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An Evaluation of Attributes and Competencies for Manufacturing Engineering Technology Graduates

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AN EVALUATION OF ATTRIBUTES AND COMPETENCIES FOR MANUFACTURING ENGINEERING TECHNOLOGY GRADUATES

by

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ABSTRACT

ATTRIBUTES AND COMPETENCIES FOR MANUFACTURING ENGINEERING TECHNOLOGY GRADUATES

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The purpose of this study is to determine the required attributes and competencies required for a graduate from a manufacturing engineering technology baccalaureate program. A document called "Competencies of Manufacturing Engineering Technology Graduates" was compiled in October 2004. This document lists twelve attributes thought to be important for MET graduates: Leadership, Professionalism, Creativity and Problem Solving, Management, Materials, Processes, Quality, Systems, Design, Communication, Safety and Environmental Issues, and Global Awareness. Under each attribute is a list of five to seven competencies creating a total of seventy-three competencies for graduates of an MET baccalaureate program. This list of attributes and competencies was converted into a survey for the purpose of evaluation by two manufacturing groups: educators and industry representatives.

Overall, educators and industry representatives rated the attributes and competencies as important. Ninety-nine percent of the combined educator's and industry representative's competency questions had a mean response of 3.50 and above. Therefore, the competencies are relevant for MET graduates.

It was determined that educators did significantly differ from industry representatives for their ratings of the attributes, but educators did not significantly differ from industry representatives for their ratings of the competencies. Generally, industry representatives rated attributes less highly than educators; however, the pattern of responses was similar across educators and industry representatives. The rankings of each attribute section from those rated most important to those rated least important were as follows: Professionalism, Communication, Creativity and Problem Solving, Manufacturing Processes, Design, Safety and Environmental Issues, Quality, Materials, Leadership, Management, Manufacturing Systems, and Global Awareness.

Current literature mentions aspects of manufacturing that are considered important and these include: global or international awareness, lean manufacturing, life long learning, and communication. This survey indicated that the Global Awareness section was rated the least important of any section. The lean manufacturing competency had an average ranking out of all seventy-three competencies. Communication has been an important concern for MET graduates since the earliest studies and the survey results suggest that communication continues to be highly valued. MET educational programs should provide many opportunities for students to improve their communication skills.

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INTRODUCTION

1.1 Background

Manufacturing Engineering Technology (MET) programs prepare graduates to work in industry. Graduates want to learn what is most important to the manufacturing industry and employers are looking for graduates that are prepared to quickly adapt to the workplace. To do this, industry should have a larger role in designing manufacturing programs (Glasman, Cibulka, & Ashby, 2002). Providing the opportunity for industry to participate in designing the MET baccalaureate program will help eliminate unnecessary or obsolete MET skills so time can be spent on subject matter that is more relevant. Unfortunately, modifying a program's curriculum takes a long time which makes it difficult for schools to keep up with changes occurring in industry (Lake 2003).

The changes in manufacturing industry require changes in MET educational programs. Educational programs have had to adapt with new technologies so their students are prepared to enter the workforce (Williams, 2002). For example MET educators started obtaining equipment in the early 1970s so CAD/CAM could be taught in the classroom (Computerized, 1984). MET departments have always tried to keep their curriculum current with the changes that occur in industry. However, education is always a step behind technology development because first the need has to be realized and then the curriculum modified before the students can be taught the new technology (Rugarcia, Felder, Woods, & Stice, 2000).

The word 'manufacture' comes from the Latin words *manu factus.* These words mean 'made by hand' (Ostwald & Munoz, 1997). Manufacturing has been around as long as there have been tools and in the industrial age it took front stage. Our society has gone from the industrial age to the information age (Craft & Mack, 2001, p. 437). MET today encompasses more than just manufacturing processes such as casting, welding, and metal forming. MET includes a wide variety of topics such as materials, design, quality, and manufacturing systems.

Manufacturing has improved and become more complicated over the years with advances in technology. The entire manufacturing process, going from the design phase to the final product, cannot be mastered by one person (Computerized, 1984). An illustration of this occurred in the 1980s and 1990s during the computer-aided movement which transitioned manufacturing from predominantly technical tasks to, "a complex product realization process" (Ziemian, 2001, p. 558). Some examples of improvements to manufacturing processes include computer numerical control (CNC) and rapid prototyping. Rapid prototyping is a relatively recent application for manufacturing where a 3d model is drawn on CAD software and a model is created by adding material in layers. The advances in technology have not only improved manufacturing processes but have created "flexible manufacturing systems and concurrent engineering" (Tseng, Kolluri, & Radhakrishnan, 1984, p. 207). The changes in engineering have occurred rapidly and the only certainty in years to come is that change is going to continue (Rugarcia, Felder, Woods, & Stice, 2000).

1.2 Problem Statement

Many MET programs are working hard to fill the needs of the manufacturing industry. Without currently knowing manufacturing industrial needs, these programs might be missing major aspects or teaching irrelevant competencies. Problems have occurred with the information that graduates have learned in a university setting and it is questionable whether graduates have the skills needed to perform well in today's more technologically advanced organizations (Nambisan & Wilemon, 2003). MET program designers do not have sufficient, current input from industry or from their educational colleagues to develop relevant manufacturing curricula.

1.3 Hypotheses and Justification

The following three hypotheses are proposed:

1. Educators will not significantly differ from industry representatives in their importance ratings of the following attributes: manufacturing processes, quality, manufacturing systems, design, materials, management, creativity and problem solving, leadership, professionalism, safety and environmental issues, and global awareness.
2. Educators will not significantly differ from industry representatives in their importance ratings of the competencies listed under the above attributes.
3. The competencies proposed by the MET faculty from Brigham Young University (BYU) are relevant for MET graduates.

Manufacturing engineering technology curriculum programs have done research starting in the late 1960s. This research specifically looked at whether there was a need to have programs at the university level. The last major study for MET educational programs was completed in 1991 and desired tasks were identified for the year 2000. This survey was done fifteen years ago and with the continuing advancement in MET, additional research is necessary.

Employers have recommended that educational programs prepare their students for the increasing complexities in engineering (Koehn, 1997). Having a program that teaches the current needs of industry will allow universities to produce graduates with the skills that industry is looking for. In turn, companies will be more willing to hire graduates of that program. A program that has a successful rate of graduates hired into good companies will attract more students and will increase the MET program's prestige. The result of this study will allow colleges or universities with MET programs to tailor their curriculum to fill industry's needs. Most universities will not need to change their whole program; they will just need to make small additions and changes.

1.4 Methodology

The structure of this research consisted of surveys sent to two different populations. The first survey, the educator survey, was sent to faculty currently teaching in MET programs. All colleges or universities involved with this study were MET baccalaureate programs accredited through ABET. The participants for this study provided additional input before a similar survey was sent to industry representatives.

These surveys asked participants to rate attributes and competencies that a recent graduate from an MET baccalaureate program should have. There was an open ended question at the end of each section for any improvements to the survey, additional competencies, or suggestions that the participants might provide. The last page contained questions that might help with the evaluation of MET programs; such as, current trends, accreditation, and enrollment status.

The last survey, the industry survey, asked industry representatives to rate each attribute and competency. This provided survey participants a manageable format to determine which attributes and competencies were important and also allowed the data to be easily combined and analyzed. Potential industry participants were contacted through the MET advisory board for Brigham Young University or through www.sme.org, the Society of Manufacturing Engineers (SME) website. Individuals from the website were either SME chapter advisors or technical leaders. The potential participants from the SME chapter advisors included a representative from each state in the United States and a select few from other countries.

The main elements of this research were completed with the internet and through e-mail. The e-mail messages were sent through the survey website which provided an address link so the survey could be taken over the internet. The answers were organized and stored in the survey software to be analyzed later.

1.5 Delimitations

In order to reduce the amount of variation in the collected data, each survey was limited to participants associated with manufacturing in either a university setting or an industrial setting. The first survey, the educator survey, was confined to professors that were teaching in the 33 accredited MET programs through the Accreditation Board for Engineering and Technology (ABET). The potential participant's information for the industry survey was found on the SME website or through a list of advisory board members over one MET baccalaureate program.

The factors of this research were limited to problems and changes that were occurring in the manufacturing field and will not be used to examine other fields of study. The process of sending and receiving data was confined to the internet through the website www.surveymonkey.com and through e-mail. Each potential participant was allowed two or three opportunities to take the survey. The final results were limited to respondents who completed the survey. The data from this survey will be available to current MET baccalaureate programs.

Chapter 2

REVIEW OF LITERATURE

2.1 Introduction

The first manufacturing program at the college level was most likely started in 1928 by Oregon State University (Allen, 1973). This program was called Industrial Shop Administrations and it was in the school of Engineering and Mechanical Arts. In 1960 the first baccalaureate MET program in the United States was started at Brigham Young University. In 1973, twelve institutions offered MET degrees at the baccalaureate level (Allen, 1973). The number of institutions increased to nineteen by the year 1990 and then there were thirty-three by the Fall of 2000 (Todd, Red, Magleby, & Coe, 2001). Currently the SME website contains a list of thirty-three ABET accredited baccalaureate MET programs in the United States. In this chapter research on MET educational programs will be summarized and a synopsis of the current needs of MET educational programs will be presented.

2.2 Savage

In 1967 Savage conducted research on the program needs for Metal Manufacturing Technology for industries along the Wasatch Front. A survey was distributed to supervisors of companies with at least one hundred employees along the Wasatch Front that employed Metal Manufacturing Technicians. It was concluded that specific objectives are required for an Associate of Science degree in metal manufacturing.

The recommended objectives for a curriculum in metal manufacturing include: (1) to communicate, read, write and understand technical information, (2) to develop needed mathematical skills dealing with technology, (3) to understand industrial policies and procedures, and (4) to have a general knowledge of metal and manufacturing, machine tool operations, welding operations, and inspection

2.3 Naegle

A study was done by Naegle in 1967 to determine the coursework requirements for manufacturing engineers and the need for an emphasis in manufacturing engineering. A questionnaire was sent to sixty-four manufacturers of durable goods. A conclusion of this study was that the current level of education was lacking for manufacturing personnel. Eighty-seven percent of respondents felt that engineering curriculum with a majority of courses in manufacturing engineering was needed for manufacturing industries. Sixty-three percent felt that a degree was needed in manufacturing engineering, and the majority preferred a four year degree. Courses recommended for manufacturing engineers were divided into five categories: (1) communication, (2) cultural & humanities, (3) management, (4) general engineering, and (5) manufacturing engineering.

2.4 Shaw

Shaw (1973) designed a model curriculum for a baccalaureate program and a masters program in manufacturing engineering. A survey was created based on a review of literature and existing manufacturing engineering curricula. This survey was distributed to a jury of experts that included thirty educators and thirty industry professionals. The manufacturing engineering baccalaureate program should contain the following areas with each area receiving a relative emphasis based on the corresponding percentages: engineering science (21%), manufacturing processes (18%), manufacturing analysis (12%), production tooling (9%), manufacturing management (7%), manufacturing research (7%), quality assurance (7%), manufacturing systems design (6%), metallurgy (6%), production control (4%), and manufacturing liason (3%).

2.5 Allen

Based on his research, Allen (1973) created performance objectives for a baccalaureate MET curriculum. During this time SME had great interest in the expansion of MET curricula. A baccalaureate level manufacturing technology curriculum was projected to be needed for the training and education of technicians, technologists, manufacturing engineers, and manufacturing managers.

Allen's study included 218 objectives that were contained in a survey. A survey was sent to educators and manufacturing supervisor. Their responses were then evaluated by a jury of seven experts. They determined that ninety-seven of the items were considered important in an MET curriculum, sixty-four items were questionable, and fifty-seven items were determined not important enough to be included in the MET curriculum.

The manufacturing engineering baccalaureate program should contain the following areas with each area receiving a relative emphasis based on the corresponding percentages: manufacturing planning (24.7%), materials/metallurgy (0%), production tooling (3.4%), quality Assurance (4.1%), production planning and control (1.0%), plant layout and materials handling (4.1%), manufacturing systems (3.1%), manufacturing management and supervision (25.7%), manufacturing development (20.6%), and plant engineering (3.1%).

2.6 Yost

A study was done by Yost in 1984 to determine the importance of ninety-nine manufacturing engineering tasks within ten categories. This study was done for manufacturing in the state of Wisconsin. The tasks for this survey came from twenty-one manufacturing engineering teachers from the University of Wisconsin, a review of eighteen other colleges and universities with manufacturing engineering programs, and a review of literature. The tasks were distributed into ten categories: (1) product design, (2) manufacturing planning, (3) manufacturing control, (4) quality control, (5) human factors, (6) manufacturing practice, (7) manufacturing cost control, (8) inventory control, (9) social responsibility, and (10) manufacturing research and development.

The survey respondents were asked to rate the current need for the objectives along with the need assumed for five years from that time. The results for the current needs found that thirteen out of the ninety-nine questions were considered very important tasks, fifty-six were considered important, twenty-four were considered somewhat important, and only six were considered not important. Interestingly, the review of literature during that time indicated the importance of computers but the computer tasks of Yost's study were not rated highly.

The thirteen very important tasks are listed in the four areas: (1) human interaction in the workplace, (2) design, (3) social responsibility, and (4) manufacturing cost control. The human interaction in the workplace area contained these four very important tasks: (1) communicate effectively, (2) develop and maintain wholesome interpersonal relationships, (3) motivate others, and (4) delegate responsibility and authority. The design area contained these four very important tasks: (1) specify materials, (2) assure that design complies with designated quality expectations, (3) set tolerances and clearances, and (4) prototype new parts and products. The social responsibility area contained these three very important tasks: (1) specify safe working conditions, (2) determine safe ways for operators to perform, (3) contribute to productivity improvements. The manufacturing cost control area contained these two very important tasks: (1) determine production costs and (2) justify equipment expenditures.

2.7 Zirbel

In 1991, Zirbel did research to obtain MET curriculum development tasks that would be wanted by the year 2000. Two studies were done to obtain and verify those tasks. The first study was done to allow a panel of experts to determine tasks that they felt would be important by the year 2000. The first part of this study was an open-ended survey which yielded sixty-nine tasks. During the second part of the study the experts rated the sixty-nine tasks on a five point Likert scale. During the final part of the study the panel members compared their responses to the majority response and then they were given the opportunity to change their answers to match the majority opinion or explain why they wanted to keep their answers. If a consensus was met, 75% had a modal rating of four or above, then that task was considered important. This study led to the identification of thirty-seven tasks.

In the second study the thirty-seven tasks obtained by the panel of experts and thirteen other tasks found in literature were combined in a survey. Random sampling was done of Texas manufacturing companies, and a total of 401 companies were asked to participate in the study. The response rate was 57%.

The results found that seven out of the fifty tasks were considered high importance tasks, thirty-seven were considered of moderately high importance, six were considered average, and none were considered of moderately low or low importance. The categories for the tasks are: manufacturing practice, human interaction in the workplace, design, manufacturing research, manufacturing planning, manufacturing control, and social responsibility.

The main tasks recommended to be included in the curriculum were: ethics in the workplace, the importance of quality, communication skills, and how to work in a team environment. This study concluded that computers will continue to increase in importance through the year 2000 and that the basics of manufacturing always need to be understood by students in an MET program.

2.8 The National Center of Excellence for Advanced Manufacturing Education

In 1995, the National Center of Excellence for Advanced Manufacturing Education (NCE/AME) was established at Sinclair Community College. This was done to develop an associate-degree curriculum for MET programs. "One major goal of the NCE/AME is to develop a novel, activity-based, competency-based, contextual, industry-verified, modular curriculum in manufacturing engineering technology that can lead to systemic change in the way technician education is delivered in the United States" (National, 1995, p. 2). Individual classes and requirements in an MET program will vary but specific competencies will be expected for all technicians to be able to perform at a high level.

A list was created of competencies required for an associate-degree program in MET. This list was condensed from eight hundred competencies to175 competencies. The activities required for a manufacturing engineering technician include: manufacturing processes and materials; production-operations management and inventory control; quality management; automation, controls, and manufacturing systems; design for manufacturing; enterprise integration; lifelong learning; interpersonal and team building skills.

NCE/AME also suggested that along with the typical course requirements in manufacturing processes and materials, there should be an equal emphasis in communication, humanities, and principles of teamwork. This paper explained that a baccalaureate degree in MET will allow opportunities in more advanced positions such as: Manufacturing Engineer, Quality Assurance Engineer, Facilities Engineer, Production Engineer, and Project Engineer.

2.9 Summary and Conclusions

The earlier studies determined specific tasks to be performed by an MET graduate. The focus of research transitioned from individual tasks, to categories, and currently to general competencies required of MET graduates. Manufacturing processes, communication, and human interaction have been consistently important aspects of MET programs. The last study of MET curricula was done over ten years ago and the current literature mentions aspects of MET that are not covered in any of the previous studies such as lean manufacturing and global awareness.

Current literature mentions aspects of manufacturing that are important and might not have enough emphasis in MET baccalaureate programs. Four main areas often recommended for greater prominence in the MET curriculum include: communication, global or international awareness, lean manufacturing, and life long learning. Communication has been an important concern for MET graduates since the earliest studies. Additionally, MET representatives have suggested revising, “engineering curriculum to ensure that students are prepared for the increasing complexity and international aspects of engineering work” (Koehn, 1997, p. 66). However, none of the past studies have examined the importance of global awareness in MET curricula. Another important aspect mentioned by current literature but not by previous studies was lean manufacturing. Lean manufacturing is a whole system of eliminating waste, improving quality, reducing production time and thereby reducing the cost for manufacturing products. Finally, with the constant changes in technology, continual learning is needed to stay current with industry. Current MET programs cannot know all the changes that will occur in the next few years. Education is always behind industry since the educators need to learn the technology before they can implement it in the classes and then teach the students.

Chapter 3

METHOD OF RESEARCH

3.1 Introduction

Changes in MET programs need to reflect what is important in the manufacturing community. The MET professors at BYU, along with their industrial advisory board, created a document called “Competencies of Manufacturing Engineering Technology Graduates”. This document was completed in October 2004. It lists twelve attributes thought to be important for MET graduates: Leadership, Professionalism, Creativity and Problem Solving, Management, Materials, Processes, Quality, Systems, Design, Communication, Safety and Environmental Issues, and Global Awareness. Under each attribute is a list of five to seven competencies that graduates of an MET baccalaureate program should have, providing a total of seventy-three competencies. This list of attributes and competencies was converted into a survey for the purpose of evaluation by two manufacturing groups, educators and industry representatives.

An internet site, www.surveymonkey.com, was used to generate and administer the survey. Two versions of the survey were created, an educator survey and an industry survey. The educator survey was designed and intended for manufacturing educators whose MET programs were accredited through the Accreditation Board for Engineering and Technology (ABET). The industry survey was designed and intended for industry representatives or individuals working in a manufacturing field.

3.2 Participants

3.2.1 Educator Survey

A collection of colleges and universities whose MET baccalaureate programs were accredited through ABET was obtained. This record was found on the Society of Manufacturing Engineers (SME) website and contained thirty-three schools located in the United States. A list of these schools is found in appendix A and was used as a basis for determining the educators selected to participate in the study. The educator's names and e-mail addresses were obtained by examining each MET program through the corresponding school's website. A total of 157 individuals made up the list of potential participants. It was later discovered that not all of these schools had a current MET program and so some of the educators were eliminated from the list. Some of e-mail addresses were not valid and these potential participants were also removed from the list. The final list of potential participants contained 140 educators from ABET-accredited baccalaureate MET programs.

3.2.2 Industry Survey

The industry survey was sent to potential participants who were connected with the manufacturing industry or community. The participants for this survey came from two groups: SME Organizational Chapters and SME Community. The SME's website contained a list of the individual organizational chapters categorized by geographic area. These areas consisted of each state in the United States, Canada, and other international areas such as Korea, Australia, and Ireland. Most areas had both senior chapters and student chapters. The names and e-mail addresses for this survey were only gathered from the senior chapter advisors. Almost every geographic area contained a senior advisor which produced 215 potential participants for this survey with 45 from outside the United States. The survey was sent out and thirty-three of the potential participants were excluded because the e-mail addresses were wrong. Overall, 182 SME chapter advisors received the opportunity to take the survey thirty-seven of which were from geographic areas outside the United States.

Another group of industry representatives was obtained from the SME website under the link “My Technical Interests”. This link provided a list of community leaders who had experience in seven different areas of manufacturing who were willing to provide information for their area of expertise. The community leaders came from six of the seven areas: Automated Manufacturing & Assembly, Forming & Fabricating, Engineering Materials Applications, Machining & Material Removal, Manufacturing Education & Research, Product and Process Design & Management, and Rapid Technologies & Additive Manufacturing. The names and e-mail addresses were obtained for community leaders connected to the manufacturing workforce. Any e-mail addresses of leaders connected to MET educational programs were excluded; to avoid duplication. The area, Engineering Materials Applications, did not list any e-mail addresses so the industry representatives from this section were excluded. The category, Manufacturing Education & Research, had only one industry representative who was not connected to a college or university. This list yielded 196 possible industry representatives who could participate in the industry survey.

An additional group of potential participants for the industry survey came from the advisory board for BYU’s MET program. This list contained seven board members. After the survey was sent out, it was concluded that one of the potential participants was no longer an advisory board member and so that participant was eliminated from the list leaving six industry representatives who could participate in this survey. The combination of industry representatives from the three groups brings the total potential participants of the industry survey up to 384.

3.3 Instructions

The internet survey for each group was introduced with a description of the purpose of the survey followed by a paragraph of instructions. The instructions were the same between the educator survey and the industry survey except educators were asked to suggest competencies that they felt should be added and to answer questions regarding their educational programs.

3.3.1 Educator Survey

The instructions for the educator survey were as follows.

This survey is divided into twelve sections, one for each of twelve student attributes. You will be asked to rank each attribute and its corresponding competencies on a scale of 1 to 5, with 1 having low importance and 5 having high importance. Your evaluation of importance should be relative to your perception of what a modern Manufacturing Engineering Technology (MET) graduate should be able to do in their first few years of professional manufacturing employment.

