable, but also acceptable. Exacerbating this policy is the relentless negative perception fostered by mainstream media creating misleading perceptions of manufacturing as a career choice. Consequently, manufacturing education programs have been at the center of this policy shift with resulting negative consequences. As a result, manufacturing educators struggle to keep their programs attractive as viable educational and career pathways.

As policymakers continue to try to revive the economy, newly proposed educational policies at the federal, state and local levels are largely tactical rather than strategic, if policies exist at all. This paper will examine manufacturing education policies and their impact on the sustainability and growth of manufacturing programs. Key aspects of manufacturing programs will be presented including student recruitment and retention, faculty and curriculum development, and laboratory and programmatic costs.

The current interest and discussions surrounding support for manufacturing, although well intentioned, are not the result of proactive manufacturing policies but rather of a belated reaction to the lingering economic downturn. A most ironic and costly notion is that the current economic downturn can be solved through a *coherent innovation policy* leading to a robust manufacturing sector, which on the face of it, is correct[1]. Regardless, there is an underlying assumption that there is a robust manufacturing education base ready and capable of undertaking the daunting task of supporting economic recovery. Despite many excellent manufacturing programs, the ability to meet this growing demand is dubious at best, given the lack of a strategic planning and a general movement and emphasis away from manufacturing at all educational levels.

Although the public is favorably disposed toward manufacturing and understand its importance to the overall economy, few would encourage their children to choose it as a career path[2]. Among 18-24 year-olds, manufacturing ranks last as a career choice when young adults compare it to other industries that they would choose to start their careers[3]. Paradoxically in the same report, the public also considers the strength of U.S. workers to be a key component of our competitiveness. Unfortunately, these widespread beliefs are rarely developed into systemic policies that support manufacturing education.

With decades of neglect and relentless attrition, the remaining vestiges of manufacturing education programs are still under unprecedented stress simply to remain operational. Despite these issues, there are some excellent models and basic policies that might, if implemented, stabilize the remaining manufacturing programs and may even contribute to their growth. This paper will explore four key aspects of manufacturing programs: student recruitment and retention, faculty professional development, curriculum development, and laboratory and programmatic costs. Among the many challenges facing manufacturing educators, student recruitment and retention, especially among underrepresented students, remains the most vexing.

Student Recruitment

Student enrollment is one of the key justifications to keep manufacturing programs open. Unlike other disciplines that are more "visible" to the public, manufacturing programs require constant attention by the institution to ensure adequate enrollments. High touch industries and programs such as health care, tourism, culinary arts and hospitality are readily understood as career pathways by the general public. Programs that offer the opportunities for creativity, such as architecture, graphic design and film studies, are also very popular. These programs often appeal to a broad base of students, particularly as life-long career options. Although students are exposed to manufactured goods, comprehending the development of those goods is often elusive or poorly understood. This is reflected in an impressive lack of understanding of the numerous career opportunities available in manufacturing. In addition, unrelenting press coverage that constantly emphasizes the offshoring of manufacturing jobs does not present a balanced perspective.

There are many misconceptions about the magnitude of manufacturing being outsourced. This is coupled with limited reporting of increased manufacturing positions caused by backshoring[4], the process of bringing back work that was once done overseas. Backshoring sometimes referred to as on-shoring or in-shoring, is occurring due to concerns over intellectual property, logistics, limited market access and quality related issues[5]. There are some reports that indicate that China is gradually losing its cost advantage due to increased wages and currency appreciation[6]. Finally, more recent reports suggest that there are an impressive number of manufacturing job positions waiting to be filled[7].

Regrettably, student recruitment too often falls to individual faculty members to develop their own recruitment techniques. In addition, recruitment strategies for manufacturing programs are often lost in the larger branding context of an institution, which regularly focuses on more popular career programs. Although comprehensive in its mission, an educational institution may choose to emphasize health care, liberal arts, or education programs. Accordingly, resource allocation for recruitment is generally geared to support the institution's main focus, which often is not manufacturing programs.

