

# A Reborn Product Design and Manufacturing Program

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## Abstract

The Manufacturing Program at Grand Valley State University has been redesigned to include a focus on products. This addresses the current challenges with recruiting students by creating a more understandable and approachable image. It also addresses the ‘outsourcing’ trends in manufacturing by revising the curriculum. This paper describes the reasoning behind the changes and the structure of the revised program.

## Introduction

Like most ABET accredited Manufacturing Engineering programs in the country, we were seeing a decline in enrollment, even though the enrollment in other disciplines was increasing. This was not because there was a lack of demand for our graduates from the manufacturing sector, but because students were selecting other areas of study. In many cases this decision was based upon poor impressions of manufacturing (the dirty factory), a lack of knowledge about Manufacturing Engineering, or impressions that manufacturing jobs were disappearing [8]. We are reversing this trend with a redesign of the program.

This paper describes a program change that should increase enrollment by reforming the manufacturing curriculum to include an emphasis on products. This change helps to define the discipline and makes it easier to clarify our public image. The expected outcomes are increased student enrollment and better prepared graduates. Briefly, the redesign involves the creation of a product design thread in the curriculum and a name change to “Product Design and Manufacturing”. The following sections include the justification for the changes and a description of the new courses and curriculum that are consistent with the ABET criteria. In fact the changes will satisfy the criteria better than the existing program.

*The program must demonstrate that graduates have proficiency in materials and manufacturing processes: understanding the behavior and properties of materials as they are altered and influenced by processing in manufacturing; process, assembly and product engineering; understanding the design of products and the equipment, tooling, and environment necessary for their manufacture; manufacturing competitiveness; understanding the creation of competitive advantage through manufacturing planning, strategy, and*

*control; manufacturing systems design: understanding the analysis, synthesis, and control of manufacturing operations using statistical and calculus based methods, simulation and information technology; laboratory experience: graduates must be able to measure manufacturing process variables in a manufacturing laboratory and make technical inferences about the process.*

## **The Manufacturing Image Gap**

Manufacturing has been changing. The introduction of new technologies and methods has increased the productivity of the average American worker and overall productivity has increased, but with fewer workers [7]. The composition of the workforce is shifting away from large numbers of hourly workers and moving towards higher levels of education. Many of the manufacturing operations that have a high manual labor component are being shifted to other parts of the world with significantly lower labor costs. As manufacturers adjust their use of manual labor there have been a number of highly publicized lay-offs. These stories have created an incorrect impression in many parts of American society that manufacturing is leaving. Even before this, manufacturing employment did not have the luxury of a positive image as illustrated by the National Association of Manufacturers report [1] that surveyed 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."*

The poor image of manufacturing causes many high school students to select alternate career paths before ever arriving at college. The small number of students who do select a manufacturing face a gauntlet of obstacles after they arrive at college. Students interested in Manufacturing are often advised to consider Mechanical Engineering as an alternate that gives them more options. In some cases the Manufacturing engineering is perceived as less rigorous, causing stronger students to select other, more challenging, options.

Students in an incoming freshman class, EGR 101 - CAD/CAM, were asked "Why do you want to be an engineer?", the comments from one section are listed below. (Note: the responses are given 'as-is' including spelling and grammar mistakes). Reading the comments it is obvious that many of these students would be attracted to Manufacturing Engineering. However, after the secondary admission process in the second year, fewer than 5% will enter the Manufacturing program.

*Because I have always been intrested in buildings and how they are constructed. I loved Legos and building whatever I could out of them and now I want to enter into a career that is similar in a sense to that. I love to build and I take pride in completing something that is going to be used by many.*

*I enjoy designing things.  
because I feel it is the most important and essential job on earth.  
Everything comes from engineering  
I would like to become an engineer because they have a hand in everything that is used by people, from toasters to automobiles. I would like to become a member of the group who makes the items we use better for everybody.  
I like to design things with AutoCAD, and I thought being an engineer would fit me best  
Engineering sounded like a career that I would enjoy the most because of my sciences interest. It also sounded like a profession that would be profitable. Finally, designing useful products is a good goal in life.  
I want to be an engineer because I make/build/design anything I want within reason and then sell it for a profit, benefiting myself, and my fellow humans.  
I am really enjoy solving complicating problems.  
I have always loved the building and mechanics of weapons, computers, and Air-craft. I wish to learn how to build and design such things and make those we have better.  
I've always loved designing and building things, especially with computers. Engineering just seemed to be the natural choice for me.  
I love computers and i dont want to be a programmer. I would love to design computer systems or something in that area. The best way to do this is to be an engineer.  
I want to be an engineer because i feel that i would excel in this career and enjoy this . I attended a camp that really helped me to decide that engineering was for me. That camp was the [name removed]  
For technology held on the [name removed] Universtiy Campus. I decided then that i really enjoyed problem solveing coming up with new and out of the box ideas. I believe that you must enjoy your job in order to be successful in your job. THis is why i choose to be an engineer.  
I think that there are really two main reasons why I want to become and engineer. The first reason is that I enjoy this kind of working. I like work that makes me think and I enjoy working through challenges. The second reason is that my dad is and engineer and so I have worked with him and that is how I have gotten some insite into the field.  
I've always like math and science and also like to design things.  
i like the challenge and i like the money and i like to play with electricity  
I have been know to be very structured and logical. Plus I love to build things especially electronics.  
I would really like to design boats some day  
I want to have a career that I can like and make a difference in a company.  
To have the ability to change, shape, and determine the future.  
It's who I am. I've always thought I would be one and it interests me.  
I like working with problems and comming up with unseen ways to fix them. We'll see how it goes!  
**I WANT TO FIND SOLUTIONS TO PROBLEMS IN THE WORLD, THAT PEOPLE HAVE BEEN UNABLE TO SOLVE.**  
I have just come to realize that engineering is the type of work that I want to do; and that was reinforced by my internship at [company name removed] this past summer.*

