Reinventing Manufacturing Engineering: Refocusing and Exploring Future Opportunities for Students

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Abstract

Open any newspaper today, search current news service websites, or turn on the television and one finds negative images of outsourcing, the closure of factories, and the loss of manufacturing jobs in our country. Many corporations find it profitable to move operations overseas seeking less expensive labor. There is outrage in our nation as we see manufacturing and product design careers and opportunities disappear. In addition, many Manufacturing Engineering and Technology programs in this country are seeing an alarming decline in enrollments. In most cases (if not all), the remaining twenty five ABET accredited manufacturing engineering programs in the U.S are shrinking as the numbers of incoming students dwindle.

If our students are indeed basing their academic choices on negative information and images promoted by mass media, it is up to educators to appeal to students and revitalize the image by promoting the positive future of manufacturing education and prepare for the opportunities of outsourcing. Educators must be prepared for this phenomenon and prepare students adequately for the new world that faces them. Moreover, we must revise our programs to reflect the new reality of manufacturing as a global enterprise where our graduates are likely to design products locally to be produced in another part of the world.

Introduction

Many Manufacturing Engineering and Technology programs in this country are seeing an alarming decline in enrollments. There are twenty-five ABET accredited manufacturing engineering programs, however there are only approximately twenty still actively recruiting students. In most cases, if not all, the programs shrinking as the numbers of incoming students dwindle. For many Americans, the word “outsourcing” and "globalization" conjures up images of manufacturing job decline [5]. Airwaves are abuzz of late with talk about the loss of manufacturing jobs, the offshoring of tech jobs, immigration, and general alarmism about the “outsourcing” of the American worker [4]. If potential student academic choices are based on negative information and images promoted by mass media, it is up to educators to appeal to students and revitalize the image by promoting the positive future of manufacturing education and prepare for the opportunities of outsourcing. Robert Reich, former Secretary of Labor, warned

Americans to cease pining after the days when millions of Americans stood along assembly lines and continuously bolted, fit, soldered, or clamped whatever went by. Reich said the blame lies, not with poor nations with low wages, but with new knowledge and technology [1]. A new perspective is needed as we view new knowledge as freeing us from routine jobs and opening the doors to new opportunities. He warned all those who lament the loss of jobs to refocus because they are overlooking the new jobs and opportunities that exist. Educators need to “refocus” by preparing students to be systems thinkers, promoting proactive viewpoints, and exploring these new opportunities for manufacturing engineering. This will not only prepare our students but attract more students to a career that is losing enrollments yearly. Moreover, we must revise our programs to reflect the new reality of manufacturing as a global enterprise where our graduates are likely to design products locally to be produced in another part of the world.

The negative perceptions are confirmed when the media shares the following types of statistics:

- An AFL-CIO study of manufacturing employment in Pennsylvania shows that 161,200 manufacturing jobs have been lost in the commonwealth since January 2001. According to the industrial union council of the labor organization, that figure means 1 of every 5 of the state's industrial workers has lost his or her job over the last few years. The losses, the council said, are a result of governmental policies that encourage outsourcing and put Americans at an economic disadvantage [3].

- Since the beginning of the recession in late 2000, Indiana has lost more than 136,000 jobs [2]. Manufacturing was hit hardest with over 90,000 jobs lost.

- The Economic Policy Institute named the states of California, New York, Michigan, Texas, and Ohio as the five states losing the most jobs between 1993 and 2000 [4].

Seldom do we read or hear of proactive approaches to this problem. Rarely do we see positive reports and examples of ongoing improvements of manufacturing operations. In fact, many higher educational institutions are partnering with state governmental leaders to reinvent and advance manufacturing. Ongoing improvement of manufacturing operations and strengthening manufacturing innovations is in line with Robert Reich’s forewarning. This paper explores these issues by examining current manufacturing programs in engineering and technology within the context of the new realities in American manufacturing.

Examples of Global Expansion

A series of articles [8][9] in the Detroit Free Press outlined how various automotive companies, including General Motors (GM), are approaching global trade. The companies are embracing India as a vast new market and a source of technical talent. India is a large underdeveloped automotive market with over a billion people and a labor force of 472 million people. The car market has grown from 559,522 four wheeled vehicles in 1996 to 934,880 in 2003. The annual motorcycle sales are 5.5 million. GM has invested $260 million in India and its market share has increased from 3,966 vehicles in 1996 to 15,155 in 2003. The sales for 2004 were projected to reach 23,763. India graduates 275,000 engineers annually, 200,000 are educated in English.

