

Assessing the competencies in the Manufacturing Engineering Technology programs

**Bob Lahidji, Ph.D., CMfgE, Jihad Albayyari, Ph.D.
Industrial Technology
Eastern Michigan University
Ypsilanti, MI. 48197**

Introduction

The rapid advancement in all aspects of technology and globalization of competition dictates a need for a knowledgeable and technically competent work force. Engineering education programs should reflect the needs of industry and prepare young engineers to meet the challenges of the competitive world of manufacturing. Industry needs engineers who have the understanding of basic manufacturing engineering theory and the ability to apply their knowledge to the real world of manufacturing. Today's integrated manufacturing environment requires a work force possessing strong technical and people skills. Therefore, the graduates of manufacturing engineering technology programs must have the knowledge and skills to direct, organize, motivate, and be able to work with today's multicultural workforce. The changes in the manufacturing field created the need to update the Manufacturing Engineering Technology programs. Therefore, to keep up with these trends and technological developments in the manufacturing fields there is a need for assessing and identifying the current competencies in the Manufacturing Engineering Technology programs by examining the curricula of these programs. The purpose of this paper is to report on the relationship between the competencies identified by the Accreditation Board for Engineering and Technology (ABET) and the competencies learned in manufacturing engineering programs.

Purpose

The accreditation body such as ABET has played a major role in identifying the competencies in the field of study. These competencies are examined and modified to reflect the needs of industry. As such, there is a need for comparison between the competencies required by ABET and the competencies learned in manufacturing programs.

Engineering Technology Programs

Four-year Engineering Technology programs started in the early 1960's because engineering programs were becoming too theoretical. Today, According to ASEE, nationwide there are about 34 colleges and universities which offer ABET accredited Manufacturing Engineering Technology programs¹ (ASEE, 2002). A baccalaureate in engineering technology prepares individuals to become engineering technologists. The Engineering Technology Council has defined engineering technology as a:

Profession in which knowledge of the **applied** mathematical and natural sciences gained by higher education, experience, and practice is devoted to the application of engineering principles and the **implementation of technological advances** for the benefit of humanity. Engineering technology education for the professional focuses primarily on analyzing, applying, implementing and improving existing technologies and is aimed at preparing graduates for the practice of engineering closest to product improvement, manufacturing, and engineering operational functions². (Engineering Technology Council, 1991, P.1)

The review of the literature reveals that the engineering technology curriculum is composed of 33% mathematics and sciences, 25% liberal studies, and 40 to 45% in the major field of study. Approximately 67% of the coursework in the major field of study are Engineering Technology subjects that involve some type of laboratory activities³. (Israel, 1995).

Accreditation:

The Technology Accreditation Commission (TAC) of the Accreditation Board for Engineering Technology (ABET) requires a minimum of 124 semester hour credits for the baccalaureate degree. In addition, the engineering technology curriculum must include the following components:

The first component is the 48 semester hours of credit in the following areas:

Technical science: Subject matter in this area requires the use of mathematics and basic science for the purpose of solving technical problems.

Technical specialties: Courses are those which provide students with the necessary skills and knowledge of appropriate methods, procedures, and techniques to adapt existing technical procedures to new situations and correctly complete given technical processes and procedures.

Technical electives: Any related technical courses that support the student's specialty.

Another curriculum component consists of 24 semester hours of basic sciences and mathematics.
Eight of the 24 hours must be in laboratory science. Twelve of the 24 hours must be in mathematics.

The third curriculum component is 24 semester hours of communications, humanities, and social science courses. According to ABET, "The remaining 28 semester hours or more should be designed for a well-rounded engineering technology graduate who can function successfully as an engineering technologist"⁴. (Accreditation Board for Engineering and Technology, 2001).

In addition, the engineering technology graduates must have computer proficiency to solve technical problems along with a cooperative education experience for a maximum of eight semester hours is strongly recommended⁴. (Accreditation Board for Engineering and Technology, 2001).