Another underlying assumption is that educational policymakers and administrations place a priority on economic development. The continuing erosion of manufacturing programs cannot validate this assumption. The reality reflects an educational philosophy that higher education is exclusively for the development of an educated citizenry, sometimes to the total exclusion of professional career programs. These tensions reflect the attitudes of the prevailing leadership based on perceptions of a quality education. As the leadership changes, policies toward technology-based programs can be altered dramatically. An increasing number of policymakers and administrators are chosen from disciplines outside technology and engineering fields that are unfamiliar with the importance of manufacturing and its impact on economic development. As leadership personnel changes, faculty members in professional career programs, and in particular manufacturing educators, repeatedly ask, "Will they get it?"

As the leadership changes and reflects an increasingly non-technical perspective, manufacturing educators must address yet another challenge: convincing the new leadership of the importance

of their technical and engineering programs. This often requires a tremendous amount of time and energy, which can be better allocated to recruiting new students and supporting program development. Therefore, faculty must not only constantly recruit students but also actively recruit and educate their leadership regarding the value of their manufacturing programs. These efforts may or may not produce the impact necessary for institutions and their programs to obtain the support they need to sustain and expand manufacturing initiatives. Regardless, there are numerous models of success in critical areas of student recruitment and retention, faculty and curriculum development and appropriate programmatic cost structures. The models highlighted in the next section of the paper provide examples of how educational institutions can support and revive manufacturing programs that ultimately educate the workforce that will positively impact economic growth in their communities as well as their state.

Branding and Recruitment Models

Articulation agreements between various educational institutions have been tremendous assets in providing seamless career paths from high schools to community colleges and universities. In order to complement these seamless pathways, emerging models of student recruitment and retention are also essential in changing the perception of manufacturing from a dead end career path to a high technology, rewarding career. The Connecticut State Colleges and Universities (ConnSCU), under their College of Technology (COT), has developed a highly successful career pathway model that includes a comprehensive approach to student recruitment, particularly for underrepresented students. The COT has been able to build on its successful infrastructure that includes a variety of entry and exit points as well as stackable credentials that provide students with a variety of career options. In 2004, The Connecticut College of Technology was awarded a National Science Foundation Advanced Technology Education (ATE) grant to establish a Regional Center for Next Generation Manufacturing (RCNGM). The Regional Center for Next Generation Manufacturing (RCNGM) is tasked with supporting the state's Technology Studies programs and Engineering Science programs in Advanced Manufacturing and capitalizes on the statewide infrastructure that the COT provides for seamless pathways in technology and engineering disciplines. This collective effort is referred to as the COT-RCNGM in the following sections of the paper.

The COT-RCNGM recruitment model—initially started as a statewide effort—is now being delivered at individual community colleges throughout Connecticut. To maximize impact and reduce costs, the statewide Manufacture Your Future model is now delivered at individual community colleges. This localized model involves the creation of learning and career exploratory symposia that demonstrate the entire product development process. Students tour a series of stations where exhibitors explain how products are developed along with the associated career opportunities. Prior to the tour, recruitment and educational materials are provided to high school educators and counselors, allowing them to explore core concepts; they then attend a training session before the symposium. This pre-symposium workshop demonstrates how high school educators can explore core concepts in their classrooms. Under guidance from the COT-RCNGM staff, other institutions throughout New England are adopting the Manufacture Your Future model. In one year after hosting an expo, community colleges have reported significant increases in the number of students enrolled in their manufacturing programs. The following is an excerpt from a faculty member regarding the impact of the Expo that was held at their college:

"Just wanted to let you know that it appears the hard work we put in on the Tech Expo paid off in ways that I had not anticipated. We were able to double enrollment for the College Connections Program with Waterbury Schools. Interesting enough, many of the students who signed up had attended the Expo. Especially for Manufacturing, the quality and caliber of student we got from these schools is much better than what we had before. We moved a lot of the lab equipment around over the summer, and all the new HS students kept asking where things were. That was when I realized that many of them attended the expo. I would never have imagined that we would have seen such a result so quickly. It literally doubled the size of the program in one year. Many thanks again to you and your staff for all the hard work you put in on this, (and I know there was a lot)."
From: Eric Stroehle, October 2011.