In the past, U.S. companies have been unable to hire enough American engineers and have had to import engineers from other countries to do technical work. The new trend is to export the technical work to markets with lower labor costs, and eliminate the expenses resulting from immigration. One such example given in the articles is GMs use of Harita Infoserve in Bangalore India to do design work including Finite Element Analysis. The article also states that Harita works with Ford, Daimler-Chrysler, and numerous auto parts suppliers. Beyond the technical, the engineers in Bangalore are trained to work with their US counterparts on a social level. This includes daily copies of news from Detroit, sports scores, and Michigan weather reports. The work schedule is aligned to the normal workday in Detroit, including clocks set to Eastern Standard Time. The teams use the Internet and telephones to keep in constant contact. A number of the employees at these companies were educated in the US and have returned to India. Harita plans to expand by 200 engineers this year and 1,000 engineers in the next three years.

The articles state that GM has established a technical center in Bangalore. This move has also drawn U.S. based companies such as Quantech Global Services to establish offices in Bangalore. A quote from the article reads "They are not hiring in the U.S., but they have not had to cut staff." Quantech employs 140 in Troy MI, but employs 300 in Bangalore, with plans to hire another 300 there. Job applicants in their Indian office face rigorous expectations including a "five-hour written engineering test in English, and a computer test in math.". Ironically the "Indians worry that their jobs could soon be outsourced to cheaper, skilled labor pools, such as Turkey or Russia."

The anecdotes from the Detroit Free Press articles serve as examples of the coming problems as the operations in India gain in technical and business experience. A manager at a Bangalore office of EASi, a U.S. company said "We are slowly migrating to complex levels and global design programs". Essentially the company wants to move from simpler parts to larger scale designs.

Low labor rates, a good supply of engineers, and new market opportunities will continue to make countries such as India attractive to American corporations. There are also threats from higher labor cost countries with much higher levels of education. The small numbers of highly educated engineers has begun to push corporations to sometimes more expensive labor markets, such as Europe, to gain access to larger pools of well educated engineers [10].

Appealing to the Future Manufacturing Engineers

To increase the number of students selecting manufacturing and/or engineering the negative image of manufacturing must be understood and overcome. A report from the National Association of Manufacturers [10] details the problems with the image of manufacturing careers among the general public, students, and teachers.

When asked to describe the images that they associate with a career in manufacturing, student respondents quickly and consistently offered phrases such as "production or assembly line work" work in a "factory" or "plant" that is "repetitious," "boring," "tedious," "dangerous," "dark" and "dirty." They felt that manufacturing required "hard work" and "long hours" but provided only "low pay," with "no chance for promotion" or "benefits." Others equated a career in manufacturing to "serving a life sentence" and being "on a chain gang," "slave to the line" or even a "robot."

Manufacturing Engineering programs can be revitalized if the image (and content) can be realigned to attract more academically qualified students. A list of positive images that should be communicated is listed below.

- not tied to a desk or a production line
- flexible time, not punching clocks
- more dynamic career choices
- designing and building
- helping society and making a difference
- using new high-technologies, computers and methods
- work with a diverse group of people
- determining the best ways to satisfy customers
- important roles in companies including management
- good salaries, benefits and bonuses
- managing large budgets
- travel to many interesting places and cultures
- support the security of the country by building self-dependence

Charting a New Course for Manufacturing Education

The challenges faced by Manufacturing Engineering are similar to those encountered and overcome by Chemical Engineering programs [12]. Potential students were being lost to programs with names such as 'bio-technology', even when the content of the programs was similar. The curriculum of many of these programs was redesigned and renamed to reverse this trend. Some strategies that can help reverse the trend for manufacturing engineering are listed below.

1. Emphasize that the complexity nature of Manufacturing Engineering requires highly talented individuals who are highly motivated, people oriented, intellectually inquisitive, have a broader perspective and want to help people. A 'shopping list' of skills is provided for the purposes of discussion.

    - likes to design and build
    - well rounded - able to relate to diverse perspectives and disciplines
    - people skills - to work with people of diverse backgrounds and interests
    - "Big Picture" - can integrate the design process
    - act as an architect to call for other disciplines when necessary. e.g., MEs for stress problems
    - solid analytical skills to tune/optimize processes and design

- understand the implications of design decisions on manufacturing
- take the product from the needs of the customer to the final result
- be agents of change - act as entrepreneurs who can reshape companies from within, or build from the ground up.
- effective communicators

2. Identify a core set of topics that are essential to Product Design and Manufacturing and recognize them as core to the discipline. Other disciplines must be encouraged to take advantage of these, but recognize them as Manufacturing Engineering topics, such as tolerancing.