In 2001 accreditation criteria under the criterion "outcome and assessment", stated that engineering-related programs must demonstrate that graduates have⁵:

- “1. an ability to apply knowledge of mathematics, science, and engineering-related applied sciences,
- 2. an ability to design and conduct experiments, as well as to analyze and interpret data,
- 3. an ability to formulate or design a system, process or program to meet desired needs;
- 4. an ability to function on multi-disciplinary teams,
- 5. an ability to identify and solve engineering- related problems,
- 6. an understanding of professional and ethical responsibility,
- 7. an ability to communicate effectively,
- 8. the broad education necessary to understand the impact of solutions in a global and societal context,
- 9. a recognition of the need for, and an ability to engage in life-long learning,
- 10. a knowledge of contemporary issues,
- 11. an ability to use the techniques, skills, and modern scientific and technical tools necessary for professional practice”.

In a recent Manufacturing Accreditation Workshop- Technology Criteria 2000 (TC2K), held in Orlando Florida by the Society of Manufacturing Engineering (SME) conducted a comparison between characteristics of current criteria for an accreditation and characteristics of TC2K for an accreditation were presented as shown below.

Characteristics of Current Criteria	Characteristics of TC2K
“Snapshot-in time” approach	Emphasis is on the competencies of graduates
Evaluate resources and inputs from program	Continuous Improvement is the hart of the system
Programs presents data & ABET draws conclusions	Program is continuity is evaluated
Accredit based on past performance	Program presents results of continuous assessment
Program is expected to have continuous improvement Plan	Accredit based on effectiveness of the quality assurance system

Source: Society of Manufacturing Engineering (SME), Manufacturing Accreditation Workshop- Technology Criteria 2000 (TC2K) at Orlando Florida, January 17-18, 2002

Furthermore, the premise of TC2K was described as: “what students learn is more important than what is presented in a curriculum, educational objectives and outcomes assessment should determine the effectiveness of a program, and assessment should be used as a continuous improvement process of program enhancement and effective student learning”⁶

Careers in Engineering Technology

The following job opportunities were identified by some of the institutions for their Manufacturing Engineering Technology graduates: process planners, quality controllers, tool designers, CNC programmers, equipment maintenance managers, production planners, technical trainers, supervisors, sales and service personnel.

Competency Gaps

In 1997 SME with participation of both the industry and educational sectors, focused on identifying the competency gaps between what is offered by educational programs and industry’s needs. The purpose of this focus was to improve manufacturing education and prepare the graduates of these programs to deal with the needs of industry. Subsequently, major competency gaps were reported to exist by the graduates of manufacturing engineers by the participants in this study in the following areas⁷:

1. Communication Skills
2. Team work
3. Personal Attribute
4. Manufacturing Principles
5. Reliability
6. Project Management
7. Manufacturing Processes
8. Business Skills
9. Quality
10. Statistics and Probability
11. Ergonomics (Human Factors)
12. Materials
13. Continuous or Lifelong Learning

In 1999 the Society of Manufacturing Engineers Ad Hoc Committee on Lifelong Learning presented a competency model for manufacturing engineers as shown below⁸.

Competency Categories

PERSONAL EFFECTIVENESS

ANALYSIS AND PROCESS IMPROVEMENT

Interpersonal Skills	Applied Science and Mathematics
Negotiation and Conflict Management	Technical Problem Solving
Meetings and Presentations	Quality Management
Written communications	Modeling and Simulation
Creativity and Innovation	Process Control
Ethics	Testing, Inspection and Validation
Knowledge Transfer and Learning	

MANUFACTURING SYSTEMS MGMNT

**BUSINESS
MANAGEMENT**

Manufacturing System Performance	Business Knowledge
Enterprise Information Systems	Customer Focus
Facilities, Operations and Process Planning	Financial Management
Operations Management	Leadership and Supervision
Supply and Materials Management	Project Management
	Regulatory Standards and External Affairs

MANUFACTURING TECH & MATERIALS

**PRODUCT AND
PROCESS DESIGN**

Manufacturing Process Technologies	Integrated Product and Process Design
Material Properties	Equipment and Tool Design
Automation and Controls	Reliability and Maintenance
	Human Factors, Ergonomics & Safety

Industry also has been assessing the competency gaps between workforce needs and competencies taught in engineering programs. Boeing Company⁹ (ASEE PRISM, 1996, p.11) identified a list of desired attributes of engineering graduates. The list included the following factors.