Another model that supports innovative interactions among educators and their students is the Virtual Ideation Platform (VIP). The VIP, another NSF-ATE project, allows faculty from community colleges and universities around New England to design and develop products using the Internet. The staff at Central Maine Community College is managing the VIP. Projects are undertaken from individual inventors and from industry in addition to projects that support the creation of new curricula. There are many attractive aspects to this model that support advances in curriculum development and delivery and increasingly, becoming a major arena for student entrepreneurship. In the past two years, four new student initiated businesses have been created. In addition, two more student businesses are under development, an unexpected result of the VIP model. Faculty members across the VIP are now exploring how to encourage, develop and foster student entrepreneurship. Finally, as the VIP model matures it provides new ways to engage students during the recruitment process.

Another important aspect to student recruitment is the integration of additive manufacturing into high school technology and pre-engineering programs. Additive manufacturing technologies have a profound effect on, and are being used to full advantage, for engaging and recruiting students. The team at Saddleback College has developed an additive manufacturing focused NSF-ATE funded National Center called RapidTech. Additive manufacturing also holds great promise to provide a pedagogical link between technology and liberal arts faculty. Regardless, these efforts continue to provide unique perspective to students as they select programs.

Faculty and Curriculum Development

Faculty development is paramount to the success of advanced manufacturing programs. This is especially important given the rapid changes in technology as well as the corresponding need to continually update curricula. Manufacturing programs, due to constant technological advances, require faculty members to constantly keep their expertise and as a result their curricula current. Relentless advances in software, hardware, tooling and related technologies require faculty to constantly learn new technologies such as additive manufacturing, rapid prototyping, and maintain their skills in software applications such as computer aided manufacturing (CAM). Fortunately, models exist to help support faculty and curriculum development.

One example of industry driven faculty development that has been successfully implemented by the COT-RCNGM is faculty externships. These externships partner faculty members with high

tech companies, enabling faculty to remain current in advanced manufacturing technologies. As part of the internship, faculty members are required to create curricula for their classrooms. The outcomes of the faculty externships have exceeded original goals and objectives and have created long-term sustainable relationships between the faculty and the industry sponsor that have resulted in scholarships for students; equipment donations; student tours; and industry guest speakers and lecturers. In addition, many of the companies have been instrumental in lobbying with government agencies and policy makers regarding the need to support manufacturing programs in the state. As a result of their efforts, over $20 million has been legislatively earmarked for capital equipment investments in 2011-12, to create four Manufacturing Centers in the State.

The support of other NSF Advanced Technology Education (ATE) Centers in specialized areas is also highly effective for keeping faculty current. Many ATE centers offer training and classes in advanced manufacturing areas for faculty from any college or secondary program. For example, training on additive manufacturing and rapid prototyping is available at RapidTech, an ATE Center in Irvine, CA. The staff at RapidTech is versed in all aspects of additive manufacturing and in industry trends and provides an annual summer workshop that assists participants with curriculum development as well as purchasing equipment for their respective laboratories. The team at RapidTech also provides innovative models for student recruitment, which have been helpful to the manufacturing community.

The loss of feeder programs such as technology education at the high school level, as well as recently proposed reductions in Perkins funding will have a long term negative impact, especially on maintaining currency in curriculum and equipment. Although costly, Project Lead the Way holds some promise in terms of encouraging students into manufacturing. Given the expense of these programs, their long-term sustainability remains dubious. The lack of statewide frameworks in technology and engineering removes the responsibility from policymakers from having to develop curricula and programs in manufacturing in the K-12 education system. Without stable feeder programs from secondary schools, the manufacturing programs in post-secondary institutions will always be in jeopardy of being closed or eliminated.