You will notice that most of these competencies are expressed at a fairly high level. This is to reduce the number of competencies to a manageable size. You are invited to add any important competencies that you believe are missing or to leave other comments by writing them in the box provided under each attribute.

There are a few questions at the end regarding your educational program. The intent of these questions is to see how MET programs are faring in our current manufacturing climate. Please leave your name and e-mail address on the last page if you would like to receive my analysis and summary of the survey results.

Thank you for your help. My intent is that this research be beneficial to all MET programs in the United States.

3.3.2 Industry Survey

The instructions for the industry survey were as follows.

This survey is divided into twelve sections, one for each of twelve student attributes. You will be asked to rank each attribute and its corresponding competencies on a scale of 1 to 5, with 1 having low importance and 5 having high importance. Your evaluation of importance should be relative to your perception of what a modern Manufacturing Engineering Technology (MET) graduate should be able to do in their first few years of professional manufacturing employment.

You will notice that most of these competencies are expressed at a fairly high level. This is to reduce the number of competencies to a manageable size. Please leave your name and e-mail address on the last page if you would like to receive my analysis and summary of the survey results.

Thank you for your help. My intent is that this research be beneficial to all MET programs in the United States.

3.4 Survey Software

The survey software, www.surveymonkey.com, was used to create the survey in a format that would be easily accessible for participants to take over the internet. The survey offered different color themes and the chosen theme was "blue metal".

Participates rated the attribute and competency questions on a Likert scale with 1 being low and 5 being high. The competency questions in each section could be randomized. All questions, except the last page for respondent information, required an answer before the respondent could continue to the next page. The complete educator survey and industry survey can be found in appendix B and appendix C, respectively. Both surveys contained fourteen pages and the titles of these pages were:

1. Survey Instructions and Information
2. Manufacturing processes
3. Quality
4. Manufacturing systems
5. Design
6. Materials
7. Management
8. Creativity and problem solving
9. Leadership
10. Professionalism
11. Communication
12. Safety and environmental issues

13. Global awareness

14. Thank you

3.4.1 Educator Survey

Each attribute and competency was rated on a 1 to 5 Likert scale. The competency questions were randomly organized within their respective attribute section. At the bottom of each page containing competencies, there was an open-ended question where the participants could provide additional competencies, comments, or questions. These open ended questions were intended to be analyzed for improvements or changes to the survey that would be sent to industry.

The "Thank you" section contained a list of questions which might be useful in evaluating the MET programs. These questions were:

1. Which of the following best describes your program?
   a. Manufacturing Engineering Technology
   b. Manufacturing Engineering
   c. Other (Please specify)
2. Is your program accredited by TAC-ABET?
   a. Yes
   b. No
3. Is your program accredited by another body?
   a. Yes
   b. No
   c. If yes, please specify
4. What is your current undergraduate enrollment in your program?

5. Is your current trend?
    a. Upwards
    b. Downwards
    c. Level
6. What is your percent placement of new graduates in manufacturing-related jobs within three months after graduation?
7. Name
8. E-mail address

3.4.2 Industry Survey

The industry survey was a copy of the educator survey with a few minor changes. Some of the competency questions needed to be given in order and so the randomization was eliminated. The open ended question below each competency section was modified to be "Please add comments below". All the attribute and competency questions stayed the same.

The "Thank you" page changed to contain the following questions:

1. Name
2. E-mail Address

3.5 Response Procedure

The survey participants were only allowed to take the survey once. The participants could stop at any point during the survey and then come back later to finish it or change their responses. Once the respondents finished the survey, the results were automatically organized and stored on the website. All the stored responses could be exported and analyzed. The e-mail list management section organized the information by e-mail address, first name, last name, custom data, and status. The status menu was a drop-down menu that contained: responded, no response, declined, and not sent. This menu was automatically controlled by the software depending on the status of the participant. The status could also be changed manually.

The e-mail messages were sent to the designated individuals with a link to open a website and start the survey. The identities of respondents were tracked through the status menu and the survey could be sent or resent to potential participants based on their status. The typical e-mail messages that were sent with the links for the surveys are listed in appendix F.

3.5.1 Educator Survey

The survey was sent out three times to the educator's list. The first time the survey was sent as a link in an e-mail message to each potential participant. The second and third time the survey was sent to educators listed as "no response" in the status column.

3.5.2 Industry Survey

The industry survey was sent several times to various lists. The survey was first sent out on November 10, 2005 and then on November 21, 2005 allowing all the industry representatives to take the survey. Due to the fact that some of the industry representatives were on vacation the survey was not sent again until after the New Year to increase the response rate.

3.6 Response Rate

The total potential participants that had the opportunity to take the industry survey were 384. The total potential participants that had the opportunity to take the educator survey were 140. Only forty individuals responded to the educator survey, yielding a response rate of 28.57%. Eighty-two individuals responded to the industry survey, yielding a response rate of 21.35%. There were thirty-seven potential participants from geographic areas outside the United States and only four took the survey. The four respondents were all from Canada.

3.7 Conclusion

The survey was created with software on the internet for convenience of distributing the survey and collecting the data. The educator survey was sent to educators to determine if it covered all the related attributes and competencies. Since none of the attribute or competency questions required changes, comparisons will be done between the educator survey and the industry survey to determine if educators rate the survey questions at the same level of importance as industry representatives. Educators who had not already responded received an extra opportunity to take the survey by receiving an individual e-mail which identified the sender. The industry survey's potential participants were given longer interval periods between survey requests to account for those individuals on vacation. The only participants living outside the United States were four industry representatives from Canada, and so this survey will not be considered an international survey.

Chapter 4

RESULTS

4.1 Introduction

Two groups of respondents, educators and industry representatives, answered twelve attribute questions and seventy-three competency questions for MET baccalaureate graduates. The twelve attribute questions will be compared with a multivariate analysis of variance (MANOVA) to determine the significance of the difference in responses between educators and industry representatives. The seventy-three competency questions will also be compared with a MANOVA to determine the significance of the difference between educators and industry representatives. For further analysis, t-tests were done comparing educator's and industry representative's responses for each competency section to determine the significance levels for each question.

Tables for the attribute questions and each competency section will be provided to show the obtained mean value, standard deviation value, and significance level. Each attribute and competency section will also have a box-plot graph which will provide further evaluation information. An overview of the open-ended responses will be provided with each competency section while appendix D and appendix E contain the exact responses. A table will be included for the competencies ranked by their combined educator-and-industry mean response. This table will accentuate the ranking of each competency question. Finally, an overview will be given of the educator responses about their baccalaureate programs.

The means and standard deviation for the attribute and competency questions are found in appendix G. The MANOVA of educator and industry representative responses to the attribute questions reveals significant differences ($p<.05$, 2-tailed). A MANOVA does not reveal significant differences in educator and industry responses to competency items ($p<.05$, 2-tailed). Despite the fact the MANOVA does not show significant differences among the competencies, educator and industry representative responses to each competency will be evaluated further. There are seventy-three competencies and evaluating multiple comparisons increases the probability that significant findings are due to random chance. The attribute section will continue to be evaluated at a .05 level of significance (2-tailed) while each competency section will be considered at the .01 level of significance (2-tailed) due to the high number of comparisons between educator and industry representative responses.

Box-plots will be used throughout this chapter as a visual representation of the comparison of the competencies. Figure 1 is an example of a box-plot, also known as box-and-whisker plot, and the comparison is between two samples. Sample 1 represents the educator responses and sample 2 represents the industry representative responses. The bottom of the whisker or vertical line shows the minimum value of the data from all the respondents in that sample group. The top of the whisker or line is the maximum value. The bottom of the box, the lower quartile, is the value at 25% of the data. The top of the box, the upper quartile, is the value at 75% of the data. The thick line in the middle represents the median value of the data. If the lower quartile has the same value as the minimum value then the whisker or line will not be shown, only the box. The same thing occurs with the upper quartile and maximum value.

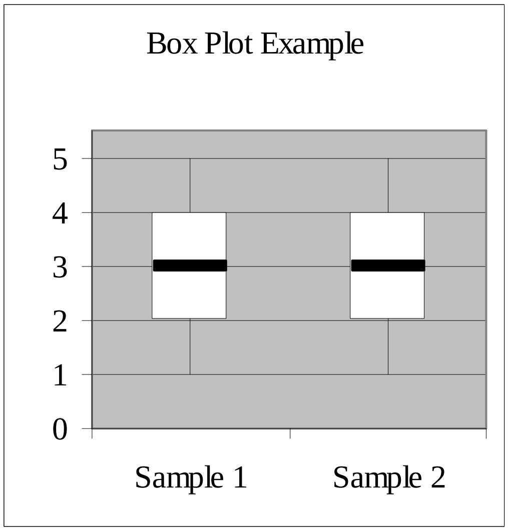

Figure 1. Box Plot Example

The educator responses to the survey question "Please add any competencies or comments below", are found in appendix D. The industry representative responses to the survey question "Please add comments below" are found in appendix E.

The survey questions were rated on a Likert scale of 1 to 5. Most of the survey's mean responses were between 4.00 and 4.50. The educator's mean response for the attributes and competency questions were almost always higher than the corresponding industry representative's mean response.

4.2 Attributes

Educator's and industry representative's mean responses for the attributes are shown in table 1. Educator and industry representative responses for each attribute are compared using a t-test. The mean values for attributes 1 through 5 and 11 are significantly different ($p<.05$, 2-tailed). The educator mean value for attribute 8, leadership, is 3.95 and the other attributes for the educator survey have a mean value above 4.00. Educator's mean values for attributes 1, 2, 7, 9, and 10 are above 4.50. The educator mean value for attribute 1, manufacturing processes, (mean = 4.83) has the highest mean value of the entire survey. Industry representative's mean values for attributes 1, 9, and 10 are above 4.50. The industry representatives rated three mean values below 4.00 and they are for attribute 3, 8, and 12. Attribute 8, leadership, has the same mean value for educators and industry representatives (mean = 3.95). There is not much difference between the educator's and industry representative's responses to competency 8 (significance level = 0.995). There is a great difference between the educator's and industry representative's responses to competency 6 (significance level = 8E-04). Attribute 9, professionalism, is the only attribute where the industry representative's mean value (mean = 4.70) is higher than the educator's mean value (mean = 4.60).

The Attribute box-plot graph of the responses for educators and industry representatives is shown in figure 2. This graph is a visual representation of the responses given and cannot be used to determine if the responses between the two samples are significantly different. For example the responses of the educators and industry representatives for Attribute 8 look very different in the box-plot but the t-test value shows that they are not. Similarly the t-test value for attribute 4 shows that the two responses are significantly different, even though the box-plot graphs for the attribute 4 responses look similar.

The box-plot uses the median value and the value given at 25% (lower quartile) and 75% (upper quartile), so even the mean values of the data might not correspond. The graph cannot be used to determine whether the responses between the two groups are significantly different, it only visually displays the skewedness of the data. The graph visually shows the high responses the educators gave for attribute 1. There is no box shown for this attribute which means that the lower quartile for the educator's responses is at 5. The lowest response given by the educators for attribute 1 is 3 since this is the value at the bottom of the line or whisker. Industry representative's upper quartiles for attributes 3 and 12 are at 4 while the rest of the upper quartiles are at 5.

Table 1. Importance of Attributes

Attributes	Educator Survey†		Industry Survey‡		T-test
	Mean (SD)	Med	Mean (SD)	Med	Sig.
1. Manufacturing Processes: An understanding of manufacturing processes and their applications.	4.83 (0.45)	5	4.56 (0.67)	5	0.011*
2. Quality: A commitment to quality and an ability to effectively measure and improve product and process quality.	4.70 (0.52)	5	4.41 (0.61)	4	0.008*
3. Manufacturing Systems: An understanding of the dynamics of manufacturing systems and supply chains and how to effectively configure systems for efficient manufacture and delivery.	4.30 (0.61)	4	3.87 (0.73)	4	8E-04*
4. Design: The ability to effectively design tooling and facilities and to participate on product-design teams to meet a set of requirements and constraints.	4.40 (0.67)	4	4.09 (0.72)	4	0.020*

Table 1—Continued

Attributes	Educator Survey†		Industry Survey‡		T-test
	Mean (SD)	Med	Mean (SD)	Med	Sig.
5. Materials: An understanding of the physical and mechanical properties of engineering materials.	4.43 (0.55)	4	4.11 (0.72)	4	0.009*
6. Management: The ability to plan, organize, staff and control projects and processes.	4.33 (0.69)	4	4.07 (0.81)	4	0.080
7. Creativity and Problem Solving: The ability to see problems from multiple and new perspectives and generate innovative solutions.	4.65 (0.58)	5	4.44 (0.70)	5	0.083
8. Leadership: The ability to develop a vision and lead a team or organization to new heights.	3.95 (0.99)	4	3.95 (0.97)	4	0.995
9. Professionalism: High ethical values, good work habits and on-going development of relevant knowledge and skills.	4.60 (0.87)	5	4.70 (0.54)	5	0.529
10. Communication: The ability to effectively communicate.	4.70 (0.52)	5	4.59 (0.63)	5	0.287
11. Safety and Environmental Issues: Commitment to and competency in safety and environmental issues related to manufacturing.	4.48 (0.72)	5	4.16 (0.73)	4	0.025*
12. Global Awareness: Competence with respect to the issues, challenges and opportunities in today's global manufacturing environment.	4.08 (0.76)	4	3.85 (0.86)	4	0.154

Notes: † N = 40; ‡ N = 82; *The values are significantly different at 0.01 (2-tailed)

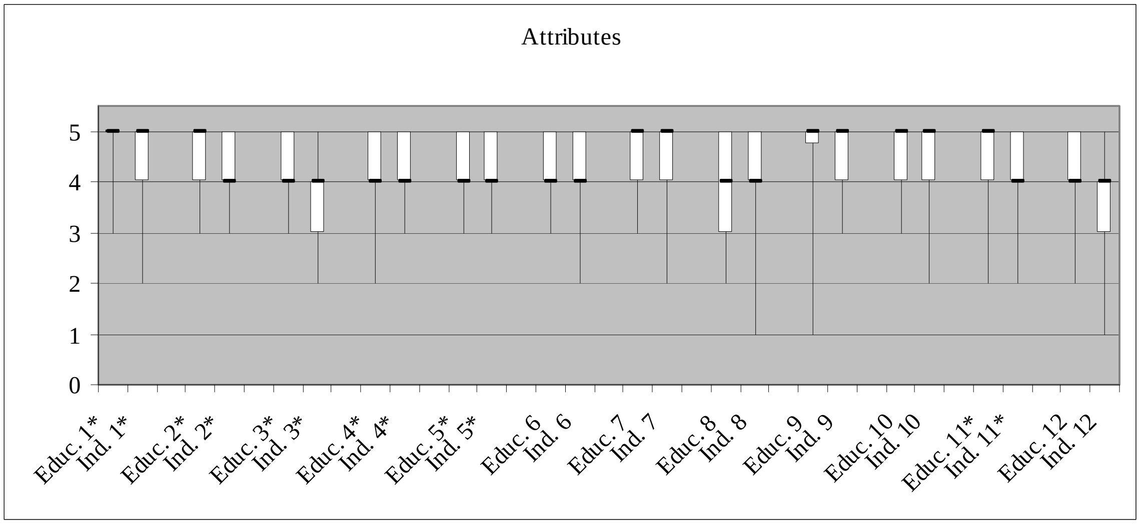

Figure 2. Box-plots for Attributes

*The values are significantly different at the 0.05 level (2-tailed)

4.3 Manufacturing Processes

Manufacturing Processes contains the first group of competencies to be examined. The mean responses for the educators and industry representatives are shown in table 2. The responses for each competency are compared using a t-test. The comparison shows that the values for competencies 2, 4, 5, and 6 are significantly different ($p<.01$, 2-tailed). The mean competency values that are significantly different between educators and industry representatives are listed in table I4 of appendix I. There is a great difference between the educator's and industry representative's solutions for the responses to competency 6 (significance level = 3E-04).

Only ten of the educator's mean values in the whole survey have a value of 4.50 or higher and three are in this section. These ten competencies are listed in table I2 of appendix I. Competency 1 (mean = 4.65), competency 2 (mean = 4.70), and competency 3 (mean = 4.50) have educator mean values at 4.50 or above. The educator's mean value for competency 2 is 4.70 and this is relatively high with only one other competency with a higher mean value. Industry representatives had three competencies with a mean value below 4.00 and these were for competency 4 (mean = 3.54), competency 5 (mean = 3.54), and competency 6 (mean = 3.82). The Manufacturing Processes box-plot graph of the responses of educators and industry representatives is shown in figure 3.

Table 2. Importance of Manufacturing Processes

Manufacturing Processes Competencies	Educator Survey†		Industry Survey‡		T-test
Graduates will be able to:	Mean (SD)	Med	Mean (SD)	Med	Sig.
1. Select appropriate processes and equipment based on their capabilities and economics.	4.65 (0.58)	5	4.30 (0.86)	5	0.010
2. Analyze a part print for manufacturability.	4.70 (0.56)	5	4.34 (0.76)	4	0.004*
3. Document a processing sequence to economically meet product specifications.	4.50 (0.75)	5	4.18 (0.77)	4	0.033
4. Select appropriate tooling and machine settings (feeds, speeds, temperatures, pressures, etc.)	4.13 (0.94)	4	3.54 (0.98)	4	0.002*
5. Analyze and select appropriate clamping and locating surfaces.	4.13 (0.94)	4	3.54 (0.91)	4	0.002*
6. Utilize appropriate manufacturing software including, CAD/CAM, CNC, etc.	4.40 (0.74)	5	3.82 (0.93)	4	3E-04*
7. Prepare process operation instructions.	4.18 (0.75)	4	4.04 (0.92)	4	0.377

Notes: † N = 40; ‡ N = 82; *The values are significantly different at 0.01 (2-tailed)

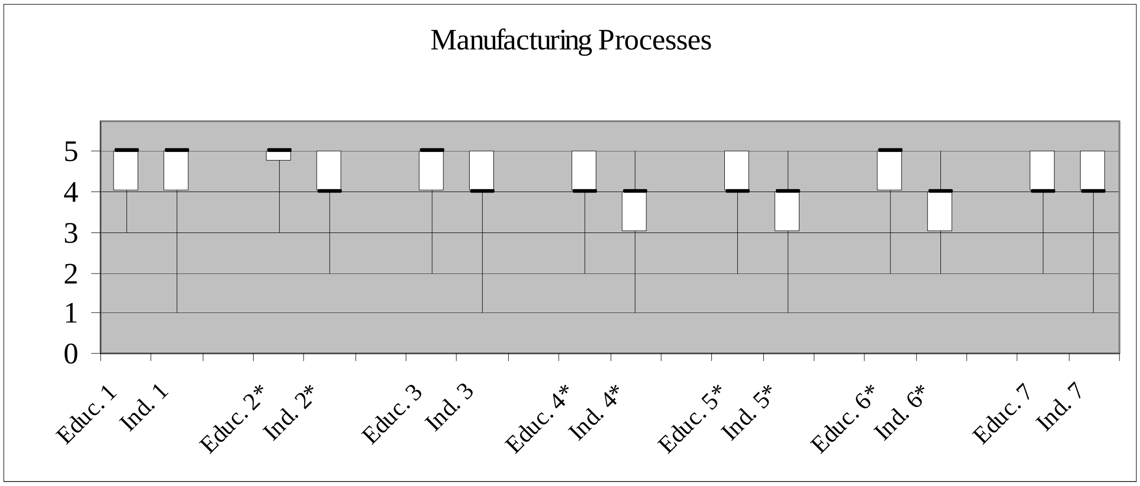

Figure 3. Box-plots for Manufacturing Processes

*The values are significantly different at the 0.01 level (2-tailed)

In the Manufacturing Processes comment section, found in appendix D, two educators mentioned that some MET programs focus too much on machining or CNC. Other educators mentioned that manufacturing processes depend on the specific industry that graduates go into. An additional competency suggested by an educator was that a graduate should be able to "control the appropriate processes". Other educators expressed that competency 4 is the responsibility of a tool engineer, programmer, or machinist.

In the Manufacturing Processes comment section, found in appendix E, an industry representative reported concern that manufacturing processes represents a broad category and the importance of the competencies will change depending on the specific job. An additional competency suggested was that "a new grad must have good visualization skills to see processes before they are even designed and efficiently communicate them to other team members." Two of the responses explained that MET employees would discuss operations with the shop floor. Three industry representatives mentioned that these competencies are developed on the job or it would be the responsibility of the machine operator.

4.4 Quality

The mean responses for the educators and industry representatives in the Quality section are shown in table 3. The results of each t-test reveal that the responses for competency 4 (significance level = 0.001) and competency 6 (significance level = 0.002) are significantly different ($p<.01$, 2-tailed). Competency 7 (mean = 3.89) has the only mean value for the educator survey that is not between 4.00 and 4.50. Competency 1 has the only industry representative's mean value above 4.00 and the lowest value is for competency 7 (mean = 3.59). Competency 7 has the lowest value in the quality section for both the educators and industry representatives.

The Quality box-plot graph of the responses of educators and industry representatives is shown in figure 4. The graphs for competencies 3 and 4 look the same but the mean values for competency 4 are significantly different while the mean values for competency 3 are not significantly different.