1. A good understanding of the engineering fundamentals, including:
 Mathematics(including statistics),
 Physical and life sciences, and
 Information technology.
2. A good grasp of the design and manufacturing process.
3. A basic understanding of the context in which engineering is practiced, including:
 Economics and business practice,
 History,
 The environment, and
 Customer and societal needs.
4. A multidisciplinary systems perspective.
5. Good communication skills:
 Written,
 Verbal,

- Graphic, and
Listening.
6. High ethical standards.
 7. An ability to think critically and creatively as well as independently and cooperatively.
 8. Flexibility -- an ability and the self-confidence to adapt to rapid/major change.
 9. Lifelong desire and commitment to learn.
 10. A profound understanding of the importance of teamwork.

The Computer and Automated Systems Association (CASA) of the Society of Manufacturing Engineers (SME) developed the CIM Wheel, which was received enthusiastically by both the membership of SME and industry¹⁰ (CASA,1993). The CIM Wheel later on was modified and became more focused on customer rather than solely on manufacturing environment.

A comparison between the competencies which are presented in the Manufacturing Enterprise Wheel and the competencies taught in engineering programs suggests that there is a need for a greater emphasis and/or improvement in the following curricular areas¹⁰:

1. People and managerial skills.
2. Written and oral communications skills.
3. Greater emphasis on educating students to work with a multi-cultural workforce.
4. Study of the global marketplace.
5. More emphasis on resources management.
6. Ethical and environmental responsibilities.
7. Capstone projects emphasizing teamwork.
8. Greater emphasis on hands-on projects that simulate the real working environment.
9. Cooperative educational experiences.

The following skills were identified as necessary attributes to succeed as a graduate of a manufacturing technology program in today's working environment and were ranked by the employers of manufacturing engineering technology graduates¹¹ (Lahidji):

1. Communication Skills ; 94% of employers rated as important and very important
2. Interpersonal/Team Work; 94% of employers rated as important and very important
3. Applied & Engineering Science; 94% of employers rated as important and very important
4. Automated Systems & Control; 81% of employers rated as important and very important
5. Production Systems and Equipment Design; 75% of employers rated as important and very important
6. Quality; 69% of employers rated as important and very important
7. Product/Process Design & Development ; 68% of employers rated as important and very important

8. Project Management/Concurrent Engineering; 62% of employers rated as important and very important
9. Computer Skills; 62% of employers rated as important and very important
10. Mathematics; 50% of employers rated as important and very important

The applied engineering, communication skills, and interpersonal/teamwork received the highest rate.

Discussion

According to ASEE, nationwide there are about 34 colleges and universities which offer ABET accredited Manufacturing Engineering Technology programs and of 34 programs, three programs titled Computer Integrated Manufacturing Engineering Technology, and one program is an option under Engineering Technology program¹ (ASEE, 2002).

After reviewing each program the following observations were concluded:

1. All programs closely follow the ABET's guidelines,
2. Differences exist in the technical specialty courses that are offered by each program,
3. Math courses offered in these programs ranged from college algebra to calculus III; however all programs, as table 1 shows required one calculus.

41 % of schools required one calculus
53 % of schools required two courses in calculus
6 % of schools required three courses in calculus

Table 1

4. 9-12 credits were required by programs in the area of written/oral communication and all programs required a technical writing course as part of written/oral communication.
5. All programs required two physics and chemistry.
6. What was lacking in the programs were greater emphasis in the areas of human factor, ergonomics, ethics, engineering law, cultural diversity, technology and environment, system integration, and courses that promote greater teamwork.

Conclusion

The thirty-four programs differ greatly in their technical core as expected, however they all fall within the guidelines and requirements of ABET. It was clear that each program had its strengths and weaknesses. For example, some programs had greater emphasis on the math skills and others on the communication skills. All the programs followed the general guidelines established by ABET. However, these programs are lacking competencies that industry considers being important, such as, human factors,

ergonomics, ethics, engineering law, cultural diversity, technology and environmental issues.

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Dr. Bob Lahidji is an associate professor and Interim Department Head in the Industrial Technology Program at Eastern Michigan University. His primary interest and expertise are in the area of manufacturing process and CNC/CAM. Dr. Lahidji has been involved with manufacturing firms as a consultant in the area of improving manufacturing processes. He has written numerous articles and is the co-author of the textbook "Maximize SURFCAM".

Dr. Albayyari is an Associate Professor of Mechanical Engineering Technology in the Department of Industrial Technology at Eastern Michigan University. He received his BS, MS and Ph.D. from the University of Cincinnati. His academic experience includes development of curricula and programs. His research interest is in the area of micro-gravity in which he received several NASA grants. Dr. Albayyari also worked with several industrial companies.