AC 2011-1720: THE 2011 STATE OF MANUFACTURING EDUCATION

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The 2011 State of Manufacturing Education

Abstract

The paper complements the work of other groups and professionals, all trying to assess the status of manufacturing education. To this end the paper documents the results of a second annual survey of manufacturing educators and professionals assessing opinions about curriculum topics and the health of manufacturing practice and education.

1. Introduction

Manufacturing engineering continues to be one of the most dynamic disciplines with constant change driven by global competition and new technologies. Obviously education is a key for preparing manufacturing professionals who have knowledge and skills that can support contemporary and emerging issues. In the face of ongoing change it is necessary to assess what has been done, the current status, and a direction for the future. This work focuses on manufacturing education in general perspectives. The work described here is not unique as prior efforts have assessed the state of the college level manufacturing programs. The contribution of this work is to present an annual update that extends work presented in 2010 covering general opinions of individuals, not only academic programs.

It is worth repeating that the assessment is not unique. Over the last few years there have been many efforts to plot a strong future for manufacturing education. Most notably there have been a set of events exclusively focused on manufacturing education.

The work presented in 2010 was met with the suggestions listed below. Item 1 was addressed by distributing the survey to a larger industrial base, and the results are analyzed accordingly. Items 4 and 5 were addressed by asking for the priority of topics. Items 2, 3, 6, 7, and 8 are points of comparison to the previous study.
1. The results are biased towards manufacturing educators perspectives.
2. Educators feel as if they will have an impact on manufacturing and the economy.
3. Educators are inconsistently receiving support or encouragement from outside the manufacturing community.
4. There is demand for more content in manufacturing programs in ALL topical areas listed.
5. Future surveys examining topical content in manufacturing programs should ask for relative importance of topics.
6. Education must be tied to the needs of manufacturers.
7. There are issues with the perceptions and/or image of manufacturing education.
8. There is a natural variation between manufacturing programs.

1. The Survey

The survey was distributed by email in a form that permitted anonymous responses. The groups included industrial contacts, manufacturing educators, and others with a relationship to manufacturing education. Given the method of distribution, and the ability to share the survey forms, it is difficult to assess the number of possible respondents, however it is estimated that it exceeded 4,000. In total there were 273 responses providing enough data to be statistically significant. As with any survey instrument there is some bias in the distribution groups, but the self reported data in tables 1, 2, and 3 show reasonable broad distributions. Table 1 shows the response distribution by role. In total there were 101 educators as opposed to at least 70+51+17=138 respondents in non-academic roles.

Table 1 - Responses to “Your Current Role”

<table>
<thead>
<tr>
<th>Role</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consultant</td>
<td>17</td>
<td>7%</td>
</tr>
<tr>
<td>Educator</td>
<td>101</td>
<td>39%</td>
</tr>
<tr>
<td>Manager</td>
<td>51</td>
<td>20%</td>
</tr>
<tr>
<td>Student</td>
<td>6</td>
<td>2%</td>
</tr>
<tr>
<td>Technical</td>
<td>70</td>
<td>27%</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>4%</td>
</tr>
</tbody>
</table>

Table 2 shows the source of the responses. The most notable discrepancy is 117 responses from Colleges that exceeds the ‘educator’ number of 101. This can be explained by the presence of administrators and special interest groups housed within colleges. Notably there were 107
respondents working for manufacturers.

Table 2 - Responses to ‘Your Employer’

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>College or University</td>
<td>117</td>
<td>45%</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>107</td>
<td>41%</td>
</tr>
<tr>
<td>Self Employed</td>
<td>11</td>
<td>4%</td>
</tr>
<tr>
<td>Support Company - e.g., training, consulting</td>
<td>6</td>
<td>2%</td>
</tr>
<tr>
<td>Support Organization - eg., SME, NSF, NAE</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>Other</td>
<td>13</td>
<td>5%</td>
</tr>
</tbody>
</table>

The typical experience of survey respondents is shown in Figure 3. This shows that the responses came from wide range of manufacturing professionals. As expected the number of people decreases with the number of years of experience. The only anomaly in the trend is the 15-19 year group which is somewhat smaller than expected.

Table 3 - Answers to “Years in Manufacturing”

<table>
<thead>
<tr>
<th>Years</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>50</td>
</tr>
<tr>
<td>5-9</td>
<td>50</td>
</tr>
<tr>
<td>10-14</td>
<td>33</td>
</tr>
<tr>
<td>15-19</td>
<td>18</td>
</tr>
<tr>
<td>20-24</td>
<td>31</td>
</tr>
<tr>
<td>25-29</td>
<td>22</td>
</tr>
<tr>
<td>30-40</td>
<td>34</td>
</tr>
<tr>
<td>40+</td>
<td>16</td>
</tr>
</tbody>
</table>

2. The Sense of the Community

There were a set of general questions asked to gauge the atmosphere in the community. The responses from manufacturers and academics are presented separately. The reason for selecting these two groups is their relevance as deliverers and consumers of education. In addition these
are two groups that are large enough to be statistically significant and uniquely identifiable.

i) In the coming years do you believe that US manufacturing and manufacturing education will...... Help the economy
   Overall - agree: 158, impartial: 11, disagree: 3
   Educators - agree: 75, impartial: 5, disagree: 2
   Manufacturers - agree: 53, impartial: 2, disagree: 1

ii) In the coming years do you believe that US manufacturing and manufacturing education will..... Be a political priority
   Overall - agree: 48, impartial: 52, disagree: 25
   Educators - agree: 25, impartial: 16, disagree: 11
   Manufacturers - agree: 15, impartial: 27, disagree: 6

iii) In the coming years do you believe that US manufacturing and manufacturing education will..... Be a social priority
    Overall - agree: 33, impartial: 65, disagree: 23
    Educators - agree: 16, impartial: 22, disagree: 12
    Manufacturers - agree: 10, impartial: 33, disagree: 8

iv) In the coming years do you believe that US manufacturing and manufacturing education will..... Have a better image
    Overall - agree: 31, impartial: 66, disagree: 14
    Educators - agree: 15, impartial: 26, disagree: 10
    Manufacturers - agree: 10, impartial: 26, disagree: 4

v) In the coming years do you believe that US manufacturing and manufacturing education will..... Improve education and industry ties
    Overall - agree: 66, impartial: 57, disagree: 6
    Educators - agree: 29, impartial: 23, disagree: 4
    Manufacturers - agree: 21, impartial: 25, disagree: 2

In brief these results can be summarized as i) there is a sense that manufacturing will have a major impact, ii) the image of manufacturing should improve, iii) industry and academia will cooperate more, but iv) manufacturing education will not be a social or political priority. The notable differences are that educators are somewhat more optimistic about political and social support.