In the Quality comment section an educator responded that graduates will need to be prepared to know how to apply quality principles to their individual employment situation. An educator mentioned that, "the issue is to be able to solve and improve processes and process problems"

An industry representative in the Quality section reported that graduates are not at a level to know everything about quality but should know the fundamentals. Another mentioned that modifications are continuously occurring to regulatory standards and another respondent mentioned that graduates should know where to obtain desired standard information. An industry representative pointed out that some of the quality competencies might fall under the requirements for mechanical engineers. Another industry representative wrote that a graduate should, “have the ability to assess which attributes of a product or process are important to the end result”

Table 3. Importance of Quality

Quality Competencies	Educator Survey†		Industry Survey‡		T-test
Graduates will be able to:	Mean (SD)	Med	Mean (SD)	Med	Sig.
1. Assess the nature, types, and impact of variation.	4.43 (0.68)	5	4.15 (0.79)	4	0.046
2. Use the basic instruments of metrology and determine the capability of measurement systems.	4.18 (0.78)	4	3.84 (0.87)	4	0.036
3. Achieve high quality in manufacturing systems through proven management methodologies.	4.15 (0.77)	4	3.93 (0.97)	4	0.171
4. Apply appropriate test and inspection procedures for evaluating product and process quality.	4.35 (0.66)	4	3.85 (0.97)	4	0.001*
5. Conduct capability studies and design, conduct and evaluate experiments.	4.20 (0.72)	4	3.87 (1.02)	4	0.039
6. Set up a quality control system including Statistical Process Control.	4.30 (0.72)	4	3.82 (0.93)	4	0.002*
7. Comply with national and international regulatory standards and certifications.	3.89 (0.89)	4	3.59 (1.08)	4	0.037

Notes: † N = 40; ‡ N = 82; *The values are significantly different at 0.01 (2-tailed)

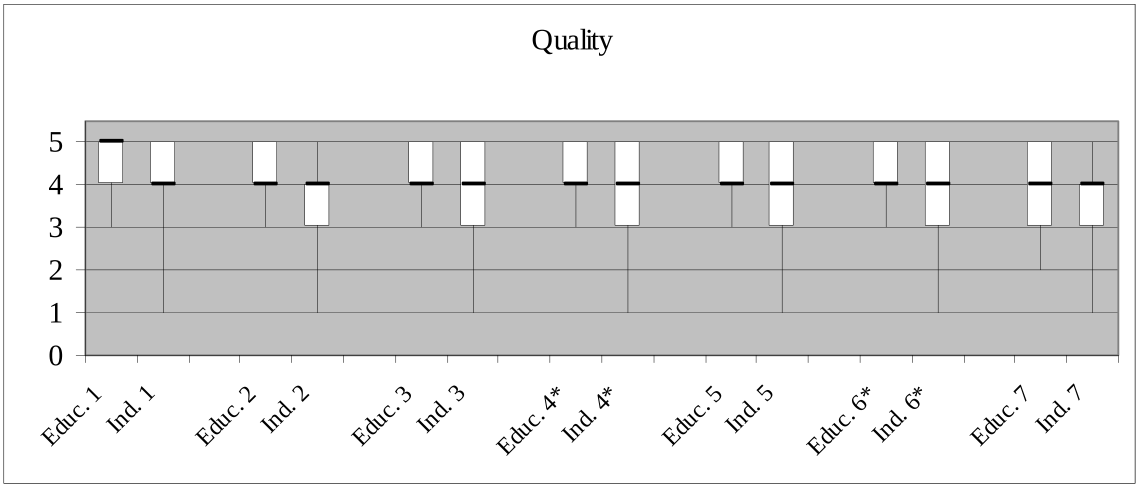

Figure 4. Box-plots for Quality

*The values are significantly different at the 0.01 level (2-tailed)

4.5 Manufacturing Systems

The mean responses for the educators and industry representatives in the Manufacturing Systems section are shown in table 4. Competency 4 (significance level = 0.006) is the only competency in this section where the responses between the educators and industry representatives are significantly different (p<.01, 2-tailed). Three of the educator's competencies have a mean value below 4.00 and these are competency 1 (mean = 3.88), competency 4 (mean = 3.93), and competency 6 (mean = 3.65). Competency 6 has the lowest educator survey mean value and two other educator survey competencies also have a mean value of 3.65. The industry representative's mean values between 3.50 and 4.00 are for competency 1 (mean = 3.79), competency 2 (mean = 3.84), and competency 5 (mean = 3.61). Only three competencies in the whole survey have a mean value below 3.50 and these mean values all come from industry representatives. These three competencies are listed in table I1 of appendix I. Two competencies with low mean values are in this section, competency 4 (mean = 3.49) and competency 6 (mean = 3.27). Competency 6 has the lowest mean value of the entire survey.

The Manufacturing Systems box-plot graph of the responses of educators and industry representatives is shown in figure 5. The box-plot graph shows a difference when comparing this section to most of the other sections of the survey. Most of the other sections contain many competencies where the lower quartile has a value of 4 and the upper quartile value of 5; an example in this section is competency 3. Three of the competencies in this section have a lower quartile value of 3 with the upper quartile value of 4. The educator's responses for competencies 1 and 4 are interesting since the lowest value given was a 3 and the lower quartile is also a 3. This means that at least 25% of the respondents answered this competency with the value of 3.

The Manufacturing Systems comment section had only two educator responses that are exclusively for manufacturing systems. The first educator remarked that every program will accentuate different manufacturing systems competencies. The second response specified that a graduate will need to understand manufacturing systems but does not need to know how to "set up" the process.

Many industry representatives reported that each employment position is different and the graduate should be able to know the basics without knowing specifics. Two respondents did not expect recent graduates to have the competencies without further education. Three industry representatives emphasized that lean manufacturing is important for an MET employee to know. One respondent did not know what was meant by system dynamics.

Table 4. Importance of Manufacturing Systems

Manufacturing Systems Competencies	Educator Survey†		Industry Survey‡		T-test
Graduates will be able to:	Mean (SD)	Med	Mean (SD)	Med	Sig.
1. Understand system dynamics and predict the performance of given manufacturing system configurations.	3.88 (0.69)	4	3.79 (0.97)	4	0.590
2. Effectively integrate processing, material handling and flow of information.	4.13 (0.72)	4	3.84 (0.84)	4	0.057
3. Implement lean manufacturing principles in a manufacturing system.	4.20 (0.82)	4	4.07 (0.98)	4	0.455
4. Analyze and specify requirements for automated controls.	3.93 (0.73)	4	3.49 (0.96)	3	0.006*
5. Set up an appropriate production control system with a feedback loop.	4.03 (0.80)	4	3.61 (0.95)	4	0.013
6. Manage a supply chain including international constituents.	3.65 (0.98)	4	3.27 (1.07)	3	0.052

Notes: † N = 40; ‡ N = 82; *The values are significantly different at 0.01 (2-tailed)

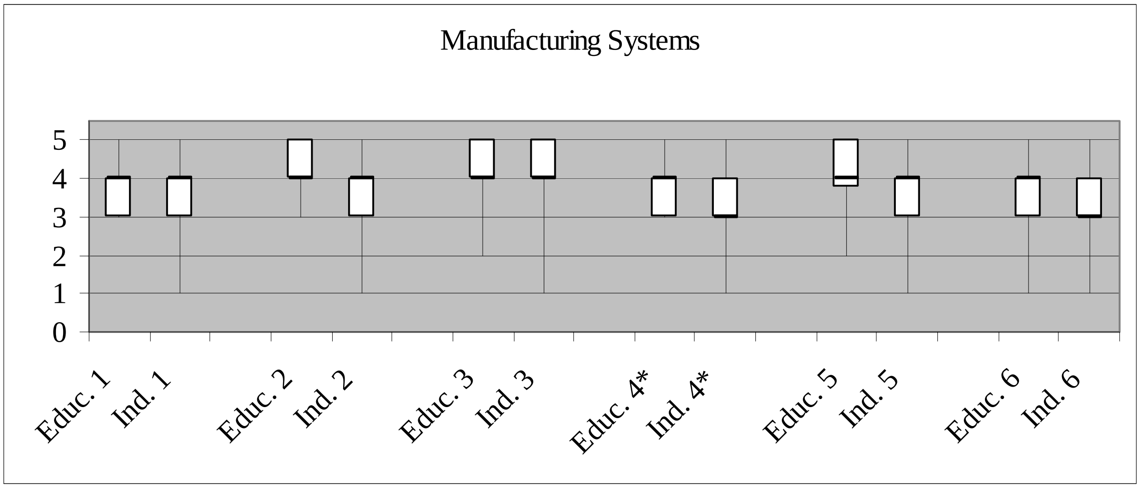

Figure 5. Box-plots for Manufacturing Systems

*The values are significantly different at the 0.01 level (2-tailed)

4.6 Design

The mean responses for the educators and industry representatives in the Design section are shown in table 5. Competency 5 (significance level = 2E-04) and competency 6 (significance level = 4E-06) are the only competencies in this section where the response values between educators and industry representatives are significantly different ($p<.01$, 2-tailed). There is a great difference between the educator's and industry representative's responses to competency 6 (significance level = 4E-06) and this difference is the greatest for the entire survey. The educator's mean values are all between 4.00 and 4.50. Two of the industry representative's mean values are below 4.00 and these are for competency 5 (mean = 3.76) and competency 6 (mean = 3.72). The Design box-plot graph of the responses of educators and industry representatives is shown in figure 6.

Table 5. Importance of Design

Design Competencies	Educator Survey†		Industry Survey‡		T-test
Graduates will be able to:	Mean (SD)	Med	Mean (SD)	Med	Sig.
1. Clearly identify the requirements and constraints to be met by a design considering all stakeholders.	4.15 (0.83)	4	4.00 (0.97)	4	0.379
2. Develop specifications that accurately reflect these requirements and constraints.	4.30 (0.72)	4	4.02 (0.87)	4	0.069
3. Understand and apply Design for Manufacturing and Assembly principles.	4.48 (0.60)	5	4.34 (0.76)	4	0.293
4. Use problem solving and other analysis techniques to predict performance and to find optimum design solutions.	4.30 (0.69)	4	4.21 (0.84)	4	0.518
5. Transform a solution concept into a final detailed design.	4.30 (0.65)	4	3.76 (0.88)	4	2E-04*
6. Make effective use of CAD and related design tools.	4.45 (0.68)	5	3.72 (0.95)	4	4E-06*

Notes: † N = 40; ‡ N = 82; *The values are significantly different at 0.01 (2-tailed)

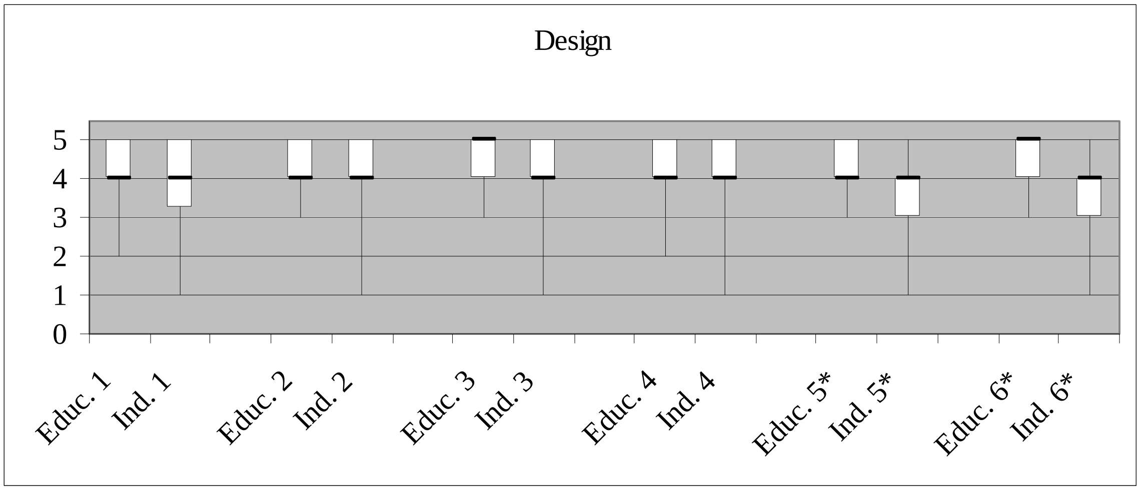

Figure 6. Box-plots for Design

*The values are significantly different at the 0.01 level (2-tailed)

In the Design comment section only one educator made a response exclusively for the design section. The response was that a tool and die maker would be the one to design tools.

Some of the industry representatives reported that graduates should know the fundamentals of design but experience is needed to improve upon their skills. Two industry representatives mentioned that MET educational programs have too much emphasis on design while another mentioned that these competencies are for a design engineer and not an MET graduate.

4.7 Materials

The mean responses for the educators and industry representatives in the Materials section are shown in table 6. Competency 1 (significance level = 0.005), competency 2 (significance level = 0.003), and competency 3 (significance level = 0.002) have mean values that are significantly different (p<.01, 2-tailed). Only one of the educator's mean values is not between 4.00 and 4.50 and it is for competency 4 (mean = 3.98). All of the industry representative's mean values are below 4.00 and competency 5 (mean = 3.65) has the lowest mean value in this section. The Materials box-plot graph of the responses of educators and industry representatives is shown in figure 7.

Table 6. Importance of Materials

Materials Competencies	Educator Survey†		Industry Survey‡		T-test
Graduates will be able to:	Mean (SD)	Med	Mean (SD)	Med	Sig.
1. Select appropriate materials for tooling and for products.	4.38 (0.77)	5	3.93 (0.87)	4	0.005*
2. Assess the effects of manufacturing processes on material properties.	4.40 (0.63)	4	3.98 (0.86)	4	0.003*
3. Best utilize the machinability, formability, and weldability of various materials.	4.33 (0.66)	4	3.88 (0.82)	4	0.002*
4. Specify treatments affecting the property and structure relationships of materials.	3.98 (0.83)	4	3.72 (0.95)	4	0.132
5. Work effectively with material supply chain issues such as cost, availability, and delivery.	4.08 (0.80)	4	3.65 (1.06)	4	0.014

Notes: † N = 40; ‡ N = 82; *The values are significantly different at 0.01 (2-tailed)

In the Materials comment section three educators mentioned that MET graduates might need to understand these competencies but do not have full responsibility. A large company might have a metallurgical department while other companies might have design engineers, structural engineers, or materials engineers who are responsible for the competencies dealing with materials.

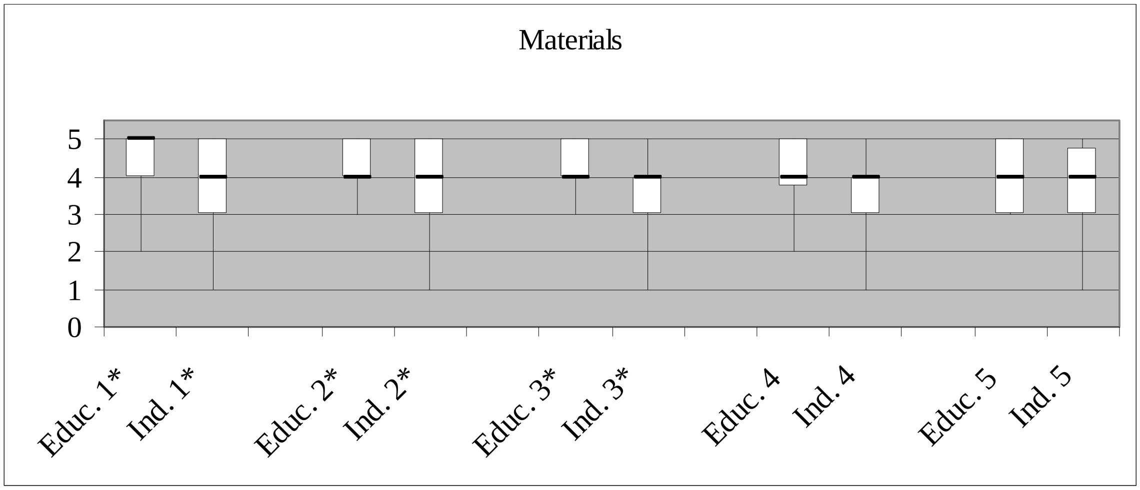

Figure 7. Box-plots for Materials

*The values are significantly different at the 0.01 level (2-tailed)

An industry representative reported that graduates should be exposed to these competencies but more experience will be required. Another industry representative responded that different disciplines will have different requirements. A response explained that an MET graduate will need to determine whether a design can be manufactured. An industry representative felt that these responsibilities are for mechanical engineers instead of MET graduates while another felt that mechanical engineers need to be consulted.

4.8 Management

The mean responses for the educators and industry representatives in the Management section are shown in table 7. None of the mean values for the competencies in this section are significantly different (p<.01, 2-tailed). Two of the educator's competencies have a mean value below 4.00 and these are for competency 1 (mean = 3.95) and competency 7 (mean = 3.65). Competency 7 has the lowest educator survey mean value and two other educator survey competencies also have this mean value. The industry representative's competencies with mean values below 4.00 are competency 1 (mean = 3.76), competency 2 (mean = 3.95), competency 3 (mean = 3.91), competency 4 (mean = 3.91), and competency 7 (mean = 3.51). The management box-plot graph of the responses of educators and industry representatives is shown in figure 8.

In the Management comment section an educator reported that "justify capital equipment expenditures" should be one competency and "be responsible for make-or-buy decisions" should be a separate competency. Another educator felt that these competencies should not be expected of a recent baccalaureate graduate but developed on the job.

Four industry representatives reported the importance of communication for management. One other representative remarked that management competencies are important for a company that will do a lot of outsourcing. Another mentioned, "the best engineers get asked to become managers and most schools do not prepare [the graduate] for that step into management and many engineers fail as managers". Three industry representatives thought that these competencies are too advanced and would be developed through the MET graduate's career. A response was that these competencies are only important for those in management positions.

Table 7. Importance of Management

Management Competencies	Educator Survey†		Industry Survey‡		T-test
Graduates will be able to:	Mean (SD)	Med	Mean (SD)	Med	Sig.
1. Use software and other tools to develop and execute a project or process plan.	3.95 (0.81)	4	3.76 (0.95)	4	0.246
2. Determine resource requirements (personnel, equipment, time, budget, etc.) for executing a plan.	4.25 (0.84)	4	3.95 (0.83)	4	0.068
3. Justify capital equipment expenditures and be responsible for make-or-buy decisions.	4.08 (0.80)	4	3.91 (1.00)	4	0.340
4. Effectively deploy resources in carrying out a plan.	4.20 (0.69)	4	3.91 (0.97)	4	0.064
5. Monitor and assess progress and performance and take appropriate corrective action when necessary.	4.23 (0.80)	4	4.02 (0.93)	4	0.221
6. Keep team members and other stakeholders informed of progress and problems.	4.20 (0.82)	4	4.15 (0.90)	4	0.744
7. Assess performances of employees and facilitate their progress.	3.65 (0.98)	4	3.51 (0.98)	4	0.467

Notes: † N = 40; ‡ N = 82

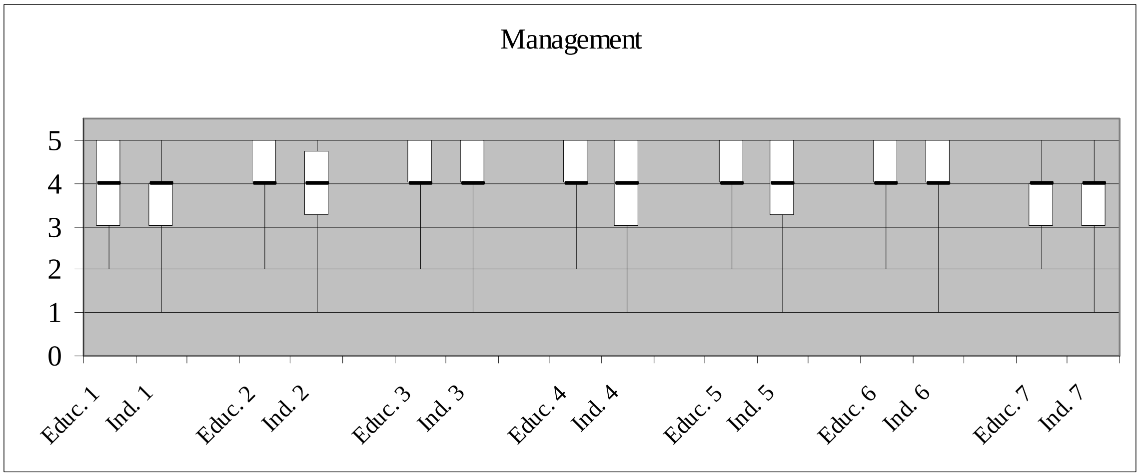

Figure 8. Box-plots for Management

4.9 Creativity and Problem Solving

The mean responses for the educators and industry representatives in the Creativity and Problem Solving section are shown in table 8. None of the mean value pairs for the competencies in this section are significantly different ($p<.01$, 2-tailed). Only 10 of the educator's mean values in the whole survey have a mean value of 4.50 or higher and Competency 5 (mean = 4.58) is one of those. The industry representative's competencies with mean values below 4.00 are competency 2 (mean = 3.98) and competency 4 (mean = 3.88). Competency 1 has a higher industry representative mean value (mean = 4.32) than educator mean value (mean = 4.28); which only occurs with four competencies in the whole survey. All four occurrences can be found in table I3 of appendix I. The Creativity and Problem Solving box-plot graph of the responses of educators and industry representatives is shown in figure 9.