Items such as the student comments above and the National Association of Manufacturers report, are useful in formulating a response to the problem of image. The following list includes a few of the important elements of a positive image of manufacturing careers.

- empowered, free individuals
  - flexible time, not punching clocks
  - not tied to a desk or a production line
  - managing large budgets and many people
  - more dynamic career choices
  - important roles in companies including management

- active
  - designing and building
  - using new high-technologies, computers and methods
- people oriented
  - work with a diverse group of people in multiple disciplines
  - travel to many interesting places and cultures
- rewarding
  - helping society and making a difference
  - good salaries, benefits and bonuses
  - determining the best ways to satisfy customers
  - support the security of the country by building self-dependence

Image is clearly important in attracting students to the discipline of Manufacturing Engineering. But, it must be backed up by a strong academic experience that prepares students to make valuable contributions.

### **What Is Manufacturing Engineering?**

Many branches of engineering have grown to support manufacturing. As a result the topical strands of manufacturing are strewn through these disciplines. In many cases Manufacturing Engineering programs have their roots in Mechanical Engineering, or still exist as part of Mechanical Engineering programs. This relationship is mutually beneficial as most Mechanical programs benefit by including elements of Manufacturing. However this close relationship has hindered the distinct development and recognition of Manufacturing as a separate discipline.

The name of the Mechanical Engineering discipline suggests mechanisms and machines with an emphasis on physical things that can be touched, owned, visualized, and understood. The key concept is that the word Mechanical is a 'what', not a 'how'. In the case of mechanical engineering the 'hows' are the course topics such as those listed below.

- stresses and FEA
- thermal sciences
- fluids
- kinematics
- power transmission
- vibrations

By contrast the title Manufacturing focuses on the 'how'. To most of the general public the process of manufacturing is foreign, even for those who have worked as machine operators. The 'what' for Manufacturing is the Product. The 'how' for Manufacturing Products includes the list

of topics below.

- plant layout and organization
- CAD
- GD&T / tolerances / quality
- process selection / DfX
- manufacturing processes
- customer driven demand to product
- materials (overlap with materials dept)

By focusing on Products the Manufacturing discipline would become much more approachable to the general public. Moreover by drawing a distinction between ‘Mechanical Design’ and ‘Product Design’ we could also start to clarify the boundaries within the discipline. GD&T is a particularly useful example. There is no question that a mechanical part should be properly dimensioned and toleranced. However, tolerances cannot be meaningfully assigned without some knowledge of manufacturing processes. Therefore the ‘Mechanical Design’ of a part may be primarily stress analysis, while the ‘Product Design’ may focus on the material/process selection and GD&T necessary to make/assemble the part.

## **A Global Perspective**

Globalization has continued to push manufacturing in two directions, highly automated domestic production and offshore with manual labor. And, some companies are exporting engineering functions, such as finite element analysis to India, and production to China. As a result, the role of a Manufacturing Engineer has shifted from performing technical tasks to organizing a global team working on the Product. The emerging role for engineers is to serve as product designers who are able to work with others world-wide to develop and manufacture new products. The professional role that we need our graduates to fill is that of product architects, able to bridge the discipline specific designs for product components, integrate the parts in a way that is efficient and inexpensive to manufacture, and to produce them.

Innovative design is recognized as a strategic advantage for U.S. companies [4] and we must build these abilities for the U.S. to remain competitive. Design is also seen as a tool to expand markets to include previously underrepresented groups [5], [6].

A vision of the role of Manufacturing Engineers in the future is provided by the Manufacturing Education Plan developed by the Education Foundation of the Society of Manufacturing Engineers (SME)[2]. The plan includes a set of educational priorities, as listed below, based upon surveys of companies and professionals. This list identifies the skills and knowledge that are needed to thrive. This list itself does not need to eliminate the core topics taught in our programs but it does suggest opportunities that can be integrated into the educational process.

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

## A Strategy for Change

Chemical Engineering programs recently faced declining enrollments [3]. They were losing students to programs with names that suggested 'bio-technology', even though their programs already contained large portions of the new material. Their response was to redesign their curriculum and rename programs. We can benefit from their experience and combat the problem using a few well planned steps as suggested below.