3. Carefully differentiate 'Manufacturing Engineering' from other disciplines such as 'Mechanical Engineering'.

4. Redesign curricula to recognize 'Products' as the driving force and rename programs accordingly.

5. Involve others in the discussion to establish recognition of the role of Manufacturing Engineers. This should include professional groups, manufacturers, schools and the media.

The Industry Perspective

The top priorities of the SME Manufacturing Education Plan [11] are listed below. The list was assembled with input from various individuals and companies who are now actively in the midst of the 'offshore outsourcing' situation. This is a useful road-map when reviewing the activities and plans for Manufacturing Education.

1. Business Knowledge/Skills
2. Supply Chain Management
3. Project Management
4. International Perspective
5. Materials
6. Manufacturing Process Control
7. Written & Oral Communication
8. Product/Process Design
9. Quality
10. Specific Manufacturing Processes
11. Manufacturing Systems
12. Problem Solving
13. Teamwork (working effectively with others)
14. Personal Attributes
15. Engineering Fundamentals

It is worth noting that the list places the process of engineering and people skills ahead of the theory of engineering. This list does not suggest that we abandoning the technical

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underpinnings of the degree, however addressing the other items will allow our graduates to be successful in the new economy.

Institutional Response - Purdue University

Purdue University's president, Martin Jischke, in May 2004, announced the plans to establish a Center for Advanced Manufacturing in an effort to boost the largest sector of Indiana's economy into a leading role in the global marketplace. In response, U.S. senator Evan Bayh remarked: "During a time when manufacturing jobs are declining, the creation of these facilities will help spur the discovery of innovative ways to produce new goods and ensure the development of new job opportunities for future generations of Hoosier workers" [6]. President Jischke outlined four ways in which the new center would contribute to Indiana's economic growth:

- Provide an infrastructure to facilitate the relationships between fundamental research, technology transfer efforts and startup companies.
- Support existing companies around the state that require significant applied product research help or product and process improvement.
- Attract additional **manufacturing companies** to Indiana, increasing the number of jobs available in the field.
- Bring emerging technologies to Indiana and foster the creation of new technologies

Advanced manufacturing consists of all manufacturing that involves a high proportion of sophisticated technology components and/or that manufacturing activity that involves a high proportion of advanced technological processes. Advanced manufacturing includes the themes of design and production automation, lean manufacturing, agility and flexibility, total quality, e-commerce, knowledge-based manufacturing, supply chain management and the extended enterprise, and collaborative manufacturing [7]. Wes Iverson, managing editor of *Automation World,* stated:

> "The U.S. must invest manufacturers who invest in sophisticated equipment technology at home can gain the upper hand for a time over lower-priced imports, thanks to the higher quality product allowed by the automation. But the automation technology used in the developing nations eventually catches up, giving products produced there the advantage. Automation only works for a period of time. The lesson for manufacturers is that they must continually reinvest in automation and innovation. If you stand still, you ultimately lose."

Investment in advancing manufacturing, a focus on innovation, and a new perspective on manufacturing will change the perception of manufacturing engineering and technology as a career. There are many focused areas of advanced manufacturing that would attract students to pursue degrees in manufacturing engineering and technology. Some of these areas are: Product Lifecycle Management, e-Enterprise, Precision Machining, Nano-manufacturing, Life-science, Bio-technology, and pharmaceutical manufacturing [7].

Purdue University's advanced manufacturing plan is based on the Central Indiana Corporate Partnership (CICP) action plan to support the manufacturing sector. One part of this plan that specifically addresses education and would be the strategy point most likely to encourage more students into manufacturing engineering and technology. It states: "Educate, retain, regain, and retrain the workforce for critical fields and skills necessary to building a strong regional economy around the three identified industries and clusters. This will be accomplished by [7]:

1. Recruiting in-state graduates by pooling technology and manufacturing firm efforts to **recruit graduates from state universities** at job fairs on their campuses.
2. Initiate a program to expand **internships and work-study programs** for students in cluster industries to gain knowledge, experience and familiarity with Indiana employers.
3. Form training consortia among firms to set design specifications for skill training and undertake annual employee education and training need surveys.
4. Establish pilot magnet schools at **K-12 public schools** around key technology and manufacturing fields throughout Indiana.
5. Form cluster-based advanced technology centers at community colleges or branch campuses on a pilot basis to help industry address needs for skilled workers.
6. Institute jobs ready skills program to address gaps in educational attainment levels of existing workforce, making the region a pilot test for this effort.