Table 8. Importance of Creativity and Problem Solving

Creativity and Problem Solving Competencies	Educator Survey[†]		Industry Survey[‡]		T-test
Graduates will be able to:	Mean (SD)	Med	Mean (SD)	Med	Sig.
1. See new and creative ways to achieve an objective (think outside the box) within set constraints.	4.28 (0.82)	4	4.32 (0.81)	4	0.790
2. Effectively utilize the tools of creativity.	4.00 (0.82)	4	3.98 (0.94)	4	0.883
3. Draw analogies and comparisons using both breadth and depth of knowledge to identify and evaluate alternative solutions to the problem.	4.20 (0.76)	4	4.16 (0.84)	4	0.785
4. Use modeling, statistical and other analysis techniques for problem solving.	4.18 (0.81)	4	3.88 (0.99)	4	0.081
5. Analyze the cause-and-effect relationships of the problem to find the root causes.	4.58 (0.64)	5	4.30 (0.87)	5	0.055
6. Implement the solution.	4.48 (0.55)	4.5	4.38 (0.86)	5	0.453

Notes: [†] N = 40; [‡] N = 82

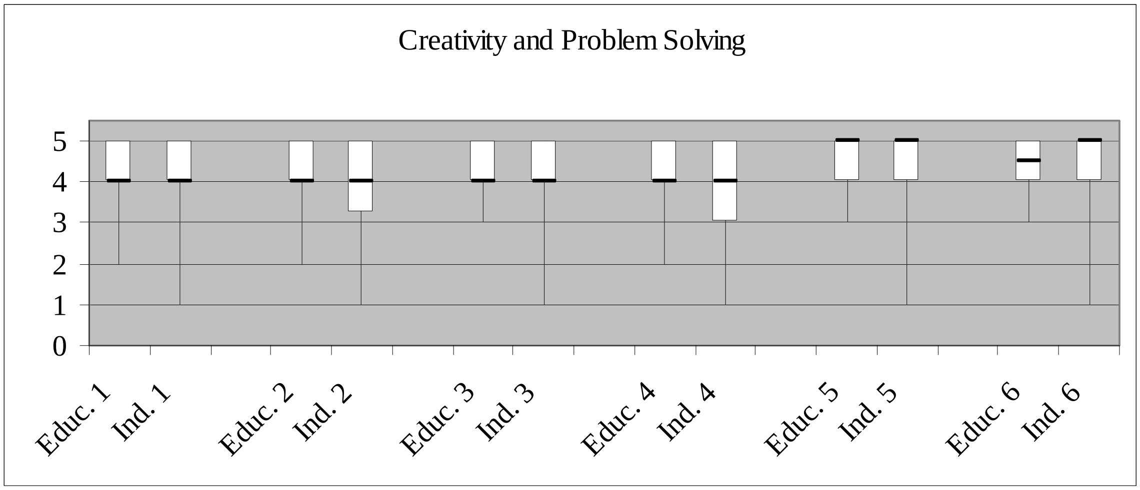

Figure 9. Box-plots for Creativity and Problem Solving

In the Creativity and Problem Solving comment section two educators mentioned that these competencies will take time to obtain and cannot be expected upon graduation. Two others mentioned that this area is important and one educator continued on to emphasize that problem solvers are needed. An educator did not like the terminology ‘tools of creativity’ or ‘creative ways’.

An industry representative would like to know what the ‘tools of creativity’ are. Three responses indicated that the fundamentals of MET are needed to be known before creativity can be taught. Two industry representatives felt that success with problem solving occurs when several people are able to come together to work on the problem.

4.10 Leadership

The mean responses for the educators and industry representatives in the Leadership section are shown in table 9. None of the mean value pairs for the competencies in this section are significantly different ($p<.01$, 2-tailed). The educator’s competencies with mean values below 4.00 are competency 2 (mean = 3.65) and competency 6 (mean = 3.80). Competency 2 has the lowest educator mean value and two other educator survey competencies also have this mean value. The industry representative's competencies with mean values below 4.00 are competency 2 (mean = 3.84) and competency 6 (mean = 3.60). There are four competencies in the survey where the industry representative mean values are greater than the educator mean values and two occur in this section. Competency 2 has a higher industry representative mean value (mean = 3.84) than educator mean value (mean = 3.65). Competency 3 has a higher industry representative mean (mean = 4.26) than educator mean value (mean = 4.15).

The Leadership box-plot graph of the responses of educators and industry representatives is shown in figure 10. Competency 2's upper quartile is a 4 for educators while the upper quartile is a five for the industry representatives. This is unique since educators commonly rank the competencies higher than the industry representatives.

Two educators feel that leadership needs to be taught even though some aspects will be too difficult to teach or for students to understand. A competency suggestion was; "the ability to develop collaborative and leadership skills". Two other educators thought that leadership skills are more important for employees with a few years of experience than for graduates.

In the Leadership comment section, found in appendix E, three industry representatives expressed that graduates will not immediately need these competencies and some of the needed skills will be learned on the job. Twice it was pointed out that only those who will be leaders are going to need to know this information while another respondent said, "leadership should be taught". An industry representative mentioned that MET graduates need to be taught "influence skills".

Table 9. Importance of Leadership

Leadership Competencies	Educator Survey[†]		Industry Survey[‡]		T-test
Graduates will be able to:	Mean (SD)	Med	Mean (SD)	Med	Sig.
1. Lead a team in the performance of an activity or project.	4.10 (0.90)	4	4.02 (0.90)	4	0.665
2. Develop a strategic plan.	3.65 (1.10)	4	3.84 (1.16)	4	0.378
3. Build relationships to gain support and commitment of others.	4.15 (0.83)	4	4.26 (0.94)	4.5	0.529
4. Effectively sell a plan or idea to others.	4.18 (0.75)	4	4.04 (1.02)	4	0.399
5. Plan and conduct a productive meeting.	4.25 (0.90)	4.5	4.10 (0.91)	4	0.384
6. Anticipate the impact of business decisions on the economy, the environment, personal well being, etc.	3.80 (1.02)	4	3.60 (1.12)	4	0.322

Notes: [†] N = 40; [‡] N = 82

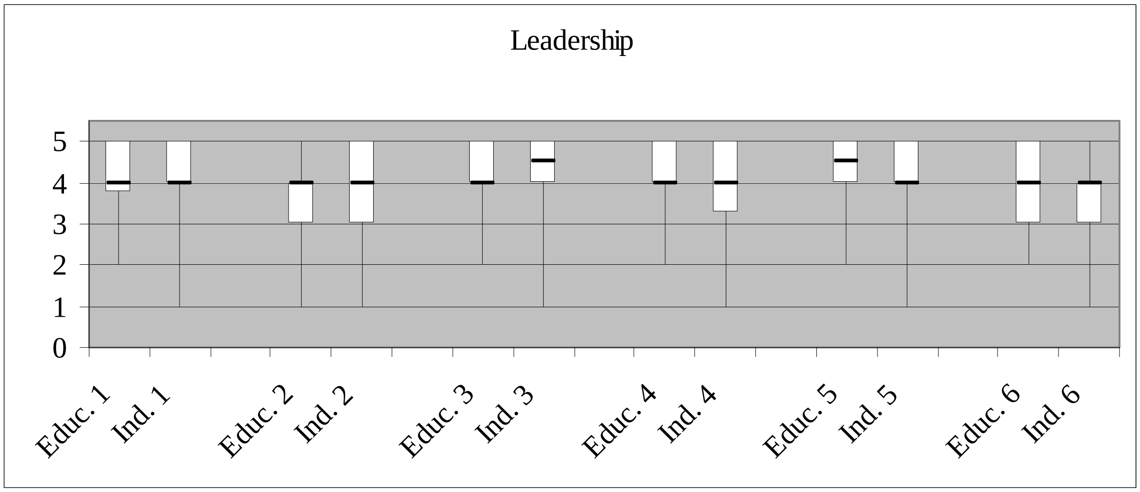

Figure 10. Box-plots for Leadership

4.11 Professionalism

The mean responses for the educators and industry representatives in the Professionalism section are shown in table 10. None of the mean value pairs for the competencies in this section are significantly different ($p<.01$, 2-tailed). Only 10 educator's mean values in the whole survey have a value of 4.50 or higher. Competency 1 (mean = 4.73) and competency 2 (mean = 4.55) have mean values higher than 4.50 and competency 1 has the highest mean educator value of the entire survey. The industry representative's competency with a mean value below 4.00 is competency 3 (mean = 3.84). It only occurs two times that industry representatives have mean values greater than 4.50 and they both occur in this section with competency 1 (mean = 4.78) and competency 2 (mean = 4.51). Industry Representative's mean response to competency 1 has the greatest value out of all the competencies in the entire survey. Competency 1 has a higher industry representative mean value (mean = 4.78) than educator mean value (mean = 4.73); which only occurs with four competencies in the whole survey.

The Professionalism box-plot graph of the responses of educators and industry representatives is shown in figure 11. The responses for competency 1 are skewed with 75% of the respondents from both groups answering a 5 since there is no box in either group. The individual responses were examined and two people answered a 1 on the Likert scale of 1 to 5.

Table 10. Importance of Professionalism

Professionalism Competencies	Educator Survey†		Industry Survey‡		T-test
Graduates will be able to:	Mean (SD)	Med	Mean (SD)	Med	Sig.
1. Be truthful, honest, trustworthy, responsible and considerate in all situations.	4.73 (0.75)	5	4.78 (0.59)	5	0.683
2. Complete work in a timely manner while maintaining high quality.	4.55 (0.75)	5	4.51 (0.71)	5	0.791
3. Keep a neat and orderly appearance and work environment.	4.08 (0.94)	4	3.84 (0.97)	4	0.208
4. Stay current in technical fields, involved in professional organizations, and be certified or licensed if appropriate.	4.43 (0.84)	5	4.27 (0.92)	4	0.352
5. Confront problems forcefully but courteously.	4.25 (0.84)	4	4.21 (0.89)	4	0.796

Notes: † N = 40; ‡ N = 82

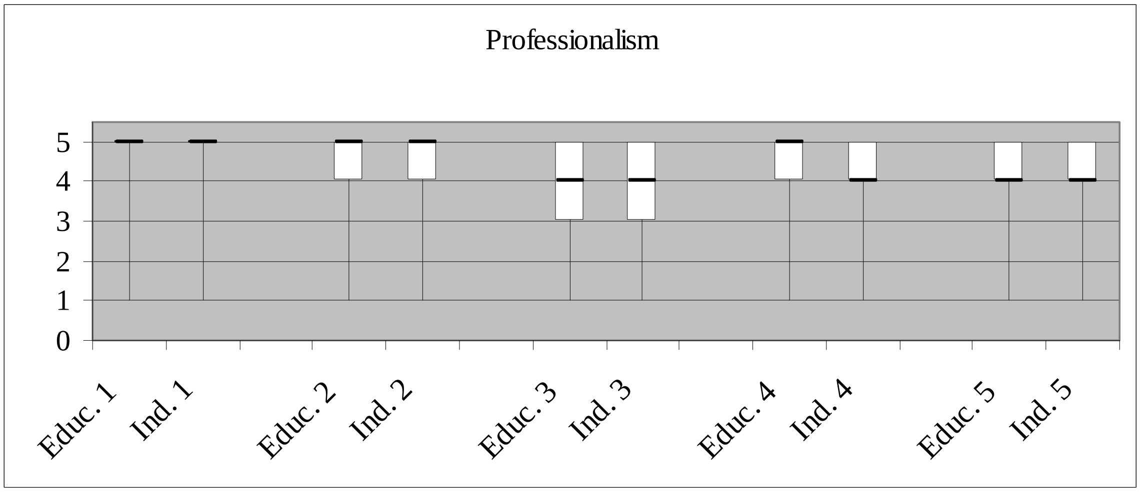

Figure 11. Box-plots for Professionalism

An educator feels that these competencies are important but they go beyond a level that can be taught in a baccalaureate MET program. Another would prefer that the term "neat" used in competency 3 be replaced with the term "safe" since this respondent feels that having a slightly disorganized area might not be harmful.

In the Professionalism comment section three industry representatives expressed the need for graduates to stay active in their industry by supporting professional organizations. An industry representative warned against being too honest while another respondent wrote, "honesty and integrity are a must".

4.12 Communication

The mean responses for the educators and industry representatives in the Communication section are shown in table 11. The results of each t-test reveal that only for competency 2 (significance level = 0.004) are the responses between educators and industry representatives significantly different ($p<.01$, 2-tailed). Four out of the ten educator competency mean values greater than 4.50 are for competency 1 (mean = 4.63), competency 2 (mean = 4.50), competency 3 (mean = 4.53), and competency 5 (mean = 4.60). All of the industry survey representative's mean values are between 4.00 and 4.50. This is the only section in the entire survey where none of the mean values are below 4.00. The Communication box-plot graph of the responses of educators and industry representatives is shown in figure 12. All the competencies have over 75% of the respondents answering at least a 4.

Table 11. Importance of Communication

Communication Competencies	Educator Survey[†]		Industry Survey[‡]		T-test
Graduates will be able to:	Mean (SD)	Med	Mean (SD)	Med	Sig.
1. Demonstrate good writing skills in memos, proposals, and specifications.	4.63 (0.59)	5	4.43 (0.77)	5	0.118
2. Effectively use charts, graphs, media, and other visual aids.	4.50 (0.68)	5	4.07 (0.89)	4	0.004*
3. Give an effective and persuasive oral presentation.	4.53 (0.68)	5	4.24 (0.90)	4	0.057
4. Know when and how much information to share with others.	4.48 (0.72)	5	4.16 (0.95)	4	0.043
5. Know when to seek for feedback and guidance.	4.60 (0.59)	5	4.38 (0.83)	5	0.092
6. Know and use modern means of communication.	4.33 (0.94)	5	4.06 (0.91)	4	0.146
7. Use appropriate business etiquette.	4.35 (0.83)	5	4.13 (0.90)	4	0.195

Notes: [†] N = 40; [‡] N = 82; *The values are significantly different at 0.01 (2-tailed)

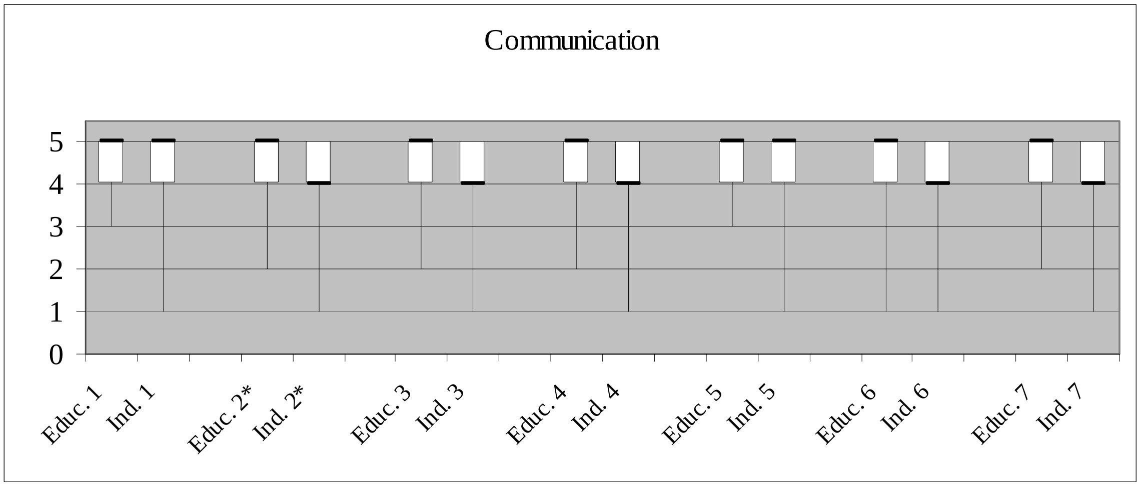

Figure 12. Box-plots for Communication

*The values are significantly different at the 0.01 level (2-tailed)

In the Communication comment section an educator said there are some areas that might be useful for recent graduates to know such as, "conflict management, diplomacy, time management, networking, interviewing, and a number of other areas". Three others responded that communication is extremely important and critical for success.

An industry representative feels, "one of the most important things a student learns is where to go for information they don't posses". Another mentioned that good listening is an important aspect of communication that was not included in the survey. An industry representative explained that engineers need to relay their good concepts while another representative mentioned the importance of writing skills.

4.13 Safety and Environmental Issues

The mean responses for the educators and industry representatives in the Safety and Environmental Issues section are shown in table 12. The results of each t-test reveal that the mean values for competency 4 (significance level = 0.009) are significantly different ($p<.01$, 2-tailed). The only mean value for the educator survey that is not between 4.00 and 4.50 is for competency 3 (mean = 3.98). The industry survey representative's mean values that are below 4.00 are for competency 1 (mean = 3.83), competency 3 (mean = 3.87), competency 4 (mean = 3.74), and competency 6 (mean = 3.87). The Safety and Environmental Issues box-plot graph of the responses of educators and industry representatives is shown in figure 13.

In the Safety and Environmental Issues comment section two educators responded that the workplace is the best place for these competencies to be taught since the teaching will be industry specific. Another educator was concerned that these competencies should be expected of those who have a few years experience instead of recent graduates. A comment from an educator was that competencies 4 and 5 will require additional training.

Two industry representatives reported that environmental regulations encompass too much information and the graduate should be able to apply principles without knowing specifics. Another industry representative explained that a graduate will need experience to be advanced enough to understand these principles. Three different respondents had opinions for who would be responsible for maintaining these competencies 1) the shop foreman, 2) the safety department, and 3) individuals specifically trained to deal with health or safety issues.

Table 12. Importance of Safety and Environmental Issues

Safety and Environmental Issues Competencies	Educator Survey†		Industry Survey‡		T-test
Graduates will be able to:	Mean (SD)	Med	Mean (SD)	Med	Sig.
1. Handle emergency situations involving hazardous materials or a fire.	4.00 (0.91)	4	3.83 (0.99)	4	0.345
2. Understand the importance of human health and safety in the workplace.	4.45 (0.75)	5	4.33 (0.83)	5	0.423
3. Understand the demands of federal and state environmental regulations relating to their operation.	3.98 (0.80)	4	3.87 (0.94)	4	0.506
4. Appreciate and minimize negative effects of manufacturing on the environment, even when this effort goes beyond the required standards.	4.15 (0.74)	4	3.74 (0.90)	4	0.009*
5. Identify safety hazards in a plant shop floor or a lab setting.	4.43 (0.68)	5	4.18 (0.94)	4	0.108
6. Apply ergonomic principles and industrial hygiene practices to their workplace.	4.10 (0.87)	4	3.87 (0.90)	4	0.172

Notes: † N = 40; ‡ N = 82; *The values are significantly different at 0.01 (2-tailed)

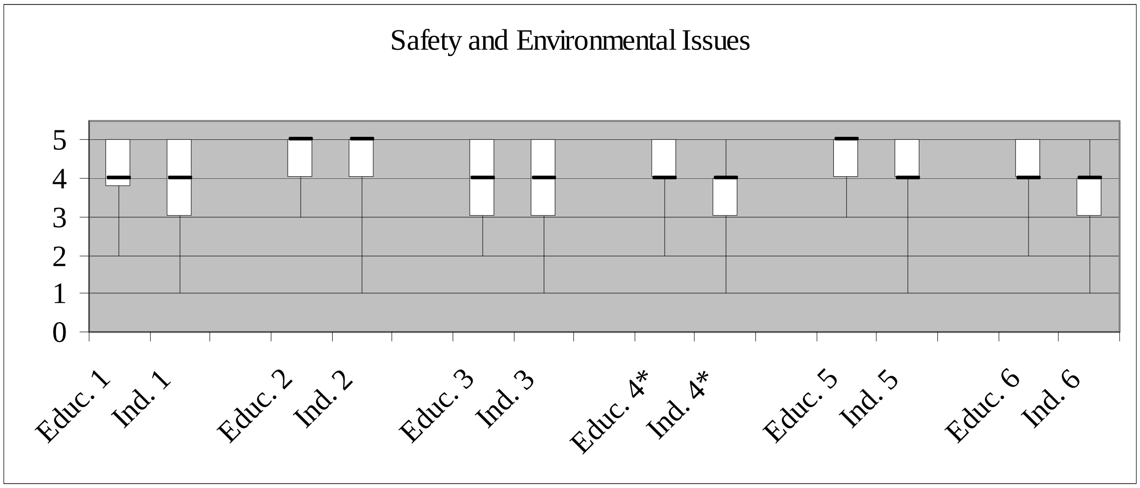

Figure 13. Box-plots for Safety and Environmental Issues

*The values are significantly different at the 0.01 level (2-tailed)

4.14 Global Awareness

The mean responses for the educators and industry representatives in the Global Awareness section are shown in table 13. None of the mean value pairs for the competencies in this section are significantly different ($p<.01$, 2-tailed). All of the means in this section are below 4.00. The lowest educator's mean values for this section are for competencies 2 and 3 with mean values of 3.70. Only three competencies in the whole survey have a mean value below 3.50 and these mean values all come from industry representatives; Competency 2 (mean = 3.49) has one of them. This is the only section where all the mean values are below 4.00. The global awareness box-plot graph of the responses of educators and industry representatives is shown in figure 14.

In the Global Awareness comment section two educators mentioned specific tasks that should be emphasized or included in this survey. This survey was developed at competency level without determining lower-level tasks. One educator explained that schools are insufficient at teaching international issues and these issues will require experience. Another responded with concern that these competencies were for graduates entering the workforce instead of those who had a few years experience.

Table 13. Importance of Global Awareness

Global Awareness Competencies	Educator Survey†		Industry Survey‡		T-test
Graduates will be able to:	Mean (SD)	Med	Mean (SD)	Med	Sig.
1. Comprehend the challenges of global supply chains.	3.95 (0.90)	4	3.70 (1.06)	4	0.172
2. Develop competencies in the operation of international manufacturing.	3.70 (0.85)	4	3.49 (1.01)	4	0.228
3. Acquire an understanding of diverse cultures, perceptions, expectations, and professional practices.	3.70 (0.97)	4	3.56 (1.06)	4	0.471
4. Understand advantages and disadvantages and contribute in decisions regarding global markets and off-shore manufacturing.	3.98 (0.89)	4	3.70 (1.05)	4	0.129
5. Understand the critical role manufacturing plays in the development and stability of a country and society.	3.98 (1.00)	4	3.63 (1.14)	4	0.095

Notes: † N = 40; ‡ N = 82

An industry representative reported that global awareness needs to be discussed but was concerned that these issues are too difficult to teach in a baccalaureate program. Another response was that the graduate's job will determine if global awareness is important. Two of the responses included information that MET employees should consider when doing global cost analysis.