Curriculum Development

There are excellent sources to help guide manufacturing faculty members as they develop curricula. Frameworks such as the four pillars provide an overarching framework for curriculum development. In addition, the creation of c2015, a Society of Manufacturing (SME) endorsed curriculum, provides a comprehensive layout of student performance objectives that are cross-walked to national credentials. These are indispensable tools for faculty members that will ensure that the curricula and programs that they are implementing are educating students with the necessary competencies for the 21st Century workforce.

A lack of resources that includes comprehensive development and grant packages is most vexing. In order to introduce new technologies, grant solicitations must include opportunities to fund faculty and curriculum development, equipment and appropriate facilities for optimum success. Some states are trying to "inject" money into manufacturing programs for equipment without any thought to faculty development or curriculum development. Some grants will provide money for equipment without support for faculty and curriculum development or vice

versa. In some cases, faculty development is routinely provided but without access to or the purchase of advanced manufacturing equipment. In other cases there are no or poor facilities. Faculty development, curriculum development, equipment and funding for facilities upgrades should all be included as part of comprehensive grant packages, in order to allow manufacturing programs to remain current and address all of the components necessary for a program to be sustainable and successful.

Laboratory Equipment

All one needs to do to get a true sense of the symptomatic problems of advanced manufacturing education is to look at the age and type of equipment currently available to educators. A cursory look at laboratory facilities shows antiquated equipment, understaffed laboratories and limited amounts of raw materials.

Tied closely to the need for faculty and curriculum development is the ever present need for advanced manufacturing equipment and tooling. This is a key area of concern since equipment is the core of advanced manufacturing education. The use of simulation software and equipment is often used to support student-learning objectives. These are no substitute for actual time spent on equipment for set-up, operation, trouble-shooting and process optimization. Time spent on equipment will maximize students' ability to undertake complex learning objectives and provide maximum value for employers. This laboratory time is important, providing valuable experiences on equipment, making students immediately productive as they go out to support companies.

Unfortunately, the purchase of advanced manufacturing equipment with the required tooling at all educational levels is a daunting task, given the expense. However, the lower-cost bench models that are moderately priced can still help demonstrate fundamental learning objectives, but they have their limitations. If students are to be proficient using industrial equipment, they need to develop the appropriate skills sets on industry units.

Unemployment and Earning Potential Based on Discipline

Of all the issues that plague manufacturing programs, the one that must be addressed, by both faculty and administration, is the potential benefit of earning degrees in the various manufacturing careers. The table below highlights some programs along with associated unemployment rates and salary potential. To equitably assess programs, some consideration should be given not only to the expense of these programs, but also the earning potential of graduates, unemployment rates, and their potential economic impact.

Table 1 Comparative Analysis for Various Disciplines, Unemployment Rates & Salary Levels [8]

Program of Study	Graduate Degree Holders	Experienced Graduates	Recent Graduates
Architecture Unemployment Rates	7.7%	9.2%	13.9%
Architecture Earnings	$71,000	$64,000	$36,000
Education Unemployment Rates	1.9%	3.9%	5.4%
Education Earnings	$56,000	$43,000	$33,000
Manufacturing Unemployment Rates	4.0%	5.1%	N.A.
Manufacturing Salaries	$99,000	$80,000	$55,000
Common Foreign Languages Unemployment Rates	3.7%	4.8%	7.9%
Common Foreign Languages Salaries	$62,000	$50,000	$32,000
Age Range	54 – 30 years old	54 – 30 years old	26 – 22 years old

The above table is simply a snapshot of various disciplines and their relative strengths in terms of employment and salary potential. Regardless, what is also needed is an assessment of the direct economic impact on the local and regional economy. This would provide a more holistic perspective for policy makers. In addition, the number of programs that are planned or already in existence needs to be considered to determine where there is over or under capacity for various disciplines.

Conclusion and Recommendations

The belated discussion regarding manufacturing is very positive but it remains to be seen what policies, beyond those that are tactical, will emerge. The overarching challenge for policymakers at all levels is to create *strategic continuity*, ensuring the long-term stability of manufacturing programs. Ironically, the stabilization of manufacturing education programs remains optional at all levels of government and this reality will always be the Achilles' heel of manufacturing education.

