Addressing Manufacturing Challenges in a Mechanical Engineering Curriculum

A. R. Jalloh, A. A. Mobasher, Z. T. Deng, R. Rojas-Oviedo, X. C. Qian
Mechanical Engineering Department
Alabama A&M University
Huntsville, Al 35762
Phone: (256) 851 5891
email: ajalloh@aamu.edu**;**
amobasher@aamu.edu**;** aamzxd01@aamu.edu; rojaso@aamu.edu**,** cian@aamu.edu

Abstract

Emerging technologies in engineering challenge the new generation of engineers to work in more specialized environments. Universities in turn are faced with the challenge of training students with the skills that will help them to adapt into a dynamic industrial environment within a brief period of time. This challenge must be met within a 4-year curriculum with a fixed number of credit hours that students must take to complete the program. Of these a good number is reserved for non-engineering courses. Therefore, the hours available for engineering courses are rather limited and must be used efficiently to ensure that students acquire the skills needed for a rapidly changing work environment. To better address industry/government professional requirements, a curriculum must be such that it can adapt to and benefit from newer instrumentation, techniques, software and hardware to stay relevant to industry's needs.

In this paper, we will address how the Mechanical Engineering Department at Alabama A&M University has utilized input from its constituencies and professional organizations to begin the process of continuous improvement of the manufacturing systems track of the Mechanical Engineering Program.

I. Introduction and Background

The Mechanical Engineering program at Alabama A&M University (AAMU) was launched in the Fall Semester of 1997. The program has been developed with the goal of being innovative and non-duplicative of any existing Mechanical Engineering program in the State of Alabama. This requirement was not only a challenge but also an opportunity to design a program that would be relevant to the rapidly changing needs of industry.

The Mechanical Engineering program seeks to be relevant to the national needs of industry and government agencies. To achieve this, the faculty reviews professional engineering publications and consults with its Industry and Government Advisory Board to find out what these needs are. Some of the publications reviewed are from professional engineering organizations such as the American Society of Mechanical Engineers, the Society for Manufacturing Engineers, the American Institute of Aeronautics and Astronautics.

II. Local and Regional Constituency

AAMU is located in Huntsville, Alabama, a city in the far north central part of the state. This area is an internationally renowned center of expertise for space transportation, advanced missile, and electronic research and development. Some of the major industry and government agencies that are located in the area are Boeing Aerospace Company, Lockheed Martin Aerospace Company, TRW, Northrup Grumman, Chrysler Electronics, NASA Marshall Space Flight Center (MSFC), the Army Aviation and Missile Command Center (AMCOM), Redstone Arsenal Testing Center and many others associated in the high tech field. It became very evident that one objectives of the ME program at AAMU was to cater for the need of these industries and agencies for large numbers of highly engineers in manufacturing.

As mentioned earlier, the Mechanical Engineering Department has an Industry and Government Advisory Board whose membership is drawn for some of these major industries and government agencies. They provide input to the faculty about the needs of local and regional industry. Members of the Board and engineers from industry are also invited to present seminars and lectures to faculty and students on technical issues that are relevant to their organizations. These seminars and lectures provide the faculty with additional input on the requirements of industry.

III. Mechanical Engineering Program at AAMU

Universities are faced with the challenge of training students with the skills that will help them to adapt into a dynamic industrial environment within a brief period of time. This challenge must be met within a 4-year curriculum with a fixed number of credit hours that students must take to complete the program. Of these, a good number is reserved for

non-engineering courses. Therefore, the hours available for engineering courses are rather limited and must be used efficiently to ensure that students acquire the skills needed for a rapidly changing work environment.

The Mechanical Engineering Program at Alabama A&M University has identified industries and government agencies that form part of its constituency. Periodically, the Department faculty meets and discusses plans and programs that pertain to the two tracks offered in the mechanical engineering program, one being in manufacturing systems while the other is in propulsion systems. The review process takes place on a continuous basis by analyzing other specialized inputs through publications from professional engineering organizations such as the American Society of Mechanical Engineers (ASME), the Society for Manufacturing Engineers (SME), the American Institute of Aeronautics and Astronautics (AIAA) and from focus group discussions with the Departmental Industry and Government Advisory Board (IGAB). Based on this input, areas such as system performance, reliability, safety, concurrent engineering, team work and communication skills were developed and given special attention.

IV. Manufacturing Systems Track in the ME Program

It is evident by studying the best practices and competency gaps as reported by professional engineering organizations such as the American Society of Mechanical Engineers (ASME), the Society for Manufacturing Engineers (SME), the American Institute of Aeronautics and Astronautics (AIAA), and the National Research Council, that almost all of them are directly related to manufacturing systems. As such, the manufacturing track of the ME program was designed to address them with the following points in mind:

1. Meet accreditation criteria as per the accreditation Board for Engineering and Technology (ABET)
2. Address national trends in manufacturing while ensuring local relevance
3. Provide flexibility within the program to allow for the changing needs of industry

The specialization in manufacturing systems is provided during the last two years of the program by taking a battery of courses that add up to sixteen credit hours in the option. This is supplemented with five semester hours of senior design experience, bringing the total to twenty one credit hours of scholarly work in manufacturing systems.