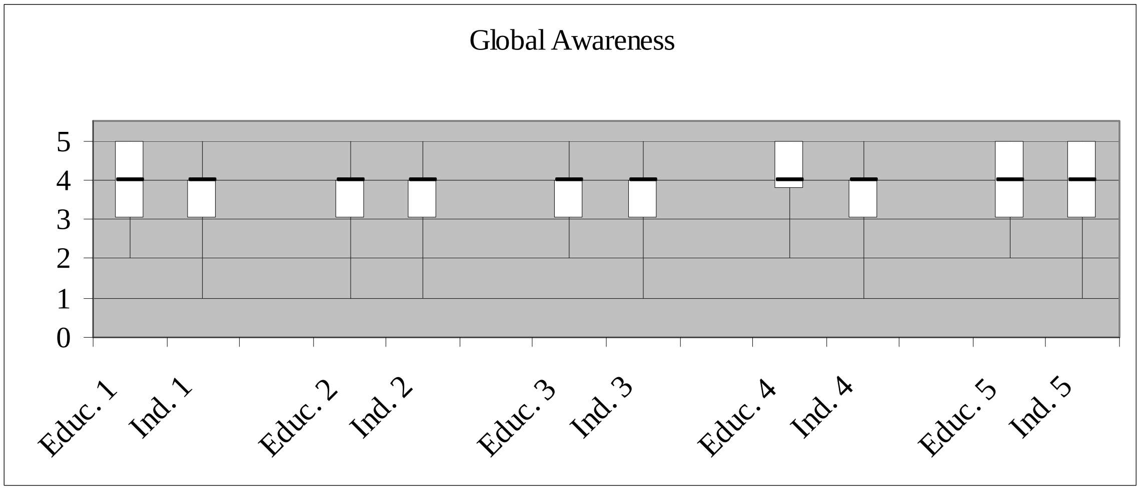

Figure 14. Box-plots for Global Awareness

4.15 Competencies Ranked by Combined Mean Responses

The industry representative responses and the educator responses were combined and then the means were calculated. The ranking of those means is found in table 14. The first two competencies have mean values above 4.50 and both of them are listed under the Professionalism section. Thirty-eight competencies have values between 4.00 and 4.50 while thirty competencies have values between 3.50 and 4.00. Only one competency has a value below 3.50 and it is contained in the manufacturing systems section.

The professionalism competencies are rated relatively high compared to the rest of the survey sections. Only one professionalism competency's mean score is below 4.00. Competencies related to communication are also ranked high since all of the competencies have values between 4.00 and 4.50. Competencies in the global awareness section are ranked low since all of the competencies have values between 3.50 and 4.00. The competencies in the manufacturing systems section are also ranked low since only one competency has a value above 4.00, four have values between 3.50 and 4.00, and the last competency's value is 3.39 and this is the lowest combined competency value.

Table 14. Competencies Ranked by Combined Mean Responses

Competency	Competency Category	Mean
Graduates will be able to:		
1. Be truthful, honest, trustworthy, responsible and considerate in all situations.	Professionalism	4.76
2. Complete work in a timely manner while maintaining high quality.	Professionalism	4.52
3. Demonstrate good writing skills in memos, proposals, and specifications.	Communication	4.49
4. Analyze a part print for manufacturability.	Manufacturing Processes	4.46
5. Know when to seek for feedback and guidance.	Communication	4.45
6. Select appropriate processes and equipment based on their capabilities and economics.	Manufacturing Processes	4.42
7. Implement the solution.	Creativity and Problem Solving	4.41
8. Understand and apply Design for Manufacturing and Assembly principles.	Design	4.39
9. Analyze the cause-and-effect relationships of the problem to find the root causes.	Creativity and Problem Solving	4.39

Table 14—*Continued*

Competency	Competency Category	Mean
Graduates will be able to:		
10. Understand the importance of human health and safety in the workplace.	Safety and Environmental Issues	4.37
11. Give an effective and persuasive oral presentation.	Communication	4.34
12. Stay current in technical fields, involved in professional organizations, and be certified or licensed if appropriate.	Professionalism	4.32
13. See new and creative ways to achieve an objective (think outside the box) within set constraints.	Creativity and Problem Solving	4.30
14. Document a processing sequence to economically meet product specifications.	Manufacturing Processes	4.29
15. Know when and how much information to share with others.	Communication	4.26
16. Identify safety hazards in a plant shop floor or a lab setting.	Safety and Environmental Issues	4.26
17. Assess the nature, types, and impact of variation.	Quality	4.24
18. Use problem solving and other analysis techniques to predict performance and to find optimum design solutions.	Design	4.24
19. Build relationships to gain support and commitment of others.	Leadership	4.22
20. Confront problems forcefully but courteously.	Professionalism	4.22
21. Effectively use charts, graphs, media, and other visual aids.	Communication	4.21
22. Use appropriate business etiquette.	Communication	4.20

Table 14—*Continued*

Competency	Competency Category	Mean
Graduates will be able to:		
23. Draw analogies and comparisons using both breadth and depth of knowledge to identify and evaluate alternative solutions to the problem.	Creativity and Problem Solving	4.17
24. Keep team members and other stakeholders informed of progress and problems.	Management	4.16
25. Plan and conduct a productive meeting.	Leadership	4.15
26. Know and use modern means of communication.	Communication	4.15
27. Implement lean manufacturing principles in a manufacturing system.	Manufacturing Systems	4.11
28. Develop specifications that accurately reflect these requirements and constraints.	Design	4.11
29. Assess the effects of manufacturing processes on material properties.	Materials	4.11
30. Monitor and assess progress and performance and take appropriate corrective action when necessary.	Management	4.09
31. Prepare process operation instructions.	Manufacturing Processes	4.08
32. Effectively sell a plan or idea to others.	Leadership	4.08
33. Select appropriate materials for tooling and for products.	Materials	4.07
34. Clearly identify the requirements and constraints to be met by a design considering all stakeholders.	Design	4.05
35. Determine resource requirements (personnel, equipment, time, budget, etc.) for executing a plan.	Management	4.05

Table 14—*Continued*

Competency	Competency Category	Mean
Graduates will be able to:		
36. Lead a team in the performance of an activity or project.	Leadership	4.05
37. Apply appropriate test and inspection procedures for evaluating product and process quality.	Quality	4.02
38. Best utilize the machinability, formability, and weldability of various materials.	Materials	4.02
39. Utilize appropriate manufacturing software including, CAD/CAM, CNC, etc.	Manufacturing Processes	4.01
40. Effectively deploy resources in carrying out a plan.	Management	4.01
41. Achieve high quality in manufacturing systems through proven management methodologies.	Quality	4.00
42. Conduct capability studies and design, conduct and evaluate experiments.	Quality	3.98
43. Set up a quality control system including Statistical Process Control.	Quality	3.98
44. Effectively utilize the tools of creativity.	Creativity and Problem Solving	3.98
45. Use modeling, statistical and other analysis techniques for problem solving.	Creativity and Problem Solving	3.98
46. Justify capital equipment expenditures and be responsible for make-or-buy decisions.	Management	3.97
47. Make effective use of CAD and related design tools.	Design	3.96
48. Use the basic instruments of metrology and determine the capability of measurement systems.	Quality	3.95

Table 14—*Continued*

Competency	Competency Category	Mean
Graduates will be able to:		
49. Apply ergonomic principles and industrial hygiene practices to their workplace.	Safety and Environmental Issues	3.94
50. Effectively integrate processing, material handling and flow of information.	Manufacturing Systems	3.93
51. Transform a solution concept into a final detailed design.	Design	3.93
52. Keep a neat and orderly appearance and work environment.	Professionalism	3.92
53. Understand the demands of federal and state environmental regulations relating to their operation.	Safety and Environmental Issues	3.90
54. Handle emergency situations involving hazardous materials or a fire.	Safety and Environmental Issues	3.89
55. Appreciate and minimize negative effects of manufacturing on the environment, even when this effort goes beyond the required standards.	Safety and Environmental Issues	3.88
56. Understand system dynamics and predict the performance of given manufacturing system configurations.	Manufacturing Systems	3.82
57. Use software and other tools to develop and execute a project or process plan.	Management	3.82
58. Specify treatments affecting the property and structure relationships of materials	Materials	3.80
59. Work effectively with material supply chain issues such as cost, availability, and delivery.	Materials	3.79

Table 14—*Continued*

Competency	Competency Category	Mean
Graduates will be able to:		
60. Understand advantages and disadvantages and contribute in decisions regarding global markets and off-shore manufacturing.	Global Awareness	3.79
61. Develop a strategic plan.	Leadership	3.78
62. Comprehend the challenges of global supply chains.	Global Awareness	3.78
63. Set up an appropriate production control system with a feedback loop.	Manufacturing Systems	3.75
64. Understand the critical role manufacturing plays in the development and stability of a country and society.	Global Awareness	3.75
65. Select appropriate tooling and machine settings (feeds, speeds, temperatures, pressures, etc.)	Manufacturing Processes	3.73
66. Analyze and select appropriate clamping and locating surfaces.	Manufacturing Processes	3.73
67. Comply with national and international regulatory standards and certifications.	Quality	3.71
68. Anticipate the impact of business decisions on the economy, the environment, personal well being, etc.	Leadership	3.66
69. Analyze and specify requirements for automated controls.	Manufacturing Systems	3.63
70. Acquire an understanding of diverse cultures, perceptions, expectations, and professional practices.	Global Awareness	3.61
71. Assess performances of employees and facilitate their progress.	Management	3.56

Table 14—*Continued*

Competency	Competency Category	Mean
Graduates will be able to:		
72. Develop competencies in the operation of international manufacturing.	Global Awareness	3.56
73. Manage a supply chain including international constituents.	Manufacturing Systems	3.39

4.16 Sections Ranked by Overall Mean Responses

The overall mean value of the attributes and competencies was calculated for each section and then ranked from highest to lowest: Professionalism (4.40), Communication (4.35), Creativity and Problem Solving (4.25), Manufacturing Processes (4.17), Design (4.12), Safety and Environmental Issues (4.07), Quality (4.04), Materials (4.00), Leadership (3.98), Management (3.97), Manufacturing Systems (3.80), and Global Awareness (3.73).

4.17 Status of Educational Programs

The last educator survey page contained questions regarding the status of their educational program. The responses will not be an equal representation of all the universities or colleges asked to participate in the survey since thirty-three schools were asked to participate in the survey and forty individuals participated in the survey. Some schools might have had greater participation and this information needs to be taken into account when analyzing the given information.

Thirty educators described their programs as Manufacturing Engineering Technology, two described their program as Manufacturing Engineering, while three described it as Mechanical Engineering Technology. Five individual programs were described as the following: all of the above, Engineering Management Technology, Mechanical and Manufacturing, Mechanical Engineering, and Mechanical and Manufacturing Engineering Technology. Most programs were accredited by TAC-ABET (response = 35). The responses given for programs accredited by another body were: Expecting ABET reaccreditation in Summer 05, TAC of ABET, NEASC (also ABET accredited), and Higher Learning Commission (also ABET accredited).

The current undergraduate enrollment in the individual programs is: 2000, 585, 500, 300, six programs have an enrollment of 200, 160, four programs have an enrollment of 150, 140, 130, 125, 120, and 105. One program has an enrollment between 100 and 125, 90, one program has an enrollment between 80 and 100, one program has an enrollment between 70 and 80, and two programs have an enrollment of 70. Three programs have an enrollment of 65, two programs have an enrollment of 60, 57, four programs have an enrollment of 50, 45, 30, and 20. Fifteen programs have a current upward trend, six programs have a current downward trend, and eighteen programs are level. The percent placement of new graduates in manufacturing-related jobs within three months after graduation are: “high” was the response from four educators, nineteen educators gave numbers between 95% and 100%, seven gave the response of 90%, and eight educators gave the response below 90%.

4.18 Conclusion

A MANOVA ($p<.05$, 2-tailed) of the attribute questions revealed significant differences between the educator's responses and the industry representative's responses and so t-tests ($p<.05$, 2-tailed) were done for further analysis. The MANOVA ($p<.05$, 2-tailed) for the competency questions did not reveal significant differences so more sensitive t-tests ($p<.01$, 2-tailed) were done for each competency section. The high response rate, over 20% for an internet survey, indicates that the participants are concerned with improving MET educational programs.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

This study was done to determine the ranked importance of a set of attributes and competencies proposed for graduates of an MET baccalaureate program. This study also investigates whether educators and industry representatives agree in their ratings of these attributes and competencies. The attributes and competencies for this study came from a document completed by BYU professors in October 2004 called, "Competencies of Manufacturing Engineering Technology (MET) Graduates". The document contains a list of twelve attributes along with seventy-three competencies that are expected to be important for graduates of an MET baccalaureate program.

The following three hypotheses were proposed for this study:

1. Educators will not significantly differ from industry representatives in their importance ratings of the following attributes: manufacturing processes, quality, manufacturing systems, design, materials, management, creativity and problem solving, leadership, professionalism, safety and environmental issues, and global awareness.
2. Educators will not significantly differ from industry representatives in their importance ratings of the competencies listed under the above attributes.

3. The competencies proposed by the MET faculty from Brigham Young University (BYU) are relevant for MET graduates.

An educator survey was created and sent to a list of 140 educators. Forty educators responded to the survey yielding a response rate of 28.57%. One purpose of this survey was to receive feedback regarding additional competencies or survey changes that would better reflect the opinions of educators teaching at ABET-accredited MET programs.

This study was designed to assess the expectations of MET graduates on a general level. The relatively few competencies suggested by educators were on a task level and more specific than the competencies evaluated in this study. Therefore, no changes were made to the wording of the attribute or competency statements for the survey subsequently sent to industry representatives. Out of 384 industry representatives, eighty-two completed the survey yielding a response rate of 21.35%.

The attribute statements with a combined educator and industry representative mean response can be summarized as follows:

- Five were rated with a mean response of 4.50 or above
- Six were rated with a mean response between 4.00 and 4.49
- One was rated with a mean response between 3.50 and 3.99
- None were rated with a mean response below 3.50

There are seventy-three competency statements and the mean competency responses of the educators can be summarized as follows:

- Ten were rated with a mean response of 4.50 or above
- Forty-eight were rated with a mean response between 4.00 and 4.49

- Fifteen were rated with a mean response between 3.50 and 3.99
- None were rated with a mean response below 3.50

The mean competency responses of the industry representatives can be summarized as follows:

- Two were rated with a mean response 4.50 or above
- Thirty-one were rated with a mean response between 4.00 and 4.49
- Thirty-seven were rated with a mean response between 3.50 and 3.99
- Three were rated with a mean response below 3.50

The competency statements with a combined educator and industry representative mean responses can be summarized as follows:

- Two were rated with a mean response of 4.50 or above
- Thirty-nine were rated with a mean response between 4.00 and 4.49
- Thirty-one were rated with a mean response between 3.50 and 3.99
- One was rated with a mean response below 3.50

5.2 Primary Conclusions and Discussion

A multivariate analysis of variance, MANOVA ($p<.05$, 2-tailed) verified that educator’s responses significantly differed from industry representative’s responses for the attributes. T-tests revealed that half of the attributes were significantly different between educators and industry representatives.

Table 15. Ranked Attribute Sections by Educators and Industry Representatives

Educators	Industry Representatives
• Manufacturing Processes	• Professionalism
• Quality/Communication	• Communication
• Creativity and Problem Solving	• Manufacturing Processes
• Professionalism	• Creativity and Problem Solving
• Safety and Environmental Issues	• Quality
• Materials	• Safety and Environmental Issues
• Design	• Materials
• Management	• Design
• Manufacturing Systems	• Management
• Global Awareness	• Leadership
• Leadership	• Manufacturing Systems
	• Global Awareness

Table 15 has the attributes listed in order of rated importance by the educators and also by the industry representatives. Educators in a typical MET program teach what they know and what is important to them and this might be why Manufacturing Processes is ranked the highest for educators. The five top ranked attributes are the same for educators and industry representatives only in a different order. Safety and Environmental Issues through Management are ranked in the same order by educators and industry representatives. The three lowest ranked attributes are the same for both groups but arranged in a different order.

Educator's ratings do not significantly differ from industry representative's ratings for the competencies based on a MANOVA ($p<.05$, 2-tailed) analysis. Even follow-up t-tests revealed that only fourteen of the seventy-three ratings for the competencies were significantly different ($p<.01$, 2-tailed) between educators and industry representatives.

All the attribute and competency responses in each section were averaged and the sections are ranked as follows:

- Professionalism (4.40)
- Communication (4.35)
- Creativity and Problem Solving (4.25)
- Manufacturing Processes (4.17)
- Design (4.12)
- Safety and Environmental Issues (4.07)
- Quality (4.04)
- Materials (4.00)
- Leadership (3.98)
- Management (3.97)
- Manufacturing Systems (3.80)
- Global Awareness (3.73)

The results of this survey suggest that the competencies proposed by faculty members from Brigham Young University (BYU) are relevant for MET graduates. All of the competency questions are also within three standard deviations from the overall mean. The competencies were rated by each respondent on a scale of 1 to 5, with 1 having low importance and 5 having high importance. A response of 3 would be of medium importance and the lowest mean response was 3.39 and so it is concluded that the competencies are relevant for MET graduates preparing for employment.

5.3 Secondary Conclusions and Discussion

Only four respondents living outside the United States replied to the survey and all four were from Canada; therefore, this survey did not have an international representation. It is not known whether any of the respondents worked for companies with global divisions or networks.

A comment mentioned by the respondents of each survey is that some of the competencies would be learned on the job and are not expected of recent graduates. At least one educator noted in each corresponding section that Professionalism, Safety and Environmental Issues, Management, Creativity and Problem Solving, Global Awareness, and Leadership competencies cannot be expected of graduates. These competencies are not taught in a typical MET program and so educators only expect to teach what is traditionally taught. At least one industry representative stated that graduates need to know the basics but not the specifics of the following: Quality, Design, Materials and Manufacturing Systems. The sections containing these competencies and attributes are the sections that are taught in a typical MET program and so industry representatives realize that graduates will need to learn on the job the specific required skills.

An MET baccalaureate program should provide opportunities for students to become competent in the areas of importance. The higher ranked competencies should have more emphasis placed upon them since these are the competencies that industry will be looking for in recent graduates they hire from MET programs.

Current articles stress the importance of global awareness but the responses to this competency section indicated that it was of less importance. On the other hand, this response could be a result of there not being an international sample of respondents. An educator's response to the Global Awareness section was that it is difficult to teach and this might be why educators rated it so low. Global Awareness is not currently expected of recent graduates but might become more important in coming years as industry realizes the relevance for their company and educators learn how to teach these competencies. Minimal importance should be currently placed on Global Awareness and the trend should be examined in coming years to determine if this topic has gained in importance to reflect current literature.

Another competency emphasized in current literature is lean manufacturing. The survey question relevant to graduates being able to implement lean manufacturing principles in a manufacturing system is contained under the Manufacturing Systems' section. The mean responses to this competency received an approximate average response rate and the overall section was the second lowest after the Global Awareness section. This average rating could reflect that some recent graduates of MET programs need to know the fundamentals of lean manufacturing but the details would be learned on the job. Some of the basic principles of lean manufacturing are the reduction of waste and production time which causes a reduction in the cost to manufacture the products. All companies are concerned with reducing costs which might be why lean manufacturing is emphasized so much in literature.

Communication is of great importance and is stressed in current literature. Even the early studies on MET baccalaureate programs found that communication was of high importance and should be greatly stressed. This conclusion continues to be true. MET educational programs should provide many opportunities for students to improve their communication skills.

Professionalism is the highest ranked section and it contains the highest ranked competency. This competency is that graduates need to be honest, truthful, responsible, trustworthy, and considerate in all situations. This competency cannot be taught and its importance should be explained to students so they are aware of what companies expect of them as their employees.

MET programs are in demand since the majority of educators replied that their program has over 100 enrolled students and over half of the educators responded that the placement of new graduates in a manufacturing-related job within three months after graduation is at 95% or higher.

5.4 Recommendations for Further Research

The recommendations for further research from the findings and conclusions of this study include the following:

1. Use the competencies in this study to review and make improvements to a particular MET educational program of study. Each MET program is different and the program developers can implement the information in this study that would best fit the program.
2. Use the competencies in this study to design a new MET baccalaureate program. No new MET educational programs have been started in the past few years. Most of the current programs have a level trend of enrollment but about a third of the respondents reported an upward trend in their program's enrollment.
3. A replication of this survey could be administered exclusively to an international group of participants. The international responses could be compared to the results of this survey.

4. For further analysis, use the information in this survey to determine specific skills within a particular attribute section for an MET program. This would only be necessary for a program whose graduates do not have the desired competency skills.
5. Revise the survey and distribute it every five years to determine the current needs of industry; thereby allowing MET programs to stay as up-to-date as possible.

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Appendix A

LIST OF ABET ACCREDITED SCHOOLS

Table A. ABET Accredited Schools

School Name	City	State
Arizona State University East	Mesa	AZ
Ball State University	Muncie	IN
Bradley University	Peoria	IL
Brigham Young University	Provo	UT
California State University – Long Beach	Long Beach	CA
Central Connecticut State University	New Britain	CT
Dayton, University of	Dayton	Ohio
East Tennessee State University	Johnson City	TN
Indiana University Purdue University, Indianapolis	Indianapolis	IN
Lake Superior State University	Sault Ste. Marie	MI
Memphis, University of	Memphis	TN
Middle Tennessee State University	Murfreesboro	TN
Midwestern State University	Wichita Falls	TX
Milwaukee School of Engineering	Milwaukee	WI
Minnesota State University – Mankato	Mankato	MN

Table A—*Continued*

School Name	City	State
Murray State University	Murray	KY
Nebraska-Omaha, University of	Omaha	NE
New Jersey Institute of Technology	Newark	NJ
North Texas, University of	Denton	TX
Northern Kentucky University	Highland Hts.	KY
Oregon Institute of Technology	Klamath Falls	Oregon
Pittsburg State University	Pittsburg	KS
Purdue University – Calumet	Hamond	IN
Purdue University – West Lafayette	West Lafayette	IN
Rochester Institute of Technology	Rochester	NY
Southwestern Oklahoma State University	Weatherford	OK
State University of New York at Farmingdale	Farmingdale	NY
Texas A&M University – College Station	College Station	TX
Weber State University	Ogden	UT
Wentworth Institute of Technology	Boston	MA
Western Carolina Technology	Cullowhee	NC
Western Michigan University – Kalamazoo	Kalamazoo	MI
Western Washington University	Bellingham	WA

Appendix B

SURVEY FOR MET EDUCATORS

Manufacturing Engineering Technology Educator Survey – 2005

1. Survey Instructions and Information

This survey is divided into twelve sections, one for each of twelve student attributes. You will be asked to rank each attribute and its corresponding competencies on a scale of 1 to 5, with 1 having low importance and 5 having high importance. Your evaluation of importance should be relative to your perception of what a modern Manufacturing Engineering Technology (MET) graduate should be able to do in their first few years of professional manufacturing employment.