The retirement of older faculty members will provide yet another impetus for closing manufacturing programs. Despite the valiant efforts of some administrators and manufacturing educators, it is difficult to strike a positive note for what remains of the educational base in manufacturing. Manufacturing education attrition will continue with the resulting economic consequences at the local, regional and national levels.

After reviewing key determinates of manufacturing education it is becoming increasingly clear that federal, state and local policymakers must try to develop comprehensive and cohesive policies regarding manufacturing education. This will require leadership at all levels to prevent

further decline. Listed below are some key policy recommendations that will encourage policymakers to move from tactical responses toward systemic solutions.

Federal Level

- Support national technology and engineering frameworks
- Support H.R. 1366, The National Manufacturing Strategy Act
    - Modify this bill to involve manufacturing administrators and educators at all levels in various sub-committees
    - Modify this bill, given the dynamic nature of manufacturing, and have committees submit strategic plans once every two years instead of the proposed four year cycle
- Develop mechanisms to help key policymakers develop an understanding of the unique challenges of advanced manufacturing education
- Perform an ongoing gap analysis with regard to manufacturers' needs and what is currently available in the educational community and make funding decisions accordingly
- Bundle grant support for advanced manufacturing that includes faculty development, advanced manufacturing equipment and facilities
- Encourage the development of a holistic understanding of advanced manufacturing as an "innovation engine" in its own right
- Develop a national clearinghouse for the dissemination of promising and proven practices similar to the NSF's ITEST structure for the Advanced Technology Education (ATE) program
- Level fund Perkins and target those funds for advanced manufacturing programs and faculty support
- Have the Small Business Administration redefine small business employee size from 500 to small threshold(s) that actually reflect current demographics of small companies to include 5, 10-25 and 50
- Maintain funding level for NSF-ATE programs and target additional funding for innovative Regional and National Centers in advanced manufacturing, to include significant funding for advanced manufacturing equipment and faculty training
- Sponsor a joint research project on the state of manufacturing education in coordination with the National Governors Association
- Adopt the metric system

State and Local Levels

- Encourage a deeper understanding of the role and economic impact of advanced manufacturing programs in K-12 education, especially with guidance counselors and admission personnel
- Encourage the adoption of proven techniques for student recruitment, and faculty and curriculum development
- Support or restart technology education programs
- Strengthen vocational high school programs in advanced manufacturing technologies
- Provide a transition period for incoming faculty members as older faculty members retire

- Allow states to target Perkins funding toward advanced manufacturing
- Quantify and publish the economic impact of manufacturing education programs at the federal, state and local levels on an ongoing basis
- Require that an economic impact statement be sent to local and regional companies before closing any manufacturing education program.
- Require that an economic impact statements be vetted and filed with the governor's office and the office of economic development before closure
- Support innovation and student entrepreneurship at all levels of education
- Provide a comparative cost analysis per student credit hour that includes the economic impact for each student placed
- Develop a holistic approach, in terms of evaluating the cost per student, which includes the economic impact in a return on investment (ROI) format to enable realistic program comparisons

Conclusion

Over the years there has been a relentless movement away from manufacturing as an economic priority. The consequence of this shift is most visible in manufacturing education. Sadly, there is little that faculty members can do to ensure the long-term strategic stability of their programs, except possibly, in the area of student recruitment and retention.

There has been no clear manufacturing agenda set forth for decades and what remains is anemic at best. Unfortunately, there are too many forces that in the past, present and in the future will continue to compromise the sustainability of manufacturing programs. These dynamics, as pointed out previously, are well known, and although problematic, they are not insurmountable. A general dialogue would be helpful, but will be complicated by the lack of a thorough knowledge of advanced manufacturing and the subsequent need for manufacturing education. In the end, when the leadership changes at various institutions, the question that manufacturing faculty members will ask is, "Will they get it?" Following that, if they do get it, "Will they act and support manufacturing?" Only time will tell.

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