The manufacturing courses comprise the following:

1. Concurrent Engineering
2. Quality and Reliability Assurance
3. Design for Manufacture and Reliability
4. Economic Evaluation of Design Projects
5. Operations Planning and Scheduling

In each of these courses, students are required to complete a class project. The students are required to work in teams, document the project in technical reports, and to make oral presentations of their project. These project are typically design oriented and they address the issues of team building, team work, conflict resolution, written and oral communications, and the many design and development issues that have been highlighted previously.

The best practices and competency gaps referred to above are documented in several reports that were issued by professional organizations in the mid-nineties. Some of the highlights from these reports are outlined below.

V. Professional Organizations

In the mid-nineties, the national view on the engineering was presented in a series of documents. Some of the findings in these documents were utilized in the development of the ME program in general and the manufacturing track in particular, as discussed briefly in the following sub-sections:

National Research Council

The Board of Engineering Education of the National Research Council in collaboration with several National Academy of Engineering, the National Aeronautics and Space Transportation (NASA), the U.S. Department of energy, the Boeing Company and Xerox Corporation issued a report in 1995. This report placed emphasis on the requirement for engineering education to be interaction among faculty, industry, government agencies, professional societies and accrediting bodies among others, to achieve the desired educational outputs.

Some of the points in this report that are relevant to manufacturing systems are:

- Development of a highly adaptable and flexible system
- Exposure to engineering practice and design principles
- Exposure to team projects, business perspective and societal issues
- Development of ability to work well in interdisciplinary teams
- Satisfy local needs while keeping an eye on global perspective
- Be amenable to use feedback from industry for continuous assessment and improvement
- Emphasize communications skills
- Train for life long learning

ASME

The American Society of Mechanical Engineers (ASME) issued a report in 1995 entitled: *Integrating the Product Realization Process (PRP) into the undergraduate Curriculum*.

The report presented the "best practices" utilized for the PRP. The list of twenty best practices presented in the survey is presented below:

	Category	No. of Comments generated
1	Teams/Teamwork	167
2	Communication	118
3	Design for Manufacture	116
4	CAD Systems	106
5	Professional Ethics	43
6	Creative Thinking	64
7	Design for Performance	16
8	Design for Reliability	129
9	Design for Safety	75
10	Concurrent Engineering	129
11	Sketching/Drawing	159
12	Design for Cost	159
13	Application of Statistics	89
14	Reliability	83
15	Geometric Tolerancing	132
16	Value Engineering	120
17	Design Reviews	140
18	Manufacturing Processes	142
19	Systems Perspective	124
20	Design for Assembly	39

SME

The Society of Manufacturing Engineers (SME) and its education foundation issued a report in 1997 entitled: *Manufacturing Education Plan: Phase I Report*. This report addressed the issue of competency gaps among recent manufacturing engineering graduates and technologists. The following major competency gaps were identified and ranked:

Rank	Competency Gap
1	Communication Skills (presentation skills, listening abilities, graphic software usage)
2	Teamwork (conflict resolution, interpersonal relations, team member, accountability)

3 Personal Attributes (leadership, sensitivity to others, consciousness of the big picture,
ability to both teach and learn from others, analytical skills, and consensus building.)
4 Manufacturing Principles (lean manufacturing, concurrent engineering, constrains)
5 Reliability (Process and products, FMEA principles, testing for expected life cycles.)
6 Project Management (resource deployment, cross functionality, planning, monitoring)
7 Manufacturing Processes (gaps between "book learning" and application of principles)

- CAD/CAM
- Geometric Dimensioning & Tolerancing
- Product Engineering
- Materials
- Blue Print Reading
- Metrology
- Hydraulics
- Electronics
- Process Improvement
- Tool Design
- Jig and Fixture Design
- Troubleshooting

8 Business Skills (Cash flow, ROI, customer focus, risk analysis/management, etc.)
9 Quality (ISO 9000 compliance)
10 Change Management (long and short term perspectives, product configuration, control and documentation, acting as a change agent.)
11 Statistics and Probability
12 Ergonomics (human factors, safety and work station/tool design)
13 Materials (materials selection, manufacturability and utilization)
14 Continuous Learning or Lifelong Learning

Additionally, SME, in its latest publication, has identified ten professional and technical competencies. Among these competencies are the following: project management, oral and written communications, and international perspective, supply chain management, manufacturing process control, manufacturing systems and quality.