**Recommendation: Manufacturing education needs social and political support to achieve the clear mission of building a better economic future.**
3. The Manufacturing Sector and Processes Priorities

To begin please consider the nature of priorities. A priority indicates needs, or new development. It does not mean that we should diminish the role of other areas. For example ‘welding and cutting’ did not receive any votes as a high priority, but there is absolutely no doubt that this is an essential manufacturing process that must be taught in any manufacturing program. As a warning, do not use this list as a justification for removing content from a curriculum.

Table 4 - Manufacturing Sectors and Processes Priorities

<table>
<thead>
<tr>
<th></th>
<th>Top Priority</th>
<th>Second Priority</th>
<th>Manufacturing Priority</th>
<th>Academic Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additive processes</td>
<td>3</td>
<td>8</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Aerospace</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>** Alternative energy</td>
<td>73</td>
<td>33</td>
<td>51</td>
<td>32</td>
</tr>
<tr>
<td>Assembly and joining</td>
<td>4</td>
<td>9</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>** Automotive</td>
<td>7</td>
<td>18</td>
<td>17</td>
<td>3</td>
</tr>
<tr>
<td>** Biomedical</td>
<td>41</td>
<td>39</td>
<td>36</td>
<td>26</td>
</tr>
<tr>
<td>Casting</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>** Electronics</td>
<td>13</td>
<td>20</td>
<td>20</td>
<td>9</td>
</tr>
<tr>
<td>Finishing and coating</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Forming and fabricating</td>
<td>12</td>
<td>12</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Heavy equipment</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Material removal</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Materials processing</td>
<td>20</td>
<td>18</td>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td>** Nanotechnology</td>
<td>19</td>
<td>39</td>
<td>19</td>
<td>26</td>
</tr>
<tr>
<td>** Plastics and composites</td>
<td>10</td>
<td>18</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>** Production equipment and tooling</td>
<td>26</td>
<td>17</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Welding and cutting</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

** Significant priority, or substantial difference between industry and academic priorities.
The results in tables 4, 5, and 6 show the first and second priority totals for the entire survey group. The results for two groups, academics and manufacturers, were totaled separately. The manufacturers group was identified by respondents who listed ‘manufacturer’ as an employer. The Academic group was identified as those who listed ‘Educator’ as their primary role. The numbers are a total of first and second priorities for those groups. This separation was seen as valuable because it captures the agreement or mismatch of priorities between educators and professionals.

The results in Table 4 address the needs from an industry perspective, using recognized sector names. As would be expected the newer technologies and developments were listed as priorities as opposed to the more established manufacturing industries. Alternative energy and biomedical manufacturing were both recognized as very high demand areas. Other areas of recognized need were all listed and could be used as a crude ranking of priority nationally, but it does not consider regional variations. There were a few mismatches between academic and manufacturing priorities, most notably in automotive and electronics manufacturing.

**Recommendation: Alternative energy and biomedical manufacturing should be very high priorities.**

**Recommendation: Academics should consider curriculum modifications for automotive and electronics manufacturing.**

4. Curriculum Priorities

A complimentary question was asked from an academic perspective, looking at curriculum areas and topics. The distribution of priorities was much more even for these choices. A few areas emerged as priorities including advanced processes, automation and controls, CAD/CAM, lean manufacturing, and product design. As expected academic responses were much more favorable for fundamental education. The manufacturing respondents were much more interested in emerging business and technology issues such as advanced processes, various business topics, and product design. Compared to the previous table these results were much less consistent indicated less alignment between industry and academic perspectives.
<table>
<thead>
<tr>
<th>Study Topics Priorities</th>
<th>Top Priority</th>
<th>Second Priority</th>
<th>Manufacturing Priority</th>
<th>Educator Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advanced processes</strong></td>
<td>23</td>
<td>18</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>Advanced theoretical methods</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td><strong>Automation and controls</strong></td>
<td>36</td>
<td>22</td>
<td>28</td>
<td>24</td>
</tr>
<tr>
<td><strong>Basic science and mathematics</strong></td>
<td>18</td>
<td>8</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td><strong>Basic processes</strong></td>
<td>12</td>
<td>9</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td><strong>Business and management</strong></td>
<td>11</td>
<td>15</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td><strong>CAD/CAM</strong></td>
<td>22</td>
<td>13</td>
<td>11</td>
<td>21</td>
</tr>
<tr>
<td>Communication</td>
<td>5</td>
<td>10</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Circuits</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Costing and economics</td>
<td>4</td>
<td>11</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Ethics and professionalism</td>
<td>4</td>
<td>7</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Instrumentation and metrology</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Lean manufacturing</strong></td>
<td>26</td>
<td>32</td>
<td>29</td>
<td>19</td>
</tr>
<tr>
<td>Materials science</td>
<td>10</td>
<td>15</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Mechanics and solids</td>
<td>7</td>
<td>6</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Production modeling and layout</td>
<td>3</td>
<td>7</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td><strong>Product design</strong></td>
<td>35</td>
<td>32</td>
<td>34</td>
<td>16</td>
</tr>
<tr>
<td><strong>Quality and statistics</strong></td>
<td>13</td>
<td>15</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td><strong>Sustainability</strong></td>
<td>15</td>
<td>14</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>Thermo-fluid sciences</td>
<td>1</td>
<td>7</td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>

**Significant priority, or substantial difference between industry and academic priorities.**

*Recommendation: Academics and Manufacturers should discuss differences in priorities.*
Recommendation: Business topics, automation/controls, product design, and lean manufacturing should be priorities for curriculum changes.

5. Education Methods

The process of delivering a curriculum is addressed in Table 6. There were clear responses that cooperative education, internships, laboratories, and project work are very high priorities. This is a clear message that ‘hands-on’ education is a very high priority. As would be expected there are mismatches in priorities between academics and manufacturers.