As ABET accredited manufacturing engineering programs continue to shrink at alarming rates, the example set by our higher educational institutions will send a positive message for future attraction of students. Establishing job fair recruiting, internships and work-study programs for present students, and K-12 initiatives for future students will send a positive message that manufacturing is alive and well and preparation requires innovation and viewing it from a new perspective.

Institutional Response - Grand Valley State University

For the last decade the engineering enrollments at Grand Valley State University (GVSU) have had a steady growth of 5-10% per year. The Manufacturing Engineering program was begun in the mid-1990s with the first graduates in 1997. The enrollments in the Manufacturing program grew until 2001 when the growth of the economy slowed. Since then the manufacturing enrollment trend has dramatically reversed. The growth of the program has been limited by negative perceptions of manufacturing careers and employment. The graduates from the program are in demand, and the employment rate is 100% for those seeking employment. However, in light of the negative perceptions, students often select, or are advised into, programs such as Mechanical Engineering.

At GVSU we are committed to manufacturing education, beyond the Manufacturing Engineering discipline. Students in all disciplines (including Electrical and Computer Engineering) are educated in manufacturing basics, beginning in the first year when they use CAD and CNC systems to design and build parts. However, it is clear that in the traditional form the original Manufacturing Engineering program is not attractive to students and will not support the emerging trends in engineering employment. Therefore the program has been restructured to include a major focus on Product Design and to provide more differentiation from Mechanical Engineering.

In the fall of 2004 the first Product Design and Manufacturing (PDM) core course was offered, EGR 301 - Analytical Product Design. This will be followed by EGR 440 - Production Models in the summer of 2005, and EGR 401 - Advanced Product Design in the winter of 2006. The first graduates of the new program are expected in the summer of 2006. These courses replace three previous courses, EGR 371 - Manufacturing Simulation, EGR 373 - Production Scheduling and Control, and EGR 470 - Product and Process Design. The old and new curriculum examples are shown in Figure 1.

> EGR 301 Analytical Product Design - An introductory course that addresses product design early in the curriculum to keep the students engaged. Topics include; rapid prototyping, patents, mathematical tolerance analysis, GD&T, customers and their needs, material and process selection.
>
> EGR 401 Advanced Product Design - Topics include advanced design, design justification, patents, etc.
>
> EGR 440 Production Models a combination of the current courses EGR 371 - Process Scheduling and Control and EGR 373 - Manufacturing System Simulation.

	Previous	New
Fundamentals	CHM 115 – Chemistry	
	CS 162 – C Programming	
	MTH 201 – Calculus I	
	MTH 202 – Calculus II	
	MTH 203 – Calculus III	
	MTH 302 – Differential Eqn	
	PHY 230 – Physics I	
	PHY 234 – Engineering Physics	
	STA 314 – SPC	
	WRT 150 – Writing	
	EGR 101 – CAD/CAM	
	EGR 103 – Data Analysis	
	EGR 209 – Statics	
	EGR 214 – Circuits	
	EGR 226 – Digital Systems	
	EGR 250 – Materials	
Required		* EGR 301 – Analytical Product Design
	EGR 309 – Machine Design I	EGR 309 – Machine Design I
	EGR 345 – Dynamic Sys Mod & Cont	EGR 345 – Dynamic Sys Mod & Cont
	EGR 360 – Thermodynamics	EGR 360 – Thermodynamics
	EGR 367 – Manufacturing Processes	EGR 367 – Manufacturing Processes
	* EGR 371 – Manufacturing Simulation	
	* EGR 373 – Scheduling and Control	
		* EGR 401 – Advanced Product Design (W/04)
		* EGR 440 – Production Models
	EGR 450 – Manufacturing Controls	EGR 450 – Manufacturing Controls
Electives	EGR 409 – Machine Design II	EGR 409 – Machine Design II
	* EGR 470 – Product and Process Design	
	EGR 474 – Systems Integration	EGR 474 – Systems Integration

Note: * indicates a course change

Figure 1 - A Sample Comparison of the Current and New Curricula

The new PDM program directly addresses the need for engineers who can work at a more global level (Product Design) and use the resources of other engineers who are trained with more specific skills (Mechanical Design). This supports the innovative design process that has been recognized as a strategic advantage for U.S. companies [13]. The new name for the program will provide an image that is more approachable to the 'general public' who generally understand and relate to 'products' more than 'manufacturing'. The new emphasis also emphasizes the elements of public service and interaction with others. Design may allow the expansion of markets and workforces to embrace previously underrepresented groups [14], [15].

Biographies

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