1. Recognize Products as the driving force behind our discipline, possibly changing program names.
2. Promote the positive image of the discipline to the general public.
3. Attract academically strong, high achieving students.
4. Revise the curriculum to address the new needs of globalization.
5. Clarify the definition of Manufacturing Engineering.
6. Encourage a recognition of the differences between Manufacturing and other disciplines.
7. Differentiate between 'Product Design' and others such as 'Mechanical Design'.

## A Product Engineering Curriculum Strawman

At Grand Valley State University we have redesigned the Manufacturing program to include a significant focus on Product Design. In addition we have renamed the program 'Product Design and Manufacturing' (PDM). Samples of the new and old plans of study are shown in Figure 1. In total EGR 371 and 373 are replaced with a more mature course, EGR 472, that combines the topics. EGR 470 - Product and Process Design is eliminated and replaced with two new design courses,

EGR 301 and 401. In this redesign many of the core courses shared with other disciplines have been left unchanged to promote short-term efficiency. However, as enrollment grows, we plan to replace these with discipline specific courses.

EGR 301 Analytical Product Design - An introductory course that addresses product design early in the curriculum to keep the students engaged. Topics include; rapid prototypes, patents, mathematical tolerance analysis, GD&T, customers and their needs, material and process selection. This could be available to Mechanical Students as an elective.

EGR 401 Advanced Product Design - A subsequent course to EGR 301 Analytical Product Design. Topics include advanced design, design justification, patents, etc.

EGR 440 Production Models - a combination of the current 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 309 – Machine Design I EGR 345 – Dynamic Sys Mod & Cont EGR 360 – Thermodynamics EGR 367 – Manufacturing Processes * EGR 371 – Manufacturing Simulation * EGR 373 – Scheduling and Control  EGR 450 – Manufacturing Controls	* EGR 301 – Analytical Product Design EGR 309 – Machine Design I EGR 345 – Dynamic Sys Mod & Cont EGR 360 – Thermodynamics EGR 367 – Manufacturing Processes  * EGR 401 – Advanced Product Design (W/04) * EGR 440 – Production Models EGR 450 – Manufacturing Controls
Electives	EGR 409 – Machine Design II * EGR 470 – Product and Process Design EGR 474 – Systems Integration	EGR 409 – Machine Design II EGR 474 – Systems Integration

Note: \* indicates a course change

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

## Conclusion

At GVSU the Manufacturing program was the only one of four programs not growing. In the fall of 2003 we reached a point where it was obvious that the enrollment trend had to be reversed or the program would be closed. The response was the revised program described in this paper. The first new course, EGR 301, was offered in the Fall of 2003. This course was very well populated, including substantial numbers of Mechanical Engineering students taking the course as an elective. The number of students selecting Manufacturing Engineering has increased for 2005, reversing the trend of declining enrollment. The revised program have received unanimous support from our industrial advisory board and strong support from others in the field.

## References

- [1] "Keeping America Competitive; How a Talent Shortage Threatens U.S. Manufacturing", a National Association of Manufacturers White Paper, <http://www.nam.org>, 2003.
- [2] "Manufacturing Education Plan; Phase III: 2001-2002 Critical Competency Gaps", the Society of Manufacturing Engineers Education Foundation, [http://www.sme.org/downloads/foundation/Competency\\_Gap.pdf](http://www.sme.org/downloads/foundation/Competency_Gap.pdf), 2001.
- [3] Halford, B., "Pursuing New Paths", ASEE Prism, [http://www.prism-magazine.org/nov03/pursuing\\_paths.cfm](http://www.prism-magazine.org/nov03/pursuing_paths.cfm), Nov., 2003.
- [4] SERVICES 2000; A Conference and Dialogue on Global Policy Developments and U.S. Business, <http://www.ita.doc.gov/td/sif/2kfullreport.htm>, 1999.
- [5] Kanter, E., "Women in the Driving Seat", Asbury Park Press, <http://www.app.com/ontherun/story/0,20853,948356,00.html>, April 21, 2004.
- [6] McNulty, Z. (translated by), "Female Printer from Epson", <http://www.techjapan.com/modules.php?op=modload&name=News&file=article&sid=170&mode=thread&order=0&thold=0>, Mar., 16, 2004
- [7] Kelley, C., Wang, M., et.al., "High-Technology Manufacturing and U.S. Competitiveness", Rand Science and Technology technical report TR-136-OSTP, March 2004, <http://www.rand.org/publications/TR/TR136/TR136.sum.pdf>.
- [8] Fussell, E., "Live with it: Outsourcing overseas is here to stay", InTech, pp. 38-41, February 2005.

## Biography

HUGH JACK earned his bachelors degree in electrical engineering, and masters and Ph.D. degrees in mechanical engineering at the University of Western Ontario. He is currently an associate professor at Grand Valley State University and chairs the graduate and manufacturing programs. His research interests include controls and automation, including the use open source software for industrial control.