Table 6 - Education Method Priorities

<table>
<thead>
<tr>
<th></th>
<th>Top Priority</th>
<th>Second Priority</th>
<th>Manufacturing Priority</th>
<th>Academic Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certifications</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Communication</td>
<td>3</td>
<td>8</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>** Coop or internship</td>
<td>69</td>
<td>35</td>
<td>65</td>
<td>17</td>
</tr>
<tr>
<td>** Distance education</td>
<td>12</td>
<td>10</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>Global study or travel</td>
<td>6</td>
<td>13</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Graduate studies</td>
<td>7</td>
<td>11</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>** Laboratory work</td>
<td>30</td>
<td>29</td>
<td>13</td>
<td>38</td>
</tr>
<tr>
<td>Liberal education</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>** Newer technologies</td>
<td>22</td>
<td>26</td>
<td>24</td>
<td>18</td>
</tr>
<tr>
<td>** Project and design work</td>
<td>67</td>
<td>57</td>
<td>54</td>
<td>48</td>
</tr>
<tr>
<td>** Self directed learning</td>
<td>15</td>
<td>12</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>Seminars</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Teamwork</td>
<td>6</td>
<td>30</td>
<td>15</td>
<td>16</td>
</tr>
</tbody>
</table>

** Significant priority, or substantial difference between industry and academic priorities.

Recommendation: Manufacturers and academics need to prioritize hands-on education opportunities.
6. Conclusions

The survey included three opportunities for free-form comments. These are listed in entirety in the appendices, with identifying language removed. The comments have been separated into three groups aligned with the previous tables. As expected the industrial comments emphasize the need for competency in a manufacturing environment and help facing the current business challenges. Academics, and to the most part other respondents mentioned the many problems facing the academic institutions. This is understandable given that manufacturing education is very much a publicly funded process that serves private industries.

Recommendation: The comments should be read to gain further insight to the quantitative survey responses and better understanding of other perspectives.

References


Appendix A - ‘Manufacturing Engineering Curriculum’ Comments

From Manufacturers

- Manufacturing education must match reality or at least the trajectory of reality. Unfortunately, manufacturing has failed in the US because of unrealistic wage/benefit expectations (the missing value proposition from the labor side which is only answered by a simple cost of labor argument) and hindered modernization (it not economically feasible to modernize yet one will set up a "greenfield" in a developing nation to take advantage of labor costs). We do not teach reality!
- Need to add to the teachings today both a return on investment and how to get along in a factory environment with various team members with different backgrounds and interests.
- Don't forget about the basics. Manufacturing still relies on production drawings. Every Engineering student must be able to produce detail drawings with the correct tolerancing that can be made by a machine shop. As an industry professional, this is the first thing I have to teach a new engineer, right out of school.
- All of the sub-topics apply. Students need to understand the path from raw material to finished goods. This applies to metals, composites, plastics, etc. They don't need to master these topics but need to be aware of all the steps required to connect the links in the chain. A basic understanding of casting, forging, machining, plastic injection molding, crystal growth, finishing processes, rust prevention, coatings, etc will all provide a toolbox filled with methods that allow ideas to be formulated taking a concept to reality. Add the perspective about how companies run and you have a winning combination.
- Create a course that teaches the basics of as many manufacturing methods as you can document. Teach it as an introduction not comprehensive. Expose students to the many ways raw material is transformed. As they progress in their understanding of other engineering disciplines they will begin to see how the transformations of ideas become physical reality.
- Lean manufacturing is another high priority study topic. But until there is a solid understanding of manufacturing plants and operations, the learning could become watered down. I think tied into a co-op program is a great way to introduce and effectively teach this material. Other topics like sustainability, costing and economics, and business management are others that could be integrated with projects in a co-op program. But would require significant cooperation with the business. In any case, the co-op learning method has been a proven winner here at [Company]. Automation and controls, along with Quality and statistics are the highest priority for me, as I've seen the most lacking in new graduates.
- I think it is both difficult and dangerous to try and prioritise like this. A sound basis of science and mathematics should be the priority and then allow this to develop according to industry demands and drivers.
- Whoever answers will always defer to their own preferences and not what is best for the country.
- converting natural resources into products that people will buy
- manufacturing processes and reliability
- cost structure development
- lecture, hands on projects that are real life
- review of existing manufacturing companies and their processes
- Alternative energy is huge and has barely begun. We have so many issues that really haven't hit yet like...sewage sludge, MSW, Pharmaceutical waste. Solar and Wind have just started the awareness.
- I believe some of our brightest young engineers are coming out of education systems where they have the opportunity to coop during there education. The [college], now [college] is an excellent example of a solid well rounded education.
- Tie the educational process to industry ASAP. Real world involvement
- LEAN! This drives most major decisions made in my organization
- Looking back at my experience while in school, I have fond memories of courses, I feel, prepared me for an engineering career by assigning projects that had required objectives and milestones. Those types of work fully prepared us for our own experiences once we graduated and were responsible for our own assignments and workload.
- I think that automotive is a huge part of [region], even though the automotive sector has been up and down, innovation and development in this area would be very beneficial.
- Risk management is an important part of working in industry that I was required to know I needed... but did not yet know. This led to some poor interactions on my co-op. I would like to see some of these considerations made in earlier classes so that risk management is a conscious process on the part of the students.
- Project design
- Automation and Electrical Controls overall "know how" are of the essence. The edge and power these, along with Mechanical, bring to the table are none matched.
● Graduates should have good WRITTEN communication skills and good knowledge of the basic sciences.
● Basic process management that reduces labor, increases efficiency will provide insight not currently available. We need to teach our future leaders how to be globally competitive using technology, resulting in reduced labor.
● Input from manufacturing associations on topics to cover as electives and/or graduate studies.
● The more usable knowledge / experience students have coming out of college the quicker and easier they are to insert into a position and yield productivity. Nothing can replace hands on experience. Teaching theory is great, but with the software out now days, do you really need 3 classes of trig to be a normal Engineer? Leave that for Eng. grad level classes. More labs and projects that force the students to apply the theories they learned.
● Also the students should be comfortable using / understand normal manufacturing acronyms; PPM, PPK, CPK, etc... The students should also be more proficient with the latest software(s) that could aid the employers. Let’s face it, once you get into industry, you use the software you are comfortable with... but there might be something better out there.
● In most cases I would rather hire someone with 2 years experience working in industry over someone with a graduate degree. I also feel that a coop and/or internship experiences are very important. Young engineers need to spend some time getting their hands dirty before starting to work on more advanced manufacturing projects. This builds a good foundation.
● Our business is focused on the integration of mechanical, electrical and software elements. These need to be integrated from design through manufacturing and require engineers who are comfortable in lean manufacturing across these very different disciplines. Additionally the trend toward higher technology manufacturing will not slow. We will need manufacturing engineers who can work on automation and controls required to produce high volume, complex products.
● There are so many important technologies. The classes and methods we use to stay ahead of the global field is really going to be difficult.
● Manufacturing still seems to be on a downward slope. Therefore, I believe that more jobs will be moving abroad and to Mexico. There should be more emphasis during schooling to focus on communications methods and getting tasks accomplished over the phone, via email, or through other means of communication."
● Alternative energy is going to be huge in the near future as corporations and individuals strive to move away from our dependency on fossil fuels.
● a stronger quality and statistics component.
● The best teaching method is supplementing education from a book with hands on experience.
● Promoting Innovation, and effectively using Communication to transfer ideas into reality.
● Engineers have a reputation in manufacturing for always proposing the most expensive options. We need to make sure that future students can balance a cost justification with an optimization model to show why proposals are recommended.
● teach more hands on with the focus of ergonomics to improve how products are made