You will notice that most of these competencies are expressed at a fairly high level. This is to reduce the number of competencies to a manageable size. Please leave your name and e-mail address on the last page if you would like to receive my analysis and summary of the survey results.

Thank you for your help. My intent is that this research be beneficial to all MET programs in the United States.

2. Manufacturing Processes

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Processes: An understanding of manufacturing processes and their applications.

1	2	3	4	5

*Competencies.
Graduates will be able to:

Select appropriate processes and equipment based on their capabilities and economics.	1	2	3	4	5
Analyze a part print for manufacturability.	1	2	3	4	5
Document a processing sequence to economically meet product specifications.	1	2	3	4	5
Select appropriate tooling and machine settings (feeds, speeds, temperatures, pressures, etc.)	1	2	3	4	5
Analyze and select appropriate clamping and locating surfaces.	1	2	3	4	5
Utilize appropriate manufacturing software including, CAD/CAM, CNC, etc.	1	2	3	4	5
Prepare process operation instructions.	1	2	3	4	5

Please add any competencies or comments below.

3. Quality

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Quality: A commitment to quality and an ability to effectively measure and improve product and process quality.

	1	2	3	4	5
Assess the nature, types, and impact of variation.	1	2	3	4	5
Use the basic instruments of metrology and determine the capability of measurement systems.	1	2	3	4	5
Achieve high quality in manufacturing systems through proven management methodologies.	1	2	3	4	5
Apply appropriate test and inspection procedures for evaluating product and process quality.	1	2	3	4	5
Conduct capability studies and design, conduct and evaluate experiments.	1	2	3	4	5
Set up a quality control system including Statistical Process Control.	1	2	3	4	5
Comply with national and international regulatory standards and certifications.	1	2	3	4	5

Please add any competencies or comments below.

4. Manufacturing Systems

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Systems: An understanding of the dynamics of manufacturing systems and supply chains and how to effectively configure systems for efficient manufacture and delivery.

1	2	3	4	5

*Competencies.
Graduates will be able to:

*Competencies.
Graduates will be able to:

Understand system dynamics and predict the performance of given manufacturing system configurations.	1	2	3	4	5
Effectively integrate processing, material handling and flow of information.	1	2	3	4	5
Implement lean manufacturing principles in a manufacturing system.	1	2	3	4	5
Analyze and specify requirements for automated controls.	1	2	3	4	5
Set up an appropriate production control system with a feedback loop.	1	2	3	4	5
Manage a supply chain including international constituents.	1	2	3	4	5

Please add any competencies or comments below.

5. Design

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Design: The ability to effectively design tooling and facilities and to participate on product-design teams to meet a set of requirements and constraints.

1	2	3	4	5

*Competencies.
Graduates will be able to:

Clearly identify the requirements and constraints to be met by a design considering all stakeholders.	1	2	3	4	5
Develop specifications that accurately reflect these requirements and constraints.	1	2	3	4	5
Understand and apply Design for Manufacturing and Assembly principles.	1	2	3	4	5
Use problem solving and other analysis techniques to predict performance and to find optimum design solutions.	1	2	3	4	5
Transform a solution concept into a final detailed design.	1	2	3	4	5
Make effective use of CAD and related design tools.	1	2	3	4	5

Please add any competencies or comments below.

6. Materials

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Materials: An understanding of the physical and mechanical properties of engineering materials.

1	2	3	4	5

*Competencies.
Graduates will be able to:

Select appropriate materials for tooling and for products.	1	2	3	4	5
Assess the effects of manufacturing processes on material properties.	1	2	3	4	5
Best utilize the machinability, formability, and weldability of various materials.	1	2	3	4	5
Specify treatments affecting the property and structure relationships of materials.	1	2	3	4	5
Work effectively with material supply chain issues such as cost, availability, and delivery.	1	2	3	4	5

Please add any competencies or comments below.

7. Management

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Management: The ability to plan, organize, staff and control projects and processes.

1 2 3 4 5

*Competencies.
Graduates will be able to:

Use software and other tools to develop and execute a project or process plan.	1	2	3	4	5
Determine resource requirements (personnel, equipment, time, budget, etc.) for executing a plan.	1	2	3	4	5
Justify capital equipment expenditures and be responsible for make-or-buy decisions.	1	2	3	4	5
Effectively deploy resources in carrying out a plan.	1	2	3	4	5
Monitor and assess progress and performance and take appropriate corrective action when necessary.	1	2	3	4	5

Keep team members and other stakeholders informed of progress and problems.	1	2	3	4	5
Assess performances of employees and facilitate their progress.	1	2	3	4	5

Please add any competencies or comments below.

8. Creativity and Problem Solving

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Creativity and Problem Solving: The ability to see problems from multiple and new perspectives and generate innovative solutions.

1 2 3 4 5

*Competencies.
Graduates will be able to:

See new and creative ways to achieve an objective (think outside the box) within set constraints.	1	2	3	4	5
Effectively utilize the tools of creativity.	1	2	3	4	5
Draw analogies and comparisons using both breadth and depth of knowledge to identify and evaluate alternative solutions to the problem.	1	2	3	4	5

Use modeling, statistical and other analysis techniques for problem solving.	1	2	3	4	5
Analyze the cause-and-effect relationships of the problem to find the root causes.	1	2	3	4	5
Implement the solution.	1	2	3	4	5

Please add any competencies or comments below.

9. Leadership

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Leadership: The ability to develop a vision and lead a team or organization to new heights.

1	2	3	4	5

*Competencies.
Graduates will be able to:

Lead a team in the performance of an activity or project.	1	2	3	4	5
Develop a strategic plan.	1	2	3	4	5
Build relationships to gain support and commitment of others.	1	2	3	4	5

Effectively sell a plan or idea to others.	1	2	3	4	5
Plan and conduct a productive meeting.	1	2	3	4	5
Anticipate the impact of business decisions on the economy, the environment, personal well being, etc.	1	2	3	4	5

Please add any competencies or comments below.

10. Professionalism

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Professionalism: High ethical values, good work habits and on-going development of relevant knowledge and skills.

1 2 3 4 5

*Competencies.
Graduates will be able to:

Be truthful, honest, trustworthy, responsible and considerate in all solutions.	1	2	3	4	5
Complete work in a timely manner while maintaining high quality.	1	2	3	4	5

Keep a neat and orderly appearance and work environment.	1	2	3	4	5
Stay current in technical fields, involved in professional organizations, and be certified or licensed if appropriate.	1	2	3	4	5
Confront problems forcefully but courteously.	1	2	3	4	5

Please add any competencies or comments below.

11. Communication

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Communication: The ability to effectively communicate.

1 2 3 4 5

*Competencies.
Graduates will be able to:

Demonstrate good writing skills in memos, proposals, and specifications.	1	2	3	4	5
Effectively use charts, graphs, media, and other visual aids.	1	2	3	4	5

Give an effective and persuasive oral presentation.	1	2	3	4	5
Know when and how much information to share with others.	1	2	3	4	5
Know when to seek for feedback and guidance.	1	2	3	4	5
Know and use modern means of communication.	1	2	3	4	5
Use appropriate business etiquette.	1	2	3	4	5

Please add any competencies or comments below.

12. Safety and Environmental Issues

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Safety and Environmental Issues: Commitment to and competency in safety and environmental issues related to manufacturing.

1	2	3	4	5

*Competencies.
Graduates will be able to:

Handle emergency situations involving hazardous materials or a fire.	1	2	3	4	5

Understand the importance of human health and safety in the workplace.	1	2	3	4	5
Understand the demands of federal and state environmental regulations relating to their operation.	1	2	3	4	5
Appreciate and minimize negative effects of manufacturing on the environment, even when this effort goes beyond the required standards.	1	2	3	4	5
Identify safety hazards in a plan shop floor or a lab setting.	1	2	3	4	5
Apply ergonomic principles and industrial hygiene practices to their workplace.	1	2	3	4	5

Please add any competencies or comments below.

13. Global Awareness

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Global Awareness: Competence with respect to the issues, challenges and opportunities in today's global manufacturing environment.

1 2 3 4 5

*Competencies.
Graduates will be able to:

Comprehend the challenges of global supply chains.	1	2	3	4	5
Develop competencies in the operation of international manufacturing.	1	2	3	4	5
Acquire an understanding of diverse cultures, perceptions, expectations, and professional practices.	1	2	3	4	5
Understand advantages and disadvantages and contribute in decisions regarding global markets and off-shore manufacturing.	1	2	3	4	5
Understand the critical role manufacturing plays in the development and stability of a country and society.	1	2	3	4	5

Please add any competencies or comments below.

Appendix C (Industry Survey)

SURVEY FOR INDUSTRY REPRESENTATIVES

Manufacturing Engineering Technology Educator Survey – 2005

1. Survey Instructions and Information

This survey is divided into twelve sections, one for each of twelve student attributes. You will be asked to rank each attribute and its corresponding competencies on a scale of 1 to 5, with 1 having low importance and 5 having high importance. Your evaluation of importance should be relative to your perception of what a modern Manufacturing Engineering Technology (MET) graduate should be able to do in their first few years of professional manufacturing employment.

You will notice that most of these competencies are expressed at a fairly high level. This is to reduce the number of competencies to a manageable size. Please leave your name and e-mail address on the last page if you would like to receive my analysis and summary of the survey results.

Thank you for your help. My intent is that this research be beneficial to all MET programs in the United States.

2. Manufacturing Processes

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Processes: An understanding of manufacturing processes and their applications.

1 2 3 4 5

*Competencies.
Graduates will be able to:

Select appropriate processes and equipment based on their capabilities and economics.	1	2	3	4	5
Analyze a part print for manufacturability.	1	2	3	4	5
Document a processing sequence to economically meet product specifications.	1	2	3	4	5
Select appropriate tooling and machine settings (feeds, speeds, temperatures, pressures, etc.)	1	2	3	4	5
Analyze and select appropriate clamping and locating surfaces.	1	2	3	4	5
Utilize appropriate manufacturing software including, CAD/CAM, CNC, etc.	1	2	3	4	5
Prepare process operation instructions.	1	2	3	4	5

Please add comments below.

3. Quality

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Quality: A commitment to quality and an ability to effectively measure and improve product and process quality.

1	2	3	4	5

*Competencies.
Graduates will be able to:

*Competencies. Graduates will be able to:	1	2	3	4	5
Assess the nature, types, and impact of variation.					
Use the basic instruments of metrology and determine the capability of measurement systems.	1	2	3	4	5
Achieve high quality in manufacturing systems through proven management methodologies.	1	2	3	4	5
Apply appropriate test and inspection procedures for evaluating product and process quality.	1	2	3	4	5
Conduct capability studies and design, conduct and evaluate experiments.	1	2	3	4	5
Set up a quality control system including Statistical Process Control.	1	2	3	4	5
Comply with national and international regulatory standards and certifications.	1	2	3	4	5

Please add comments below.

4. Manufacturing Systems

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Systems: An understanding of the dynamics of manufacturing systems and supply chains and how to effectively configure systems for efficient manufacture and delivery.

1 2 3 4 5

*Competencies.
Graduates will be able to:

Understand system dynamics and predict the performance of given manufacturing system configurations.	1	2	3	4	5
Effectively integrate processing, material handling and flow of information.	1	2	3	4	5
Implement lean manufacturing principles in a manufacturing system.	1	2	3	4	5
Analyze and specify requirements for automated controls.	1	2	3	4	5
Set up an appropriate production control system with a feedback loop.	1	2	3	4	5
Manage a supply chain including international constituents.	1	2	3	4	5

Please add comments below.

5. Design

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Design: The ability to effectively design tooling and facilities and to participate on product-design teams to meet a set of requirements and constraints.

1 2 3 4 5

*Competencies.
Graduates will be able to:

Clearly identify the requirements and constraints to be met by a design considering all stakeholders.	1	2	3	4	5
Develop specifications that accurately reflect these requirements and constraints.	1	2	3	4	5
Understand and apply Design for Manufacturing and Assembly principles.	1	2	3	4	5
Use problem solving and other analysis techniques to predict performance and to find optimum design solutions.	1	2	3	4	5
Transform a solution concept into a final detailed design.	1	2	3	4	5

Make effective use of CAD and related design tools.	1	2	3	4	5

Please add comments below.

6. Materials

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Materials: An understanding of the physical and mechanical properties of engineering materials.

1	2	3	4	5

*Competencies.
Graduates will be able to:

Select appropriate materials for tooling and for products.	1	2	3	4	5
Assess the effects of manufacturing processes on material properties.	1	2	3	4	5
Best utilize the machinability, formability, and weldability of various materials.	1	2	3	4	5
Specify treatments affecting the property and structure relationships of materials.	1	2	3	4	5

Work effectively with material supply chain issues such as cost, availability, and delivery.	1	2	3	4	5

Please add comments below.

7. Management

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Management: The ability to plan, organize, staff and control projects and processes.

1	2	3	4	5

*Competencies.
Graduates will be able to:

Use software and other tools to develop and execute a project or process plan.	1	2	3	4	5
Determine resource requirements (personnel, equipment, time, budget, etc.) for executing a plan.	1	2	3	4	5
Justify capital equipment expenditures and be responsible for make-or-buy decisions.	1	2	3	4	5
Effectively deploy resources in carrying out a plan.	1	2	3	4	5

Monitor and assess progress and performance and take appropriate corrective action when necessary.	1	2	3	4	5
Keep team members and other stakeholders informed of progress and problems.	1	2	3	4	5
Assess performances of employees and facilitate their progress.	1	2	3	4	5

Please add comments below.

8. Creativity and Problem Solving

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Creativity and Problem Solving: The ability to see problems from multiple and new perspectives and generate innovative solutions.

1 2 3 4 5

*Competencies.
Graduates will be able to:

See new and creative ways to achieve an objective (think outside the box) within set constraints.	1	2	3	4	5
Effectively utilize the tools of creativity.	1	2	3	4	5

Draw analogies and comparisons using both breadth and depth of knowledge to identify and evaluate alternative solutions to the problem.	1	2	3	4	5
Use modeling, statistical and other analysis techniques for problem solving.	1	2	3	4	5
Analyze the cause-and-effect relationships of the problem to find the root causes.	1	2	3	4	5
Implement the solution.	1	2	3	4	5

Please add comments below.

9. Leadership

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Leadership: The ability to develop a vision and lead a team or organization to new heights.

1	2	3	4	5

*Competencies.
Graduates will be able to:

Lead a team in the performance of an activity or project.	1	2	3	4	5

Develop a strategic plan.	1	2	3	4	5
Build relationships to gain support and commitment of others.	1	2	3	4	5
Effectively sell a plan or idea to others.	1	2	3	4	5
Plan and conduct a productive meeting.	1	2	3	4	5
Anticipate the impact of business decisions on the economy, the environment, personal well being, etc.	1	2	3	4	5

Please add comments below.

10. Professionalism

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Professionalism: High ethical values, good work habits and on-going development of relevant knowledge and skills.

1	2	3	4	5

*Competencies.
Graduates will be able to:

Be truthful, honest, trustworthy, responsible and considerate in all solutions.	1	2	3	4	5
Complete work in a timely manner while maintaining high quality.	1	2	3	4	5
Keep a neat and orderly appearance and work environment.	1	2	3	4	5
Stay current in technical fields, involved in professional organizations, and be certified or licensed if appropriate.	1	2	3	4	5
Confront problems forcefully but courteously.	1	2	3	4	5

Please add comments below.

11. Communication

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Communication: The ability to effectively communicate.

1 2 3 4 5

*Competencies.
Graduates will be able to:

Demonstrate good writing skills in memos, proposals, and specifications.	1	2	3	4	5
Effectively use charts, graphs, media, and other visual aids.	1	2	3	4	5
Give an effective and persuasive oral presentation.	1	2	3	4	5
Know when and how much information to share with others.	1	2	3	4	5
Know when to seek for feedback and guidance.	1	2	3	4	5
Know and use modern means of communication.	1	2	3	4	5
Use appropriate business etiquette.	1	2	3	4	5

Please add comments below.

12. Safety and Environmental Issues

Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Safety and Environmental Issues: Commitment to and competency in safety and environmental issues related to manufacturing.

1	2	3	4	5

*Competencies.
Graduates will be able to:

Handle emergency situations involving hazardous materials or a fire.	1	2	3	4	5
Understand the importance of human health and safety in the workplace.	1	2	3	4	5
Understand the demands of federal and state environmental regulations relating to their operation.	1	2	3	4	5
Appreciate and minimize negative effects of manufacturing on the environment, even when this effort goes beyond the required standards.	1	2	3	4	5
Identify safety hazards in a plan shop floor or a lab setting.	1	2	3	4	5
Apply ergonomic principles and industrial hygiene practices to their workplace.	1	2	3	4	5

Please add comments below.

Global Awareness
Please rank the following attribute and its corresponding competencies on a scale of 1 to 5, where 1 represents low importance to MET graduates and 5 represents high importance to MET graduates.

*Attribute.
Global Awareness: Competence with respect to the issues, challenges and opportunities in today's global manufacturing environment.

1 2 3 4 5

*Competencies.
Graduates will be able to:

Comprehend the challenges of global supply chains.	1	2	3	4	5
Develop competencies in the operation of international manufacturing.	1	2	3	4	5
Acquire an understanding of diverse cultures, perceptions, expectations, and professional practices.	1	2	3	4	5
Understand advantages and disadvantages and contribute in decisions regarding global markets and off-shore manufacturing.	1	2	3	4	5
Understand the critical role manufacturing plays in the development and stability of a country and society.	1	2	3	4	5

Please add comments below.

Appendix D

SURVEY RESPONSES FOR EDUCATORS

1. Manufacturing Processes
   a. *
   b. Ability to to do hand sketches.
   c. none
   d. Really, they could all be 5s...but if something has to give...
   e. These questions are mostly slanted toward machining - that's very expensive for mass production, and it's overemphasized in many programs. Seek balance here.
   f. Comment for all competencies: Only ONE competency per statement. Do NOT 'piggyback' one evaluation criterion atop another. How can such ambiguous statements be properly evaluated? Because each statement does NOT address only ONE criterion, the results of this survey will be of limited usefulness. Please contact me if you wish further comments.
   g. Work effectively with associates in a team setting to solve manufacturing problems.
   h. Control the appropriate processes.

i. All of these are important... I don't want manufacturing engineering technology to be limited to the traditional chip-making processes and the CAD-CAM-CNC

j. I really believe the answers to the questions have much to do with the industry in which the graduate lands. My answers are those most suited to my experience with regards to the industry I work.

k. Some of these are very manufacturing industry, and individuals position in the company dependent.

l. Tooling locations and feed and speed information are being made by tool engineers and the machine operator or N/C programmer

m. None

2. Quality

   a. 8

   b. none

   c. Comment for all competencies: Only ONE competency per statement. Do NOT 'piggyback' one evaluation criterion atop another. How can such ambiguous statements be properly evaluated? Because each statement does NOT address only ONE criterion, the results of this survey will be of limited usefulness. Please contact me if you wish further comments.

   d. A point that is often a challenge for new grads to become comfortable with is an understanding within their specific industry, or types of product in that industry, the characteristics in a product that are acceptable in terms of quality.

e. This area is one of great improtance. The issue is to be able to solve and improve processes and process problems. Understanding and appling statistical tools to a given process is greatly needed. The cost of quality in industry today is still unknown and maybe unknowable . . . but we have a long way to go.

3. Manufacturing Systems

a. none

b. Comment for all competencies: Only ONE competency per statement. Do NOT 'piggyback' one evaluation criterion atop another. How can such ambiguous statements be properly evaluated? Because each statement does NOT address only ONE criterion, the results of this survey will be of limited usefulness. Please contact me if you wish further comments.

c. Again all are important but the emphasis will vary from program to program

d. The term 'Set up' is what lessens the importance/ranking of the graduate on the competency above. He/she will need to understand and perform within the PC system but not expected to set up as a recent grad.

4. Design

a. none

b. Comment for all competencies: Only ONE competency per statement. Do NOT 'piggyback' one evaluation criterion atop another. How can such ambiguous statements be properly evaluated? Because each statement does

NOT address only ONE criterion, the results of this survey will be of limited usefulness. Please contact me if you wish further comments.

c. It is not the job of manufacturing Eng. Technologist to design tools. Tool and die makers are more appropriate individuals to do this job.

5. Materials

   a. none

   b. Comment for all competencies: Only ONE competency per statement. Do NOT 'piggyback' one evaluation criterion atop another. How can such ambiguous statements be properly evaluated? Because each statement does NOT address only ONE criterion, the results of this survey will be of limited usefulness. Please contact me if you wish further comments.

   c. It has been my experience that many of the larger companies will have their own metallurgical departments who will designate and test many of the used materials.

   d. Design engineers specify the material and heat treaments and the Mfg. Engineer usually needs and understanding of this for machineability but not for strength etc.

   e. Structural or Materials Engineering needed to assess material properties and consequences of changes. MET may understand result but not all the influences that could occur.

6. Management

   a. none

b. Comment for all competencies: Only ONE competency per statement. Do NOT 'piggyback' one evaluation criterion atop another. How can such ambiguous statements be properly evaluated? Because each statement does NOT address only ONE criterion, the results of this survey will be of limited usefulness. Please contact me if you wish further comments.

c. Critical skills that go well beyond materials, processes and the core technical topics

d. Make buy decisions should be seperate from equipment justification. They are closely related to each other. Having said that capital equipment justification is another area of great waste in industry, the wrong equipment is purchased and the wrong size is purchased. This almost rates with quality in lost dollars because of the inability to identify the proper equipment after the process has been identified. Being able to justify and show a simple ROR needs to be taught.

e. Most of these attributes should/could be developed after several years on a specific job.