VI. Conclusion

A manufacturing systems track has been developed as part of the Mechanical Engineering Program at AAMU. The design of the program allows for as much input from relevant constituencies as possible. Input is sought continuously to improve on the

program. The course work in the track addresses design issues in: manufacture, cost, reliability, materials, safety, communications and team work.

The program has been designed with sufficient flexibility to enable it to adapt to and benefit from newer instrumentation, techniques, software and hardware to stay relevant to the needs of industry.

The Mechanical Engineering Program has graduated three students so far. Two of these graduated hold manufacturing engineering positions in the Huntsville-Decatur area of Alabama.

Bibliography/References

1. Engineering Education – Designing an Adaptive System - Edited by the Board on Engineering Education, Commission on Engineering and Technical Systems, Office of Scientific and Engineering Personnel, National Research Council. National Academy Press. Washington D.C. 1995.
2. Manufacturing Education Plan: Phase I Report. "Industry Identifies Competency Gaps Among Newly Hired Engineering graduates. Published by the Society of Manufacturing engineers and the SME Education Foundation, 1997
3. Integrating the Product Realization Process (PRP) into the Undergraduate Curriculum, The American Society of Mechanical Engineers, December 1995.
4. Curriculum Integrated Product and Process Development - Patrick F. Cunniff, David C. Holloway, James W. Dally, Peter A. Minderman, Jr. , Jane F. Fines and Thomas M. Regan. A. James Clark School of Engineering, University of Maryland, College Park, MD 20742-3011.
5. Manufacturing Education Plan: 1999 Critical Competency Gaps; 1999 Industry Updates Competency Gaps Among Newly Hired Engineering graduates. Published by the Society of Manufacturing engineers and the SME Education Foundation, 1999.

ABDUL JALLOH
A. Jalloh is Assistant Professor of the Department of Mechanical Engineering at Alabama A&M University in Huntsville, AL. Dr. Jalloh earned his Ph.D.in Mechanical Engineering, with a minor in Engineering Mechanics from the University of Arizona, he obtained his M.S. Mechanical Engineering also from the University of Arizona, and he holds a B.Eng. in Mechanical Engineering from University of Sierra Leone. His research interest is in areas of mechanical vibrations, structural dynamics, structural mechanics, applied elasticity, probabilistic design, finite element analysis, manufacturing and reliability.

AMIR MOBASHER
Amir Mobasher is Assistant Professor of the Department of Mechanical Engineering at Alabama A&M University in Huntsville, AL. He holds a Ph.D. degree in Mechanical Engineering from University of Alabama in Huntsville. He has research interest in the areas of Computational Fluid Dynamics, Biomechanics, and Control and Automation. His primary area of interest at AAMU is Automation, Control and Fluid Dynamics. After graduating from UAH, he worked at U.S. Army Aeromedical Research Laboratory at Fort Rucker, Alabama. During his employment there, his research focused on aircrew protection and head-supported mass and center of mass placement for the U.S. Army aviation. As a Ph.D. candidate at UAH, his research focused primarily on shock-wave turbulent boundary layer interactions

ZENGTHAO DENG
Z.T. Deng is Assistant Professor of the Department of Mechanical Engineering at Alabama A&M University in Huntsville, AL. Dr. Deng has an extensive background and research experience in numerical simulation in particular high speed aerodynamics/flows with heat transfer phenomena. He earned his

Ph.D., Aerospace Engineering, University of Tennessee, 1991., and his Bachelor of Science, Aerospace and Mechanical Engineering, from Beijing University of Aeronautics and Astronautics in 1985.

RUBEN ROJAS-OVIEDO
Ruben Rojas-Oviedo is Chairperson and Associate Professor of the Department of Mechanical Engineering at Alabama A&M University in Huntsville AL. Dr. Rojas-Oviedo has international engineering experience working both in academe and industry. He has an engineering consulting company and conducts applied research. He earned a Ph. D. In Aerospace Engineering from Auburn University, he has two Masters degrees one in Mechanical Engineering from N.C. State at Raleigh and the other in Applied Mathematics from Auburn. He earned a B.S. degree in Aeronautical Engineering from the National Polytechnic Institute – Escuela Superior de Ingenieria Mecanica y Electrica - in Mexico City, Mexico.

XIAOQING (CATHY) QIAN
Cathy Qian is Assistant Professor of the Department of Mechanical Engineering at Alabama A&M University in Huntsville, AL. Dr. Qian earned her Ph.D. and M.S. in Mechanical Engineering from the University of Tennessee. Dr. Qian worked in industry for five years as a Senior Systems Engineer. She has an extensive experience in instrumentation, measurements, and numerical simulation in particular heat transfer phenomena, and systems engineering.