From Educators

● There is nothing new. Major revisions are required.
● More green and sustainable focus, efficiency and continuous improvement, both process and product
● Leadership, management, creativity and innovation are not in the ABET a-k criteria for engineering accreditation. If you want to improve something, you need to get it into the ABET criteria.
● The Manufacturing Engineering criteria are knowledge based, not ability based. I think they are too specific.
● Focus of manuf. education should be on methods for competing in a global economy
● Need more hands-on real world technologies to enable students to hit the floor running
● Manufacturing Methods and Processes
● PLTW
● CAD/CAM
● Manufacturing Technology
● Mechanical Engineering Technology
● CIM
● Innovation, process of design, communication and teamwork
● I feel that we are way to steep in the theory of math and physics versus the practical application.
● Manufacturing Sectors and Processes - Top Priority: "Automation and Affordable Productivity Enhancements" [Reasoning: Keeping jobs in the US requires working/producing items smarter and faster with less direct labor. This goal is achievable only via intelligently designed and appropriately deployed automated lines.]
● Education Methods - Second Priority: "Multidisciplinary courses" [Reasoning: Engineers, technologists and even technicians need to learn to work in multidisciplinary teams. Our multidisciplinary capstone design/build course—comprised of upper division students from business (management & and marketing) and engineering technology (manufacturing and product development)—has been successfully offered for two decades. Alumni consistently report that it is by far the most “real world” experience we offer.]
● Education Methods - Third Priority: "Faculty/Student Research Opportunities" [Reasoning: There is no better way of intellectually involving students than by including them in aspects of faculty research (basic &/or applied). To make it more appealing (esp to busy
faculties), small internally-funded grants can be used as a means of stimulating activity.

- Manufacturing performance modeling
- Manufacturing process measurement
- Manufacturing process performance analysis and control
- I strongly believe that a solid understanding of the basics is most important. It is critical to understand applications of theory, rather than just theory by itself. Practical understanding is key to grasping the many facets of manufacturing.
- I currently direct and teach for a biotech manufacturing training program, and so I believe that the biomedical sector should be top priority because (1) health care is an issue of national concern, (2) the technical advances in medicine, medical devices, medical diagnostics, nanobiotechnology, etc. are changing how medicine is practiced and hence the products used to do so, and (3) the biomedical sector has experienced considerable growth, even in during the economic downturn, and will continue to do so because of the importance of health.
- Because our local/regional biotech industry is so diverse, our program has focused on giving students critical core competencies in quality systems & regulations, as requested by our industry advisors - technical expertise (e.g. how to perform technical tasks or run instrumentation), the advisors say, industry would prefer to teach. Quality and regulations are fairly "dry" subjects, and our program has chosen to rely heavily on hands-on, practical-based learning methods to most efficiently and effectively teach these topics and to realize the best retention by the students.
- With respect to biotech research and manufacturing curriculum, this field is still relatively young and there are no national standards that can be applied across the nation. This lack of standards makes it difficult to offer industry-supported and -recognized certification of core competencies that is portable to other regions/states/countries. Because of our program's focus on quality and regulations, we will rely on existing accredited certifying bodies (e.g. American Society for Quality) to provide such certifications to our students.
- Overall, I believe that quality and regulations are very critical to proper workforce training. These topics are typically not covered in formal education training programs, but rather left for on-the-job learning, and if you're lucky, your employer's willingness to send you to (costly!) professional development training in these areas. Quality and regulations are very difficult to learn well on the job. Thus, in addition to technical knowledge, manufacturing education programs should also include knowledge in quality and regulations.
- I was a practicing IE for many years before getting into higher educ as a dept head at a community college (14 years)- IE and Mfg engr tech and now CAD design in a 4 year univ. Emphasis should be placed on future technologies, self directed learning, team work and global issues. The basis still needs to be stds, methods etc in which to build future tech on.
- I teach CNC Machining and CAD Design at [college].
- We must utilize new technologies for making education more efficient and more effective. Some of these are technologies being developed for distance learning, but if we relegate it to that arena, we'll have missed the boat.
- Interfacing Manufacturing and Engineering with Business Activities
- AC/DC circuits, digital circuits, robotics and controls. I like to use hands on in all my classes
- I teach machine design, mechanical assembly, electrical power, controls, & robotics. My academic interest is assembly and automation.
- Graduate skills & knowledge????? Mine , what we need, or?????
- Accredited manufacturing engineering & engineering technology programs should be required to have focused courses in kinematics, hydraulics, pneumatics, electronic controls including PLC's, and an integrated course in automation system design which includes the preceding mentioned disciplines, with an intro to mechanical system design with robotics & CNC, sensor technology and data acquisition. These courses must be accompanied with structured, instructor guided hands-on lab experiences. "Open" and self guided labs are a waste of time and a joke. The growth in manufacturing in the USA is in highly automated, high productivity systems using a minimum of human production workers. Our current academic manufacturing E & ET programs are not preparing the graduates for this high tech hardware/software environment. Most programs have too much "soft" content - many look more like IE or Production E, or management programs or devote too much time on theory courses. Let the mechanical & electrical engineering programs handle the theory #2 & #3 courses. do that. Few manufacturing e & et grads could design or even spec a simple electro-pneumatic automatic assembly machine - including industry/government standards & specifications; component sizing, etc.
- Graduates need a broad skill base, to be able to serve as engineers and/or managers, and still be able to comfortably communicate and work with shop floor workers. Management skills, engineering methods, communication skills, and being able to not only model parts but make and read engineering drawings.
- Operations, Supply Chain/Logistics, Quality, Lean
- All mfg. sectors and processes are important to our recovery as a nation. Not sure I can determine which is a higher priority, all have their role. I assume that priorities are mostly driven by regional and political influences and interests. We must be careful not to short change any specific sector or process.
- Engineering
- Tooling should be listed as one of the priorities.
- There is no one method for top priority. Laboratory work, team work, and etc are important.
- We have found that students need expertise in design, in particular the use of 2D and 3D software. Also the integration of additive manufacturing into the curriculum has become a requirement of our programs
The world is passing us by. I've been in manufacturing all of my life. From a production worker, skilled trade, through professor and we have made little progress in staying competitive. Every time economy is good we go back to our old ways of not cooperating and reducing education about manufacturing. We have abandoned the traditional methods of engineering education while China, India, and Europe continue to stress solid math and science. They also have a system for skilled trades with apprenticeships. We have destroyed these in the US for "new" approaches. I offer this question: Just as we abandon traditional education in our elementary and secondary schools we have seen the results of poor performance, why do we thing manufacturing/engineering education will be different?