7. Creativity and Problem Solving

a. none

b. What are these various 'tools of creativity' and 'creative ways?' Pretty mushy terminology; sounds more like a psuedo-product development/ industrial design competiency. Are you speaking more of processes (e.g., brainstorming, conceptual sketching & modeling, etc.) or applications (e.g., 3D CAD, simulations, etc.). There is nothing wrong with thinking outside the box as long as the environment outside the box is based upon firm engineering & scientific principles.

c. Comment for all competencies: Only ONE competency per statement. Do NOT 'piggyback' one evaluation criterion atop another. How can such ambiguous statements be properly evaluated? Because each statement does NOT address only ONE criterion, the results of this survey will be of limited usefulness. Please contact me if you wish further comments.

d. I am assuming you are addressing competencies at graduation--NOT 2-3 years after graduation.

e. Key functional skills that graduates should master. The thinking skills are critical.

f. I believe this is one of the most important competencies that the MET graduates will need to have. We need problem solvers, not just those who can 'complain' and 'find' problems.

g. This area has been really over looked in industry for years, I think additional training is needed in this area . . . I liked the way 'Out of the Crisis' by Demining handles this. This should be required reading and do a book report or project from the book.

h. These also will take some time to develop.

8. Leadership

a. Leadership qualities need to be developed, and the ability to capture the vision are useful for undergraduate students. The ability to develop a vision may be beyond the expectations of a BS in Manufacturing and requires a breadth and depth that is grounded in principles but often customer, product and/or environmental issues of reality are required to recognize limitations also provide opportunities.

b. none

c. 'developing a vision' and leading teams 'to new heights' sounds a bit overblown. How about 'the ability to develop collaborative and leadership skills?'

d. Comment for all competencies: Only ONE competency per statement. Do NOT 'piggyback' one evaluation criterion atop another. How can such ambiguous statements be properly evaluated? Because each statement does NOT address only ONE criterion, the results of this survey will be of limited usefulness. Please contact me if you wish further comments.

e. I am assuming you are addressing competencies at graduation--NOT 2-3 years after graduation.

f. This attribute is important after the first 5-7 years but not necessary in the beginning.

g. 'develop a vision' and 'lead a team ...' are different attributes. I believe the leading aspect is critical, not the vision-setting role.

h. This represents a skill set that is a requirement of Mfg. Engr. Tech grads. The employers of our graudates are looking for this. It is, however very difficult to develop these skills.

9. Professionalism

a. none

b. Conspicuously absent from the forth item is the term 'safe.' Unfortunately, keeping things neat is not necessarily the same as keeping things safe. The ability to work in a 'cluttered' (slightly disorganized) environment is not necessarily a bad thing. In an R&D type environment, clutter happens. In a lean, JIT, or ergonomically optimized production environment, fighting 'clutter' is part of the continuous improvement process. Ensuring that any type 'clutter' never leads to an unsafe working environment _is_ a hugely desireable skill.

c. Comment for all competencies: Only ONE competency per statement. Do NOT 'piggyback' one evaluation criterion atop another. How can such ambiguous statements be properly evaluated? Because each statement does NOT address only ONE criterion, the results of this survey will be of limited usefulness. Please contact me if you wish further comments.

d. Again... functional skills that graduates must have. These too go well beyond the technical skills we can teach. These are not technology dependent and will help our graduates deal with changes and the future.

10. Communication

a. Critical for both scholarly and professional success.

b. none

c. What are 'modern means of communication.' Talking is prehistoric, drawing is ancient, and writing has been around for centuries. The telephone is a pretty effective means of communication but the underlying technology is getting pretty long in the tooth. If competency in using information technologies (hardware and applications) is what you want, then say it. In that case, change my answer to '5.'

d. In general, college grads would benefit from basic training in a number of personal development areas - conflict management, diplomacy, time management, networking, interviewing, and a number of other areas. A course could be constructed around these, but there is an issue of whether these are appropriate in an engineering curriculum.

e. Comment for all competencies: Only ONE competency per statement. Do NOT 'piggyback' one evaluation criterion atop another. How can such ambiguous statements be properly evaluated? Because each statement does NOT address only ONE criterion, the results of this survey will be of limited usefulness. What are ':modern means of communication' and 'good writing skills'? These are so general in nature that they are useless. Please contact me if you wish further comments.

f. Critical skills that graduates must have. Communication is hard work and requires careful attention. All forms... oral, visual/graphic, written... All these need attention

g. These are extremely important.

11. Safety and Environmental Issues

a. While these factors are critical, they are best focused in training specific to the industry rather than an academic attempt to broadly cover industries and materials in a diluted course setting.

b. none

c. This item could possibly be combined with the ethics/team/leadership attribute. There is a large amount of overlap.

d. Comment for all competencies: Only ONE competency per statement. Do NOT 'piggyback' one evaluation criterion atop another. How can such ambiguous statements be properly evaluated? Because each statement does NOT address only ONE criterion, the results of this survey will be of limited usefulness. Please contact me if you wish further comments.

e. I am assuming you are addressing competencies at graduation--NOT 2-3 years after graduation.

f. This will come with work experience. It is not an easy thing to teach in the class.

g. It is hard not to have safety number one. The key will be the role the Mfg. Engr. Tech grad plays along with others in the company

h. Numbers 4 and 5 will take specific in-depth training to aquire.

12. Global Awareness

a. none

b. Manufacturing's role in creating wealth (and stability) in a society is an important public policy topic. Giving graduates the knowledge and tools to effectively justify, procure, and utilize cost saving technologies and processes (automation, lean, CAD/CAM/CIM, etc.) is something an MET program _should_ cover. Talking points won't keep jobs in a country; legislating tax credits for automation will.

c. 13 is Important, but not at entry level. MISSING COMPETENCIES: (A) Ability to understand and handle electrical components and systems, especially including PLC use. Grads should be able to construct, wire, and program a PLC-controlled device.

d. Comment for all competencies: Only ONE competency per statement. Do NOT 'piggyback' one evaluation criterion atop another. How can such ambiguous statements be properly evaluated? Because each statement does NOT address only ONE criterion, the results of this survey will be of limited usefulness. Please contact me if you wish further comments.

e. I am assuming you are addressing competencies at graduation--NOT 2-3 years after graduation.

f. Critical too... we live in a global economy and students should be given opportunities for exposure to global issues.

g. These will take international experience to aquire, and are not taught well in school.

Appendix E

SURVEY RESPONSES FOR INDUSTRY REPRESENTATIVES

1. Manufacturing Processes
   a. A student should have a general knowledge of what is needed to produce a part. It becomes difficult to teach the details because they are different from facility to facility (and even from shift to shift if your processes are out of control).
   b. It is imperative that graduates understand the general elements of manufacturing processes. Additionally, the graduating student must have a grasp of basic analytical skills so they can apply them in typical manufacturing processes, as well as researching alternative or new technologies (whether new to them or industry). This knowledge includes competency in Design of Experiments, Design for Manufacturability, Reliability Analysis, Return on Investment. By having a clear understanding of the technical and business aspects of industry/processes, one can become a key contributor to the success of a company. Selecting appropriate tool settings, etc. is a specific task to the application at hand and is generally learned 'on the job' and specific to a particular machine or technology.
   c. none

d. Determining things like the placement of clamps, feeds, feeds & speeds is, in my view, the realm of the peson who programs the machine tools. A Manufacturing Engineer might discuss this sort of thing with a senior shop person but ME's should focus on manufacturability, materials, sequence of operations etc.

e. comment

f. Become familar with and utilize Finite Element Analyses and Computational Fluid Dynamic computer programs to define part design and product reliability.

g. Todays industry requires Skilled Manufacturing Problem Solvers Analyze,Document,Processing and Economics of issues. Manufacturing Technicians look after the details.

h. A new grad will gain experience fast in related selection tasks once on the job. Experienced shop floor people and seasoned engineers will offer their established methods and the where/how to perform them. A new grad must have good visualization skills to see processes before they are even designed and efficiently communicate them to other team members.

i. Part of their education must happen at the job site. Technolgy is progressing at a high rate. For example -- finish machining of titanium has improved by a factor of 6X in the past 7 years. Also, each shop has their own culture -- this fact should be taught, but the details must be learned in the specific shop.

j. Competencies will definitely grow with experience in industry.

2. Quality

   a. Quality is vital. You don't need to produce an expert, but you need to produce someone who has a basic understanding, and who speaks the language.

   b. Stressing the understanding of quality concepts, when to use SPC, and how best to test for and assure quality are key elements of this subject matter. Additionally, it is important to have the ability to assess which attributes of a product or process are important to the end result. In other words, which process or product attribute(s) must be assessed to ensure quality?

   c. Sometimes instigate a change to improve national and international standards and certification.

   d. Should also be versed in where & how to find applicable regulatory agencies, standards and resources.

   e. This fuction is a Community College function.

   f. We require MEs to do the DOE; METs will typically execute other people's studies and experiments.

   g. Many have yet to realize that quality is an 'Effect', it is an effect of solid system development. No amount of 'quality' programs will truly build in quality. It must be in the design and processes used in manufacturing.

   h. Quality is omnipotent. All manufacturing professionals should strive to achieve an expert level early on to really appreciate how far we have come and why we must maintain standards.

   i. Standards are changing almost yearly.

   j. Join ASQ to gain access to resources such as books and technical groups.

3. Manufacturing Systems

    a. Again, the engineer needs to know the language, then he can learn the specifics of the place he is working.
    b. How about being aware that international information sharing is not always in the best intersts of national security.
    c. I think these are important functions but these types of systems are very dependent on the how a company is set up and as such are mastered on the job. I think the student should have an understanding of these systems and their basics but the ability to implement and test is learned on the job.
    d. LEAN systems are the key to success. Without LEAN, you cannot WIN....
    e. What do you mean by 'system dynamics'???????
    f. We must Be lean and have a continuous improvement process in place to survive in the united states.
    g. I realize that the graduate will still be learning as he starts on his job. Some things like lean Manufacturing, he should have studied well in school, so I should have marked that a 5. However, he will still need to learn a lot on implementing this in a real world environment, so it's hard to score that one.
    h. These competencies are a little bit more advanced for a recent grad , but requires continuing education. Such as a professional organization has to offer.
    i. To truly understand, one must experience so knowing the end results of various dynamics is not a prerequisite. Studying and embracing proven

approaches and systems will launch a new grad onto a more level learning field instead of one of unnecessary compensations.

j. Changes are happening fast, and each shop has unique equipment and processes.

k. Many of these areas will take time for a young graduate to learn and develop. Experience after the college education will be the ideal time to develp these skills.

4. Design

a. Have the student exposed to the basics. He then can learn the details of the facility he/she is working at.

b. The design of successful products and processes are one of the most important facets of company success. A graduating student must have the basic elements in place to contribute to a successful product design, specification, assembly or manufacturing process. Success in these areas means that the product meets/exceeds the customer's needs, corporate objectives, and stakeholders value. The design of the product, process, and facility is the backbone to a company's success.

c. Be aware that a designer needs to be spoken to in a proffesional manner about sugguesttions that involve a change. The best designer are concientious and don't like overlooking something.

d. Requirements and constraints are generally given to a new graduate his/her manager. The student must be able to understand those constraints and translate them into a design. The final detailed design is at some level collaborative and the student must be able to work with others to hash out the design.

e. Engineering belongs to the Design Engineer.

f. Competency in CAD takes time and experience, so I marked it 4 instead of 5. The graduate should have good experience in it, but it still takes time to get really good - especially since a CAD class doesn't cover the deeper aspects of all the CAD modules available in each CAD system.

g. Somecomps are more advanced

h. Sometimes to much emphasis is placed on CAD. Design by experience and or request assistance of more experienced engineer. There are many variables in fixture design. Different processes present different types of forces to a fixture.

i. All too often we encounter graduates with great skill on the computer with various software programs, yet little practical ability to translate the power of the software into viable solutions in the real world. You need to move beyond reliance on the computer to solve problems. They must first know how to solve the problem before applying the computer to the equation. Garbage in - garbage out

j. Experience, experience and more experience. Cad skills and efficient design renderings snowball with exposure but any engineer better understand the parameters of the project before 'finalizing' it.

k. One small machine shop that I know uses 4 NC programming languages -- I think this is not efficient, but it is a fact.

5. Materials
    a. The student needs to be exposed. He/She will have to depend on more experienced mentors to critique the design.
    b. Product material selection is Product Design Engineering arena. ME/IE should have knowledge of materials but not selection respoinsibilities.
    c. This is one of the most important functions of a MET graduate. Designers tend to have an understanding of materials but it is the manufacturing specialist who is responsible for making sure that a design is manufacturable
    d. We should understand a problem solver is a skilled manufacturing engineer who served an apprentice in hands on manufacturing.
    e. A MET should be more familiar with the product at hand not supply chain management which is upper level management typr stuff or another function i.e. purchasing
    f. Tooling needs to be cost effective, the design must be sound. In the real world purchasing departments will negotiate the best price from suppliers. Supply chain management does not factor as much as the media buzz words would imply in large companies.
    g. The material vendors have wonderful websites and tech catalogs to get a new grad safe and close with a selection. They must ask aforementioned experienced team members about the what-if's of changing properties from changing processes. Some teachers can help but only if they lived through the problems.

h. Large airframe companies use their own allowables for specific material alloys and these values are not the same between companies.

i. This is an area that varies across different industries. Experience will be a key factor in developing the skills listed above and applying them to a specific industry (such as chemicals, electrical cable, metal tubing, etc.).

j. A single engineer can't be an expert at everything and this is typically an area when a good mechanincal engineer would be involved, rather than expecting this of a manufacturing engineer.

6. Management

   a. The student needs to be exposed to the project management skills and programs.

   b. Good communication habits and understanding the return on investment are the two important attributes in this section. Return on investment is not only monetary (i.e. capital equipment justification), but also analyzing resource allocations. Of course leadership skills is not mentioned here, but that is what management is all about. Engineers are generally not the best communicators or strong leaders, so emphasis on these skills, plus understanding the 'big picture' are important.

   c. From the perspective of a large, multi-national corporation, where over 80% of the manufacturing of aerospace components is outsourced, this is a very important area.

d. A MET graduate should have good communication skills and a sound understanding of engineering economy but as a recent graduate will have to learn how those concepts are applied to their company.
e. Most of the responsibility for the projects and the assessment of other employees would not fall to a new graduate MET. We would expect development of skills through experience.
f. Here again upper level.
g. A new grad should be well versed in all communication tools but will not be good enough to determine every resource requirement, effectively deploy those resources and assess others since a new grad has walked the walk long enough. Focus on team play and a manageable ego.
h. Even though you asked me to focus on the short term the best engineers get asked to become managers and most schools do not prepare us for that step into management and many engineers fail as managers. We need to beef up this area so they can make this transition.
i. 'People' skills are essential for a manager of a project. The greatest challenges will be communication between all project team members and the need to overcome personality conflicts.
j. Some of these would be important only if in a management postion.

7. Creativity and Problem Solving
    a. Root cause analysis is vital to a student when he/she gets out into industry. The tools of creativity are very helpful.

b. As over 25% of engineering work engineering work is outsourced at this company, this is another very important area.
c. What are 'the tools of creativity????????????
d. Now you are talking common sence.
e. We must utiize the tools developed by Dr. Deming and the use of Six-Sigma to remain lean.
f. Its great to see outside the box but one needs to know the fundamentals first.
g. There are good tools for creativity, and brainstroming is not one of them; in fact, it is one of the least productive in the engineering domain for development work. contact me for more information...
h. A new grad can only think out of the box since a new grad has not gotten into the box to see its restraints. All kidding aside, a new grad should be passionate and daring because conservatism and politics will come soon enough. So Analyze, Solve, Implement and have Fun!
i. What good are great ideas and solutions if you do not have the skills to implement them. This is an area that I was weak in during my early years.
j. Creativity is a nice skill to have. The more that one is able to involve others in addressing a problem, then greater is the chance of achieving success in solving the problem.
k. In today's environment, few problems will be resolved by a single individual, so the ability to work in a group in problem-resolution is especially important.

8. Leadership

a. Leadership should be taught.

b. Leadership does not mean intimdate employees by threating layoffs 7/24 and embarrasing them in front of others or micromanaging ther job activities
c. This area becomes more important after a few years on the job.
d. I don't necessarily envison a MET graduate stepping directly into a management possition. A MET graduate should have the base skills that will allow them to be group leaders but I don't think there is time for that to be a large focus of the curriculum.
e. Teach Influence skills
f. CEO or president type stuff
g. Most engineers can do with attending a Dale Carnigie (sp?) course - practise in personal skills. TOC has a great tool for the last item - called a Future Reality Tree, to aid people in decision making and possible impacts
h. My turn to ask questions: 1)Why does everyone got to be the leader? 2)Isn't it hard to think 'out of the box' when hindered by boring things as budgets, pollution and other people's safety? Answers: 1)Most manufacturing successes were borne out by the many good 'followers' who learned about respect before they learned their technical skills. 2)Just kidding. We must be aware of costs, pollution and even the least of society but thinking can exact sacrifices from these entities. Don't limit your thinking! You'll make your 'leaders' look smart.
i. This is another area in which experience will allow the graduate to both learn and grow. Leadership is a building process and the ability to work with various people (and personalities) is a key attribute.

9. Professionalism

    a. Not real big on Certification, but need to stay current in the field by staying active in Professional Organizations.
    b. Manners count.
    c. With respect to competency number 1 above, one sometimes has to be careful not too be too honest.
    d. Yes
    e. Support professional society membership
    f. Honesty and integrity are a must. If you can not be truthful to yourself, who can you be truthful to?
    g. Absolutly.
    h. Maintain a military bearing. It exudes intelligence, dependability, courage, honesty and order. Some of the same traits of successful engineers.
    i. Technology is progressing at a fast pace -- schooling has to continue for your lifetime.
    j. Professional appearance and behavior do pay dividends. Employers value discipline and reliability. Professional associations such as SME and ASQ are a good investment of one's time.

10. Communication

    a. Communication is key.
    b. Dale Carnegie with a business twist.
    c. I strongly feel that one of the most important things a student learns is where to go for information they don't posses. At a job they are not being tested to

see what they have stored in their head but how they use it. And often they won't know the answer and will need help and they need to know this is expected and required for professional development.

d. We covered this before. Intellectual exchanges will get enhanced as the members of the conversation vary in knowledge. An engineer, to be effective, must be able to share her/his good concepts through voice and on napkins sometimes before anyone know that person is a good engineer.Kill the shyness!Launch the idea!

e. I think good listening is the most important part of communication, but I do not see it specifically listed above.

f. Writing skills are very important, especially when working with senior management. Organzation is also an important attribute.

11. Safety and Environmental Issues

a. Safety should always be at the top of the list.

b. This topic is hard to teach and hard for a new engineer to affect an outcome. Ethics are essential. The various environmental rules are too specific to teach. The student just needs to know they exist and to watch out for them.

c. This goes back to being an ethical profesional. The student should understand that safety is important but haveing a working knowledge of one the the many governing bodies' standards isn't required.

d. You cannot be LEAN if you are not safe....

e. having been in the Amazon of Brazil to launch a new car, this one could fill a book

f. The last item is the shop forman's responsibility rather than the manufacturing engineer. However, the manufacturing engineer must know the principlesand practices and be able to recognize when they are or are not being applied.
g. Emergency situations and health and safety will be handled by safety departments. One should be aware and consult if needed. Health and saftey requires on going training to stay current. Most engineers are not current.
h. Safety is Quality is omnipotent. This is a common sense area I hope all engineers learned from their parents early on and have applied it to their profession since we hope to benefit mankind and not destroy or injure it.
i. This is an area that will require experience in order for the graduate to understand industry specfic safety guidelines and best practices.
j. This is important to everyone, to some degree, but most companies have specially-trained people to provide health/safety expertise.

12. Global Awareness

a. This is difficult to do on an undergraduate level. It needs to be discussed.
b. Offshore manufacturing IS NOT always the best way to go simlpy because of short term capital gains. The long term cost will far offset the fleeting high gains in the short term. Alos, if national companies are expected to comply to envirnomental and saftey regulations and specs, true ethics requires that work is not sent to foriegn companies where thes laws are not enforced.
c. Understanding of the world economy is important. Make or buy decisions are often made purely on a cost basis which leads you off shores. Understanding your companies philosophy on that is helpful but not always critical. I don't

think of the MET curriculum as being a political pulpet. There are definitely political aspects to any job but I don't think that should be pressed in school.

d. Again top level stuff. Good to be aware but what impact they will have on corporation depends. On the job for 2 months , I doubt they will persuade the CEO of GM to move everything back to the States.
e. As an American, I disagree with the current playing field. Young American engineering grads should remind themselves of the great country that gave them this privilige to learn and contribute vitally to society as a whole and avoid contributing to foreign societies that will injure this great experiment called America!
f. Whether or not this section is relevant will depend on the company.

Appendix F

TYPICAL E-MAIL MESSAGES

1. Typical letter sent to MET educators.

Dear manufacturing educator:

This survey is being sent to instructors in Manufacturing Engineering Technology programs in the United States to seek your evaluation of a set of proposed attributes and competencies that MET programs might develop in their graduates.

I am conducting this research as part of my master-of-science thesis in engineering technology at Brigham Young University. Your assessment of these attributes and competencies, along with additional competencies that you may suggest, will be used to prepare another survey that will be sent to industries that employ MET graduates. Their assessment, along with yours, will be used as part of the basis for a plan for building a modern MET curriculum. I will make my analysis and summaries available to all who participate.

Here is a link to the survey:

[SurveyLink]

Thanks for your participation,

Loni Williamson

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.

[RemoveLink]

2. Typical letter sent to MET industry representatives.

Dear [FirstName] [LastName],

Improvements need to be made in current manufacturing education to keep up with the changing trends in the manufacturing world. With your participation in this survey, manufacturing graduates will be better prepared for industry.

I am conducting this research as part of my master-of-science thesis in engineering technology at Brigham Young University. Your assessment of these attributes and competencies will be the basis for improving modern Manufacturing Engineering Technology curriculum. Please take a few minutes to complete this survey.