- Students have to also be taught about value added and where they can contribute to the process.
- Basic skills & overall advanced manufacturing
- Supply Chain Management and better use and management of resources.
- Improve understanding of process flow and manufacturing strategies.
- Requiring all university students to study technology.
- SME should be leading the world in developing modern manufacturing engineering education programs at the undergraduate level. This requires the implementation of SME BS level programs at the top engineering schools in the country. Modern SME curriculum at these schools would then serve as role models for others to implement BS SME programs. SME must provide the leadership for this to happen. Government and industry must both be involved. Government puts up money for schools to write proposals against to develop named SME programs. The schools must find a company or person to match the government funds and thus get the department named after them.
- I believe that advanced manufacturing topics with complete computerization of manufacturing as well as personalized manufacturing should have a prominent place in our manufacturing curricula. While China wants to be "the factory of the world" as a response the USA should be "the master of world technology".
- Very difficult to maintain a balance between pure research, applied research, outreach/consulting, curricular updates, means of instructional delivery, priorities established by states and the federal government with respect to funding, whether to lead or follow, just in time training/education, etc.
- CAD, CAM, Pattern making, composites, forging, casting, materials joining (welding, brazing, soldering, epoxy, polyurethane)
- Mathematics (algebra and trig), Statistics
- Basic electricity (AC and DC), Basic electronics, basic digital circuits
- Students need a strong background in the basics of manufacturing - material removal processes, assembly... In addition to the basics the students should be exposed to nanomaterials, composites, electronic manufacturing and other specialized 'advanced' processes and materials.
- Most students are woefully inadequate in analytical and constructive skills. Ban multiple choice tests. Make students design and build things to solve problems. The most important thing a student will learn is how to learn on their own (educators hate to hear this) Stop trying to evaluate the curriculum 10 minutes after the student graduates. An educator won't know if they succeeded until five years after the student graduates.

From Others:

- Teaching should be project based; allowing students to create, design (draft), and manufacture a worthwhile idea into a practical finished project. Increasing the level of difficulty with each year of education
- emphasis on team-projects with effective individual accountability for contribution, co-op experiences that are coordinated with the student's current educational coursework.
- The most important and relevant skill that the industry needs but is completely absent in virtually every graduate is the ability to THINK! System thinking, complex problem solving, change management, robust engineering are highly recommended.
- Communication (incl. presentation, public speaking, etc.) skills are paramount for success of an individual. It does no matter how brilliant their ideas are if they cannot sell them.
- Communication. Management. Ethics. Morals. Motivation. Leadership. These are all extremely important for the engineering field. Being able to tackle issues both from a technical side AND business side sets individuals apart.
- US costs cannot compete with China (10:1 for tooling and piece price in most assemblies that include injection molded components). Even the importing only costs $6-8,000 per 40' container, door to door. Our only competitive advantage is technology and advanced manufacturing processes. Unfortunately, China is catching us at an alarming rate. We must focus our college educating on advanced processes and product development.
- On education methods, I believe the biggest impact will be in the restructuring of how and what we teach in technology curriculums. In electronics I am pioneering systems thinking concepts and the top-down approach to teaching technology topics. For students today they need to be able to see the big picture or systems view first before they even begin basic technology courses. In electronics this might be an entertainment system where you consider all the components, (LCD TV, audio surround sound, satellite or cable...) as a complete system and then go into more details of each component. From here every time a new topic is introduce you refer back to the systems view and talk about where in the system this topic is found or is used. Students walk in to class with an iPhone and we sit them down in their first lab activities breadboarding transistors, capacitor, resistors... which we do not use anymore due to advances in semiconductor manufacturing processes. See www.esyst.org for more details.
- Principles of Machining; Casting and Forming and Joining. Lecture plus hands on labs in all three. Freshmen engineering technology
courses. Establishing fundamentals.

- Education needs to be more focused on what will be important to the US in the future. Things like sustainability and renewable resource manufacturing should be focused on more.
- Too many factors involved to pick from the list. The priorities are unique and subjective. Each one on the list will be a "top priority" to someone based upon his needs and other pertinent factors too numerous to mention.
- All indications are that the direction of global need will be headed in the direction of providing basic life support for the masses with limited resources. Manufacturing education needs to start producing engineers that can find ways to deliver basic life support (water, food, shelter) to the millions of people with little or no resources. As fossil fuels and minerals become more scarce, fewer and fewer people will be able to obtain the basics, let alone transportation or entertainment, unless new products which use fewer resources are developed and manufactured.
- Community integration with manufacturing, community sustainability and methods of utilizing community support. (Analysis of the give and take between the manufacturing community and local resources, symbiosis on the local to state level alongside lean manufacturing).
- In my opinion the focus on lean manufacturing and outsourcing has focused solely on cost minimization without factoring in the benefits of local resources into the equation.
- What is the epistemological framework of manufacturing education. No one really seems to know. Manufacturing seems to get lost in all the more "sexy" engineering core programs (i.e., mechanical, aerospace, bio, etc.)
- Production of pharmaceuticals, medical devices and diagnostics according to FDA regulations. Teach skills necessary for entry level hourly employee.
- A push for global engineering needs to be made. I have been the first student at my university to ever intern outside of the United States and only the second student to ever study abroad in the last 20 years. The engineering department has the worst study abroad record for any discipline at our university. I see this as a common trend among universities.
- A standalone manufacturing degree which might help. I also think that going on site to observe these processes and getting the chance to ask questions from industry would be beneficial.
- Today's product development and manufacturing are trending towards ever more sophisticated output. Manufacturing, product design, business, materials engineering, embedded & non-embedded software, etc. should be taught in a manner encouraging cross-fertilization and bringing about exposure to multidisciplinary thinking in product & technology life cycles.
- The students coming into industry today need to have the experience that comes from a lot of projects and laboratory work. The industry is changing in such a way that just having the theoretical or book versions of things is not going to cut it. Students NEED that hands on work that comes from projects and comes from laboratory work so that they can experience problems that they might encounter in a manufacturing environment.
- Students need to learn how to start their own businesses. More emphasis needs to be put on the patent process and laws. Students need to learn how to take their designs and develop their own business models to produce them.

Appendix B - ‘Industry Interaction’ Comments

From Manufacturers:

- We need to figure out how to get these students into our businesses and then keep them employed for the long term.
- We need people that can roll up their sleeves and work in the trenches, doing the mundane work well, with the prudence to see the big picture and identify trends and anticipate problems or opportunities. This is not easy and often comes with experience, however dedication and a strong work ethic cannot be discounted. Engineering does not advance on instantaneous gratification despite the acceleration of communications and technology in general.
- Industry and educational institutions need to continue to maintain partnerships including student internship at factories and businesses.
- I believe that for manufacturing in the future must tackle higher technology sectors like Nanotechnology and Electronics in order to stay competitive, and at the leading edge in the global economy.
- Industry needs to be more involved at a practical level in interacting with students. Educators are just that and will always be removed from the hard realities of the workplace.
- Industry also needs to accept vocational routes to excellence. For every ship their is only one captain but without the technicians in the engine room no-one is going anywhere.
- This country doesn't need more managers and MBA’s, it needs people who are educated, practical and can implement ideas in the workplace.
- For the individuals who are currently employed in the industry for which they are training, they should be able to get credit for their co-op education without having to pay the tuition fees. The university's contribution in this situation is nil.
- The interaction of materials and processes to develop new technologies and products.
- The benefits achieved through the various semester projects in other engineering classes was invaluable to my experience as an engineer. The position I fell into as a co-op completely changed my mind, in a positive way, towards finding what exactly I wanted to be doing further on in my career.
Need to focus on technologies and products that cannot be easily copied. We need to get the US back it's technology advantage in areas that foreign interests cannot duplicate easily. A key differentiator between the US and Asian competitors is our hands on knowledge. We need to leverage our schools' ability to get students the hands on application experience gives us an advantage.

- Co-op's are very valuable
- Contributions: Interns / co-ops / job shadowing.
- Needs: Engineers eager and able to fill a position with minimal learning curve.
- Trends: Engineers that can fill multiple disciplines...ex. Design / Mfg / Quality all in one. Keeps overhead down, reduces communication issues, relies on very organized individuals (multi-task).
- Overall industry and society needs to put a higher value on innovation and innovative technical people. I read survey a couple years back that reported that most wealthy people would not encourage their children to enter a technical field because they could be better elsewhere. If you examine the wages structure in industry you will find that less technical people are in higher paying management jobs mainly because of their people and networking skills. Often times the only way for an engineer to get up to the next level is to take on a management position that is not the best fit and where too much time is spent on administrative matters. Sorry for rambling on...this really isn't what you are looking for.

- Our business needs to be more involved in cooperative education on the manufacturing side. Operators, team leaders and manufacturing/process engineers would all benefit from this interaction. The manufacturing industry needs to be clearer with the education community in what their future needs are likely to be. One of the best ways to do this is through the co-operative education programs, where the students see first hand what the future of the business is and can drive that as consumers of the educational products offered by the university.
- Toyotas made their name in the market on quality of products. We need to be concerned about creativity, quality and integrating electronics with biotech with chemistry and other fields. More training across fields will lead to more creativity and innovation.
- Who ever thought electricity could a lightbulb without wires. No one until recently.
- We need to show that US manufacturing is superior to outsourced manufacturing. This is the only way manufacturing jobs will be brought back to the US.
- Academics needs industry and industry needs academics... the greatest challenge facing the US is overcoming the loss of a "knowledge pool" that was in stronger existence when the manufacturing sector was itself stronger.
- Competing in a Global Market, Process Control, Communication.
- Lean culture is as crucial to a manufacturing environment as lean tools are. Please don't confuse our future engineers and present lean manufacturing as a tool kit only.
- more interaction with industry at an earlier time in the education process

From Educators:
- Very weak. Major emphasis should be given.
- Industry needs to commit resources - materials, equipment, processes
- Industry trends here are to cut back on helping education but still expect to get good graduates.
- Most job openings will be in High Tech technologies and automation and controls.
- Internships
- Could use more. It's difficult to time industry needs with student availability especially when enrollment is low
- Industry needs engineers no doubt. I feel there is also a need for Engineering Techs.
- Once they get enough money to start funding grants and such, industry partners could fund institutionally awarded mini-grants for innovative programs and research activities. It won't hurt at all if these grants could purchase not only supplies and equipment but faculty's most cherished item: time (in the form of one (1) course of release time for, say, one academic semester).
- Trend (bad): State legislatures are already pressuring public higher ed institutions to increase "academic productivity" (e.g., increasing the numbers of B.S. degrees awarded within six years with no corresponding increases in full time faculty, academic infrastructure, or tuition assistance (for students)). Industrial partners should stand firm with faculty and accrediting agencies to ensure that sufficient curricular rigor and state-level support remains for both engineering, engineering technology, and other STEM programs. Primary and secondary education is already in a sorry state of "teachers teaching the tests" and pushing out ill-prepared, non-critically thinking high school graduates. Unfortunately, without the help & support of industry, things will be getting worse.
- Although we hear a great deal about the interaction of industry and academia, the reality does not seem to optimize the real opportunities that exist. It is more sizzle without the steak. When manufacturers are increasingly providing opportunities overseas while the domestic market contracts, while at the same time educational funding is decreasing, it appears that we will soon reach a tipping point that may have already been reached in regard to students here being able to deliver on increased activity in the United States as compared to the rest of the world. The idiom "think globally and act locally" has seemingly been lost in the rhetoric of what is actually occurring.
- "A strong relationship between industry and education is essential to effective manufacturing education training.
- While our local industry has been fairly good about answering questions when we ask, our relationships can be more actively engaging. It is important not only for industry needs to be heard by education in order to respond appropriately in a timely manner,
but also for education to be heard by industry in order to inform industry of the limitations that local community colleges & universities, and other training programs may have in fulfilling industry needs, and how industry may be able to help regarding these limitations.