Here is a link to the survey:
[SurveyLink]

Thanks for your participation,

Loni Williamson

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.
[RemoveLink]

Appendix G

TABLE FOR COMBINED CALCULATIONS

Table G. Solutions For MANOVA Calculations

Survey Components	Educator Mean (SD)	Industry Mean (SD)
Manufacturing Processes		
Processes: An understanding of manufacturing processes and their applications.	4.83 (0.45)	4.56 (0.67)
Graduates will be able to:		
1. Select appropriate processes and equipment based on their capabilities and economics.	4.65 (0.58)	4.30 (0.86)
2. Analyze a part print for manufacturability.	4.70 (0.56)	4.34 (0.76)
3. Document a processing sequence to economically meet product specifications.	4.50 (0.75)	4.18 (0.77)
4. Select appropriate tooling and machine settings (feeds, speeds, temperatures, pressures, etc.)	4.13 (0.94)	3.54 (0.98)
5. Analyze and select appropriate clamping and locating surfaces.	4.13 (0.94)	3.54 (0.91)
6. Utilize appropriate manufacturing software including, CAD/CAM, CNC, etc.	4.40 (0.74)	3.82 (0.93)
7. Prepare process operation instructions.	4.18 (0.75)	4.04 (0.92)

Table G—*Continued*

Survey Components	Educator Mean (SD)	Industry Mean (SD)
Quality		
Quality: A commitment to quality and an ability to effectively measure and improve product and process quality.	4.70 (0.52)	4.41 (0.61)
Graduates will be able to:		
1. Assess the nature, types, and impact of variation.	4.43 (0.68)	4.15 (0.79)
2. Use the basic instruments of metrology and determine the capability of measurement systems.	4.18 (0.78)	3.84 (0.87)
3. Achieve high quality in manufacturing systems through proven management methodologies.	4.15 (0.77)	3.93 (0.97)
4. Apply appropriate test and inspection procedures for evaluating product and process quality.	4.35 (0.66)	3.85 (0.97)
5. Conduct capability studies and design, conduct and evaluate experiments.	4.20 (0.72)	3.87 (1.02)
6. Set up a quality control system including Statistical Process Control.	4.30 (0.72)	3.82 (0.93)
7. Comply with national and international regulatory standards and certifications.	3.89 (0.89)	3.59 (1.08)
Manufacturing Systems		
Systems: An understanding of the dynamics of manufacturing systems and supply chains and how to effectively configure systems for efficient manufacture and delivery.	4.30 (0.61)	3.87 (0.73)

Table G—*Continued*

Survey Components	Educator Mean (SD)	Industry Mean (SD)
Graduates will be able to:		
1. Understand system dynamics and predict the performance of given manufacturing system configurations.	3.88 (0.69)	3.79 (0.97)
2. Effectively integrate processing, material handling and flow of information.	4.13 (0.72)	3.84 (0.84)
3. Implement lean manufacturing principles in a manufacturing system.	4.20 (0.82)	4.07 (0.98)
4. Analyze and specify requirements for automated controls.	3.93 (0.73)	3.49 (0.96)
5. Set up a quality control system including Statistical Process Control.	4.03 (0.80)	3.61 (0.95)
6. Manage a supply chain including international constituents.	3.65 (0.98)	3.27 (1.07)
Design		
Design: The ability to effectively design tooling and facilities and to participate on product-design teams to meet a set of requirements and constraints.	4.40 (0.67)	4.09 (0.72)
Graduates will be able to:		
1. Clearly identify the requirements and constraints to be met by a design considering all stakeholders.	4.15 (0.83)	4.00 (0.97)
2. Develop specifications that accurately reflect these requirements and constraints.	4.30 (0.72)	4.02 (0.87)
3. Understand and apply Design for Manufacturing and Assembly principles.	4.48 (0.60)	4.34 (0.76)

Table G—*Continued*

Survey Components	Educator Mean (SD)	Industry Mean (SD)
4. Use problem solving and other analysis techniques to predict performance and to find optimum design solutions.	4.30 (0.69)	4.21 (0.84)
5. Transform a solution concept into a final detailed design.	4.30 (0.65)	3.76 (0.88)
6. Make effective use of CAD and related design tools.	4.45 (0.68)	3.72 (0.95)
Materials		
Materials: An understanding of the physical and mechanical properties of engineering materials.	4.43 (0.55)	4.11 (0.72)
Graduates will be able to:		
1. Select appropriate materials for tooling and for products.	4.38 (0.77)	3.93 (0.87)
2. Assess the effects of manufacturing processes on material properties.	4.40 (0.63)	3.98 (0.86)
3. Best utilize the machinability, formability, and weldability of various materials.	4.33 (0.66)	3.88 (0.82)
4. Specify treatments affecting the property and structure relationships of materials.	3.98 (0.83)	3.72 (0.95)
5. Work effectively with material supply chain issues such as cost, availability, and delivery.	4.08 (0.80)	3.65 (1.06)
Management		
Management: The ability to plan, organize, staff and control projects and processes.	4.33 (0.69)	4.07 (0.81)

Table G—*Continued*

Survey Components	Educator Mean (SD)	Industry Mean (SD)
Graduates will be able to:		
1. Use software and other tools to develop and execute a project or process plan.	3.95 (0.81)	3.76 (0.95)
2. Determine resource requirements (personnel, equipment, time, budget, etc.) for executing a plan.	4.25 (0.84)	3.95 (0.83)
3. Justify capital equipment expenditures and be responsible for make-or-buy decisions.	4.08 (0.80)	3.91 (1.00)
4. Effectively deploy resources in carrying out a plan.	4.20 (0.69)	3.91 (0.97)
5. Monitor and assess progress and performance and take appropriate corrective action when necessary.	4.23 (0.80)	4.02 (0.93)
6. Keep team members and other stakeholders informed of progress and problems.	4.20 (0.82)	4.15 (0.90)
7. Assess performances of employees and facilitate their progress.	3.65 (0.98)	3.51 (0.98)
Creativity and Problem Solving		
Creativity and Problem Solving: The ability to see problems from multiple and new perspectives and generate innovative solutions.	4.65 (0.58)	4.44 (0.70)
Graduates will be able to:		
1. See new and creative ways to achieve an objective (think outside the box) within set constraints.	4.28 (0.82)	4.32 (0.81)
2. Effectively utilize the tools of creativity.	4.00 (0.82)	3.98 (0.94)

Table G—*Continued*

Survey Components	Educator Mean (SD)	Industry Mean (SD)
3. Draw analogies and comparisons using both breadth and depth of knowledge to identify and evaluate alternative solutions to the problem.	4.20 (0.76)	4.16 (0.84)
4. Use modeling, statistical and other analysis techniques for problem solving	4.18 (0.81)	3.88 (0.99)
5. Analyze the cause-and-effect relationships of the problem to find the root causes.	4.58 (0.64)	4.30 (0.87)
6. Implement the solution.	4.48 (0.55)	4.38 (0.86)
Leadership		
Leadership: The ability to develop a vision and lead a team or organization to new heights.	3.95 (0.99)	3.95 (0.97)
Graduates will be able to:		
1. Lead a team in the performance of an activity or project.	4.10 (0.90)	4.02 (0.90)
2. Develop a strategic plan.	3.65 (1.10)	3.84 (1.16)
3. Build relationships to gain support and commitment of others.	4.15 (0.83)	4.26 (0.94)
4. Effectively sell a plan or idea to others.	4.18 (0.75)	4.04 (1.02)
5. Plan and conduct a productive meeting.	4.25 (0.90)	4.10 (0.91)
6. Anticipate the impact of business decisions on the economy, the environment, personal well being, etc.	3.80 (1.02)	3.60 (1.12)

Table G—*Continued*

Survey Components	Educator Mean (SD)	Industry Mean (SD)
Professionalism		
Professionalism: High ethical values, good work habits and on-going development of relevant knowledge and skills.	4.60 (0.87)	4.70 (0.54)
Graduates will be able to:		
1. Be truthful, honest, trustworthy, responsible and considerate in all situations.	4.73 (0.75)	4.78 (0.59)
2. Complete work in a timely manner while maintaining high quality.	4.55 (0.75)	4.51 (0.71)
3. Keep a neat and orderly appearance and work environment.	4.08 (0.94)	3.84 (0.97)
4. Stay current in technical fields, involved in professional organizations, and be certified or licensed if appropriate.	4.43 (0.84)	4.27 (0.92)
5. Confront problems forcefully but courteously.	4.25 (0.84)	4.21 (0.89)
Communication		
Communication: The ability to effectively communicate.	4.70 (0.52)	4.59 (0.63)
Graduates will be able to:		
1. Demonstrate good writing skills in memos, proposals, and specifications.	4.63 (0.59)	4.43 (0.77)
2. Effectively use charts, graphs, media, and other visual aids.	4.50 (0.68)	4.07 (0.89)
3. Give an effective and persuasive oral presentation.	4.53 (0.68)	4.24 (0.90)
4. Know when and how much information to share with others.	4.48 (0.72)	4.16 (0.95)

Table G—*Continued*

Survey Components	Educator Mean (SD)	Industry Mean (SD)
5. Know when to seek for feedback and guidance.	4.60 (0.59)	4.38 (0.83)
6. Know and use modern means of communication.	4.33 (0.94)	4.06 (0.91)
7. Use appropriate business etiquette.	4.35 (0.83)	4.13 (0.90)
Safety and Environmental Issues		
Safety and Environmental Issues: Commitment to and competency in safety and environmental issues related to manufacturing.	4.48 (0.72)	4.16 (0.73)
Graduates will be able to:		
1. Handle emergency situations involving hazardous materials or a fire.	4.00 (0.91)	3.83 (0.99)
2. Understand the importance of human health and safety in the workplace.	4.45 (0.75)	4.33 (0.83)
3. Understand the demands of federal and state environmental regulations relating to their operation.	3.98 (0.80)	3.87 (0.94)
4. Appreciate and minimize negative effects of manufacturing on the environment, even when this effort goes beyond the required standards.	4.15 (0.74)	3.74 (0.90)
5. Identify safety hazards in a plant shop floor or a lab setting.	4.43 (0.68)	4.18 (0.94)
6. Apply ergonomic principles and industrial hygiene practices to their workplace.	4.10 (0.87)	3.87 (0.90)

Table G—*Continued*

Survey Components	Educator Mean (SD)	Industry Mean (SD)
Global Awareness		
Global Awareness: Competence with respect to the issues, challenges and opportunities in today's global manufacturing environment.	4.08 (0.76)	3.85 (0.86)
Graduates will be able to:		
1. Comprehend the challenges of global supply chains.	3.95 (0.90)	3.70 (1.06)
2. Develop competencies in the operation of international manufacturing.	3.70 (0.85)	3.49 (1.01)
3. Acquire an understanding of diverse cultures, perceptions, expectations, and professional practices.	3.70 (0.97)	3.56 (1.06)
4. Understand advantages and disadvantages and contribute in decisions regarding global markets and off-shore manufacturing.	3.98 (0.89)	3.70 (1.05)
5. Understand the critical role manufacturing plays in the development and stability of a country and society.	3.98 (1.00)	3.63 (1.14)

Appendix H

TABLE FOR COMBINED COMPETENCY RESPONSES

Table H. Combined Competency Responses

Survey Competencies	Mean (SD)	Median
Manufacturing Processes		
Graduates will be able to:		
1. Select appropriate processes and equipment based on their capabilities and economics.	4.42 (0.79)	5
2. Analyze a part print for manufacturability.	4.46 (0.72)	5
3. Document a processing sequence to economically meet product specifications.	4.29 (0.78)	4
4. Select appropriate tooling and machine settings (feeds, speeds, temperatures, pressures, etc.)	3.73 (1.00)	4
5. Analyze and select appropriate clamping and locating surfaces.	3.73 (0.95)	4
6. Utilize appropriate manufacturing software including, CAD/CAM, CNC, etc.	4.01 (0.91)	4
7. Prepare process operation instructions.	4.08 (0.87)	4

Table H—*Continued*

Survey Competencies	Mean (SD)	Median
Quality		
Graduates will be able to:		
1. Assess the nature, types, and impact of variation.	4.24 (0.76)	4
2. Use the basic instruments of metrology and determine the capability of measurement systems.	3.95 (0.85)	4
3. Achieve high quality in manufacturing systems through proven management methodologies.	4.00 (0.91)	4
4. Apply appropriate test and inspection procedures for evaluating product and process quality.	4.02 (0.91)	4
5. Conduct capability studies and design, conduct and evaluate experiments.	3.98 (0.94)	4
6. Set up a quality control system including Statistical Process Control.	3.98 (0.90)	4
7. Comply with national and international regulatory standards and certifications.	3.71 (1.03)	4
Manufacturing Systems		
Graduates will be able to:		
1. Understand system dynamics and predict the performance of given manufacturing system configurations.	3.82 (0.88)	4
2. Effectively integrate processing, material handling and flow of information.	3.93 (0.81)	4
3. Implement lean manufacturing principles in a manufacturing system.	4.11 (0.93)	4

Table H—*Continued*

Survey Competencies	Mean (SD)	Median
4. Analyze and specify requirements for automated controls.	3.63 (0.91)	4
5. Set up a quality control system including Statistical Process Control.	3.75 (0.92)	4
6. Manage a supply chain including international constituents.	3.39 (1.05)	3
Design		
Graduates will be able to:		
1. Clearly identify the requirements and constraints to be met by a design considering all stakeholders.	4.05 (0.93)	4
2. Develop specifications that accurately reflect these requirements and constraints.	4.11 (0.84)	4
3. Understand and apply Design for Manufacturing and Assembly principles.	4.39 (0.71)	4
4. Use problem solving and other analysis techniques to predict performance and to find optimum design solutions.	4.24 (0.79)	4
5. Transform a solution concept into a final detailed design.	3.93 (0.85)	4
6. Make effective use of CAD and related design tools.	3.96 (0.93)	4
Materials		
Graduates will be able to:		
1. Select appropriate materials for tooling and for products.	4.07 (0.86)	4
2. Assess the effects of manufacturing processes on material properties.	4.11 (0.82)	4

Table H—*Continued*

Survey Competencies	Mean (SD)	Median
3. Best utilize the machinability, formability, and weldability of various materials.	4.02 (0.80)	4
4. Specify treatments affecting the property and structure relationships of materials.	3.80 (0.91)	4
5. Work effectively with material supply chain issues such as cost, availability, and delivery.	3.79 (1.00)	4
Management		
Graduates will be able to:		
1. Use software and other tools to develop and execute a project or process plan.	3.82 (0.91)	4
2. Determine resource requirements (personnel, equipment, time, budget, etc.) for executing a plan.	4.05 (0.84)	4
3. Justify capital equipment expenditures and be responsible for make-or-buy decisions.	3.97 (0.94)	4
4. Effectively deploy resources in carrying out a plan.	4.01 (0.90)	4
5. Monitor and assess progress and performance and take appropriate corrective action when necessary.	4.09 (0.89)	4
6. Keep team members and other stakeholders informed of progress and problems.	4.16 (0.88)	4
7. Assess performances of employees and facilitate their progress.	3.56 (0.98)	4

Table H—*Continued*

Survey Competencies	Mean (SD)	Median
Creativity and Problem Solving		
Graduates will be able to:		
1. See new and creative ways to achieve an objective (think outside the box) within set constraints.	4.30 (0.81)	4
2. Effectively utilize the tools of creativity.	3.98 (0.90)	4
3. Draw analogies and comparisons using both breadth and depth of knowledge to identify and evaluate alternative solutions to the problem.	4.17 (0.81)	4
4. Use modeling, statistical and other analysis techniques for problem solving	3.98 (0.94)	4
5. Analyze the cause-and-effect relationships of the problem to find the root causes.	4.39 (0.81)	5
6. Implement the solution.	4.41 (0.77)	5
Leadership		
Graduates will be able to:		
1. Lead a team in the performance of an activity or project.	4.05 (0.90)	4
2. Develop a strategic plan.	3.78 (1.14)	4
3. Build relationships to gain support and commitment of others.	4.22 (0.90)	4
4. Effectively sell a plan or idea to others.	4.08 (0.94)	4
5. Plan and conduct a productive meeting.	4.15 (0.91)	4
6. Anticipate the impact of business decisions on the economy, the environment, personal well being, etc.	3.66 (1.09)	4

Table H—*Continued*

Survey Competencies	Mean (SD)	Median
Professionalism		
Graduates will be able to:		
1. Be truthful, honest, trustworthy, responsible and considerate in all situations.	4.76 (0.64)	5
2. Complete work in a timely manner while maintaining high quality.	4.52 (0.72)	5
3. Keep a neat and orderly appearance and work environment.	3.92 (0.97)	4
4. Stay current in technical fields, involved in professional organizations, and be certified or licensed if appropriate.	4.32 (0.89)	5
5. Confront problems forcefully but courteously.	4.22 (0.87)	4
Communication		
Graduates will be able to:		
1. Demonstrate good writing skills in memos, proposals, and specifications.	4.49 (0.72)	5
2. Effectively use charts, graphs, media, and other visual aids.	4.21 (0.85)	4
3. Give an effective and persuasive oral presentation.	4.34 (0.84)	5
4. Know when and how much information to share with others.	4.26 (0.89)	4
5. Know when to seek for feedback and guidance.	4.45 (0.76)	5
6. Know and use modern means of communication.	4.15 (0.92)	4
7. Use appropriate business etiquette.	4.20 (0.88)	4

Table H—*Continued*

Survey Competencies	Mean (SD)	Median
Safety and Environmental Issues		
Graduates will be able to:		
1. Handle emergency situations involving hazardous materials or a fire.	3.89 (0.96)	4
2. Understand the importance of human health and safety in the workplace.	4.37 (0.80)	5
3. Understand the demands of federal and state environmental regulations relating to their operation.	3.90 (0.89)	4
4. Appreciate and minimize negative effects of manufacturing on the environment, even when this effort goes beyond the required standards.	3.88 (0.87)	4
5. Identify safety hazards in a plant shop floor or a lab setting.	4.26 (0.87)	4
6. Apply ergonomic principles and industrial hygiene practices to their workplace.	3.94 (0.89)	4
Global Awareness		
Graduates will be able to:		
1. Comprehend the challenges of global supply chains.	3.78 (1.02)	4
2. Develop competencies in the operation of international manufacturing.	3.56 (0.96)	4
3. Acquire an understanding of diverse cultures, perceptions, expectations, and professional practices.	3.61 (1.02)	4

Table H—*Continued*

Survey Competencies	Mean (SD)	Median
4. Understand advantages and disadvantages and contribute in decisions regarding global markets and off-shore manufacturing.	3.79 (1.01)	4
5. Understand the critical role manufacturing plays in the development and stability of a country and society.	3.75 (1.10)	4

Appendix I

TABLES FOR RESULTS

Table I1. Industry Representative's Mean Competency Values Below 3.50

Competency	Competency Category	Mean
Graduates will be able to:		
1. Manage a supply chain including international constituents.	Manufacturing Systems	3.27
2. Analyze and specify requirements for automated controls.	Manufacturing Systems	3.49
3. Develop competencies in the operation of international manufacturing.	Global Awareness	3.49

Table I2. Competencies Mean Values 4.50 and Above

Competency	Competency Category	Educator Survey Mean	Industry Survey Mean
Graduates will be able to:			
1. Be truthful, honest, trustworthy, responsible and considerate in all situations.	Professionalism	4.73	4.78
2. Complete work in a timely manner while maintaining high quality.	Professionalism	4.55	4.51
3. Demonstrate good writing skills in memos, proposals, and specifications.	Communication	4.63	--
4. Analyze a part print for manufacturability.	Manufacturing Processes	4.70	--
5. Know when to seek for feedback and guidance.	Communication	4.60	--
6. Select appropriate processes and equipment based on their capabilities and economics.	Manufacturing Processes	4.65	--
7. Analyze the cause-and-effect relationships of the problem to find the root causes.	Creativity and Problem Solving	4.58	--
8. Give an effective and persuasive oral presentation.	Communication	4.53	--
9. Document a processing sequence to economically meet product specifications.	Manufacturing Processes	4.50	--
10. Effectively use charts, graphs, media, and other visual aids.	Communication	4.50	--

Table I3. Industry Representative's Mean Ranked Higher than Educator's Mean

Competency	Category	Educator Survey Mean	Industry Survey Mean
Graduates will be able to:			
Develop a strategic plan.	Leadership	3.65	3.84
Build relationships to gain support and commitment of others.	Leadership	4.15	4.26
Professionalism: High ethical values, good work habits and on-going development of relevant knowledge and skills.	Professionalism (Attribute)	4.60	4.70
Be truthful, honest, trustworthy, responsible and considerate in all situations.	Professionalism	4.73	4.78
See new and creative ways to achieve an objective (think outside the box) within set constraints.	Creativity and Problem Solving	4.28	4.32
Leadership: The ability to develop a vision and lead a team or organization to new heights.	Leadership (Attribute)	3.95	3.95

Table I4. Significantly Different Competency Responses

Competency	Category	Educator Survey Mean	Industry Survey Mean	T-test (Sig.)
Graduates will be able to:				
Make effective use of CAD and related design tools.	Design	4.45	3.72	4E-06
Transform a solution concept into a final detailed design.	Design	4.30	3.76	2E-04
Utilize appropriate manufacturing software including, CAD/CAM, CNC, etc.	Manufacturing Processes	4.40	3.82	3E-04
Apply appropriate test and inspection procedures for evaluating product and process quality.	Quality	4.35	3.85	0.001
Best utilize the machinability, formability, and weldability of various materials.	Materials	4.33	3.88	0.002
Set up a quality control system including Statistical Process Control.	Quality	4.30	3.82	0.002
Select appropriate tooling and machine settings (feeds, speeds, temperatures, pressures, etc.)	Manufacturing Processes	4.13	3.54	0.002
Analyze and select appropriate clamping and locating surfaces.	Manufacturing Processes	4.13	3.54	0.002
Assess the effects of manufacturing processes on material properties.	Materials	4.40	3.98	0.003
Analyze a part print for manufacturability.	Manufacturing Processes	4.70	4.34	0.004

Table I4—*Continued*

Competency	Category	Educator Survey Mean	Industry Survey Mean	T-test (Sig.)
Graduates will be able to:				
Effectively use charts, graphs, media, and other visual aids.	Communication	4.50	4.07	0.004
Select appropriate materials for tooling and for products.	Materials	4.38	3.93	0.005
Analyze and specify requirements for automated controls.	Manufacturing Systems	3.93	3.49	0.006
Appreciate and minimize negative effects of manufacturing on the environment, even when this effort goes beyond the required standards.	Safety and Environmental Issues	4.15	3.74	0.009