- Fostering strong relations will certainly help education programs help industry, thereby improving workforce training and the community as a whole.
- Co-op, guest speakers and plant tours etc so students can see the past, present and future with example plants in mfg. etc.
- Biomedical exploding and automation / automated systems.
- Industry needs some casting engineers as well but not that many needed in the US overall.
- Guidance on implementation and evaluation of software and soft technologies
- Co-Op or internship in a manufacturing environment should be a requirement for graduation in the manufacturing engineering field.
- Industry needs employees that are competitive in the global workforce and thus further justify keeping jobs in America. Manufacturers need to partner with local and regional universities and trade schools to ensure quality graduates, promote research and development, and take an active role in the educational objectives for the upcoming workforce.
- Lean in its various forms
- In order to continue producing qualified industry professionals, manufacturing education programs need more direct financial and in-kind support from Industry. This becomes more and more important with on going budget cuts by the states and in turn by the Universities and Colleges. Chasing research dollars, while helpful in many ways, does not solve the problem. More industries need to invest in the process as well. It is not always high dollar items that are needed.
- every other country has strong industry/education relationship
- Industry needs to advocate for manufacturing education, educators can no longer do it alone. Given the aggressive budget cutting in education that has started and continue for years to come, I fear, the few remaining manufacturing programs will be closed or absorbed by larger programs such as mechanical.
- Industry must play a primary role in the development of curricula for our programs - in particular we need to be sure that the graduates of our programs have the requisite skills that industry has identified for entry level manufacturing engineers and technicians.
- We also have been able to solicit industry support for student internships; part-time employment and scholarships.
- Industry, education, and government need to abandon the short term thinking of training for today and re-focus on long term education. Jobs will change with technology, but well educated individuals will adapt. I don't mean just formal education. Life long learning in all fields
- Industry has to support education through internships, scholarships, input to the curriculum, and other means.
- Importance of manufacturing on the economy and promotion of manufacturing in
- high schools and middle schools.
- Students who are better prepared for college.
- More emphasis on application based science and math in high schools.
- We are finding HS less prepared for our technology related courses.
- Students no longer spend time working with things or on hobbies, etc.
- Industry support for technology in the communities, high schools and colleges so that students can learn by doing.
- America is still number one in manufacturing. The number of manufacturing jobs will continue to decrease as we implement more automation and automation as part of the lean manufacturing revolution. The whole objective of the lean production system design is to minimize material (inventory) and people by reducing waste everywhere. This revolution requires a new brand of engineer. I call him the lean engineer. He knows all the basics of manufacturing engineering and all the basics of lean manufacturing as well. To design and implement manufacturing cells, he knows about machine design, tool design , cutting tool design, process design, in-process inspection, design of poka-yokes and decouplers and preventive maintenance.
- In a knowledge-based society like ours, industry and technological education are locked together. There is no success of one without the other. Brilliant engineers that drive our economy don't just appear from nowhere. Our students need state-of-the art equipment to succeed. Given that to create an engineer costs much more then to create any other major - industry must help in this efforts, both with direct funding and indirectly by advocating at the federal level for increased funding of all of engineering education.
- Small engineering programs constitute about 70% of the engineering education base. These are often overlooked when funding is concerned. Industrial partners (all branches of industry) should strongly support these programs.
- advisory board, co-op positions, internships.
- Co-ops and internships. Students need to get their noses out of their Text devices and Blackberrys and get into the real world. They need to fail and have their feelings hurt and learn how to get back up and keep going. This applies to the faculty as much as the students. Get them out there, too.

From Others:
- As part of the projects, students should be encouraged to partner with participating employers. Through partnerships with local or regional industry allow students to survey/intern or work at industrial firms. Conduct project development in partnership with the needs of local businesses or the needs of community based organizations.
● Engagement in co-op experience design, participation if student chapters of professional organizations, site tours, capstone projects, guest lecturers.

● It is essential to understand that the University customer is not the student (it is a product) but the industry. Working with customers, discovering their future needs and shaping your product to satisfy these needs assures success of the product and hence the University.

● To help make students ready for their careers, continuing to encourage internships is a must. I would encourage students to have as many as possible - with different companies. The more base knowledge coming out of school the better.

● Students must have better command of verbal and written communications. Presentations, reports, studies, etc. from current graduates are woefully inadequate. Industry should not have to teach communications, it should only have to show style requirements.

● MORE TOURS OF LOCAL MANUFACTURERS!!!

● Industry could contribute to education of faculty with externship programs to share their latest technology so it can be brought into the classroom. Industry needs technicians and engineers that can think from the systems perspective. No longer do we have just electronics techs, mechanical techs, equipment engineers... All of these positions need to know all aspects of the systems they will encounter when they graduate.

● Restart of hands on programs to train our next generation of machinists, welders, etc.

● Systems thinking needed to achieve national competitiveness in manufacturing. Succeeding in a way that reestablishes a sustainable balance of trade is this generation's Sputnik challenge. That has to have an effect on curricula.

● Global, global, global...

● Flexibility is required to respond to the dynamics involved.

● Industry will continue to turn to schools to reduce their labor costs by: 1. Producing more graduates than can be employed. 2. Relying on schools to preform research and prototyping at low cost which would otherwise need to be undertaken by industry staff.

● Future product innovations seem to lie with the development of scientifically complex or high tech fields such as alternative energy.

● Medium complexity goods seem likely to remain overseas as outsourcing of medium complexity designs or design improvements benefit most from the level of training and lower wages of overseas firms, justifying the difficulties of outsourcing mid to high volume products.

● I see a shift away from global sourcing of simple manufactured goods and low quantity production runs. This will likely indicate a return to local sourcing of such products due to the complexity, cost and delays of outsourcing such products.

● Academia needs to do a better job at getting engaged in industry. Academia is there to serve industry, not the other way around.

● [State]’s bioscience industry very involved in developing implemented curriculum across the state

● Like i said, i think we should have more interactions between industry and students directly.

● Given that the US economy tends to be rooted in innovation and invention, towards reinvigorating and reinventing manufacturing, I believe serious focus should be given to the emerging disciplines of 3D printing, advanced rapid prototyping, cost-effective small production runs, remote manufacturing, and other techniques to support an invention culture of the future.

● The way that the manufacturing industry is going is that it wants to be able to do more with less. The industry is leaning towards manufacturing that uses less people, more automation, and makes a high quality product. Long gone are the days were there where multiple engineers on a project. The future engineers need to be confident in their abilities and confident in their decision making

Appendix C - ‘Other’ Comments

From Manufacturers:

● Last year's comment on state or federal funding for internships and co-op positions is right on the mark. However, I strongly recommend those are timed for summers between major semesters and allow engineering students to get on a 4 year track. Coming out of college with a great GPA and the equivalent of a house mortgage in debt is not a good system. Get on a 4 year track and support students along the way. This permits me as a manager to plan for summers when the work load bogs down (vacations) and students in other disciplines are looking for work.

● The US people (and government) must recognize the high return on manufacturing jobs. They must also recognize, high school education will not provide the job pay it once provided. College level education and higher public emphasis on the "coolness" of manufacturing will help us increase and improve our manufacturing base.

● Manufacturing and the utilization of our natural resources is critical to the survival of our country and its perceived standard of living. Schools play a key role in educating the public of this necessity and limiting regulation to make it possible and profitable.

● Do not abandon the fundamentals of science and math. These foundations are the keys to logical thinking and solution generation

● I would have loved to have had more upcoming technology taught through the engineering departments. Programming in Java seemed outdated 5 years ago and is near useless now. More hardware-software interaction would have been very helpful for any computer engineer. While I feel that there were some fundamentals that needed to be taught, I feel like they're lost on CE's. (Statics, for example).

● Co-op was the most important part of the education process, it gets you into the industry early with your name out there. Also provides a good way into a career, whether it be through your own co-op or through another students co-op who recommends you to their company.

● We simply cannot be globally competitive until management and industry owners allow manufacturing to reduce labor. Develop better
business process and reduce labor costs to a manageable level. Use comprehensive accounting practices that include total cost when deciding if China parts are a good decision.

- I cannot see any specific direction that the economy is heading at the moment. I think that for the next couple of years, specifically in [region], less emphasis will be placed on automotive.
- China's manufacturing power is dominating the world. Yeah, a lot of what they generate is substandard goods (read: poor quality) but unfortunately people all over the world are buying it because the knockoffs are much cheaper than the major brand goods. Need to find out what goods people are willing to pay extra for and go after that instead of trying to compete on commodity type product. When I was growing up the phrase "jap crap" was commonly heard. Back then it was the Japanese manufacturing that dominated. Eventually labor costs went up and the Japanese could no longer compete in the manufacturing sector. They are now dominating the automotive sector due to styling, cost, automation and reliability.
- Get manufacturing back in the US by learning from the past and how other countries dealt with it.
- My viewpoints come from the development engineering side and extensive experience with cooperative education in development engineering.
- For those of us in the working in the manufacturing field we need to stay on top of new technologies through on-line classes. People do not have time to commute to classes or seminars. A number of companies have video or conference capabilities to use. As a university you could offer a technology expo for biotech advances, for nanotechnology advances, for flexible chips technology or other exciting new process/products.
- Need to have the right people in the right jobs by using teamwork and technical skills.
- The world is getting smaller so working together well is going to create a better product, work place and world.
- I think another important point is the perception of education compared from our country to others. Speaking in generalities, in the US education is perceived as a "burden", in many other countries, education is an "opportunity".
- Typically engineering educators reward a complex solution and extended explanations that may or may not find resolution while manufacturing rewards simple solutions that can be achieved quickly. This culture can and should be brought to the classroom.
- The people that manufacturing engineers work with are rarely other engineers. Typically they work with people with little or no education, skilled trades of a tech school/hands on background, and some business school grads. Being able to communicate effectively in a manner that those that are not engineers can relate and understand is critical for success. Manufacturing engineers need to be able to communicate in simple terms as well as complex.

From Educators:

- Need to bridge the gap for interdisciplinary manufacturing.
- The government at all levels needs to make the same commitment as is expected of industry.
- You should design the survey so the importance of each of the times could be rated, rather than chose two items and use the comment boxes.
- Robots, robots, robots.
- We must excite young people about the myriad opportunities available in the manufacturing sector. We have not done a good job of that during the past 50 years. Professionally I have articles both local and regional that decry the dearth of skilled workers during that time and yet positive gains are not seen. We will see other articles with the same complaint during this decade and we will collectively shake our heads and say "what is wrong with manufacturing?" And with a deep sigh, we will form another committee to examine the problem and likely come to no new conclusion or solution. That is sad indeed.
- My general opinion (see above) may be too optimistic as there still appears to be a somewhat negative perception of the manufacturing industry as a whole - I am still hearing parents of high schoolers counsel their children not to enter the manufacturing field because they feel it only provides dead-end jobs. Educators need to help change this perception. With the number of manufacturers (esp. in the medical device sector) moving manufacturing back to the US from overseas due to quality issues, we need more people willing to train for a career in manufacturing.
- Mfg is vital to the US and nobody is going to realize this until we are a third world country and have to start mfg parts for other superpowers!
- Manufacturing sectors: energy equipment (wind turbines, batteries, etc.)
- Promote ALL manufacturing programs (Manufacturing Engineering, Industrial Technology, Trade Schools, etc.)
- Market programs at the high school level
- Emphasize the basics (i.e. blueprint reading) along with advanced topics
- Set up government/industry/academia partnerships
- In general we get what we pay for and the salaries in Manufacturing are much lower than in business, medicine, sports, and etc. The priority for manufacturing in not very high - a top athlete is paid 10 times or more what a top manufacturer is paid. The finance executives are paid considerably more than executives in the same size of manufacturers.
- We have also observed the need for students to be introduced to lean and supply chain curricula. Professional skills especially team building need to be an essential component of the courses and labs.
- The introduction of entrepreneurship also has been raised as an important component of our programs and we are exploring the
development of entrepreneurship courses and program options for our manufacturing programs.

- Manufacturing has a bad name because of outsourcing. The US has an internal Tariff on manufacturing; Social Security, Unemployment Insurance, Health Care...Get rid of this tariff on US manufacturing, and we will blow the Chinese out of the water. We need less internal regulation and more external security. (It's their damn job anyway.) The other thing: Get the government OUT of education. They are a hindrance more than a help.

From Others:

- Strong emphasis on how to build, manufacture the projects. need students to understand financial aspects of decisions, material and process choices
- The most basic of academic preparation is woefully lacking in the bulk of ALL individuals enrolling in career-technical education programs at the post-secondary level. Sadly, close to 25% of the total number of credits a student needs to register for in a two-semester diploma program are for purposes of remediation, which adds another full semester to a two-semester diploma program.
- Overall, I feel that the focus of education should be on the industries where manufacturing excellence are required for continued prosperity and growth. We are in a global economy where cars and medical needs are not going anywhere. The production may shift from country to country, but overall the production demand, and thus the expertise to make more efficient, will still be prevalent
- Needs are changing at an ever increasing pace. New technology creates new needs. Industry and academia will have to keep pace with the changes and be flexible in order to respond in a timely fashion. All of the items on the above lists will be important to someone. Academic institutions should endeavor to become leaders in the area(s) in which they have been developing expertise and partner with relevant industry. Resources are limited and must be allocated where the return will maximized.
- (Employer- Other, Field-Other) - indicates that I am a patent attorney, with 10+ years of prior history as an engineer. My current role is now to support and assist with local manufacturing firms by securing their intellectual property rights and by protect their innovations.