

## **AC 2009-1371: MANUFACTURING EDUCATION LEADERSHIP FORUMS**

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# **Manufacturing Education Leadership Forums**

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## **Abstract**

Two invited forums were held during 2008 to explore the future directions for educational programs that include *manufacturing* as a major content feature. The forums were organized and conducted by the Manufacturing Education & Research Community of the Society of Manufacturing Engineers (SME) and many of the planners and participants are also active members of the ASEE Manufacturing Division. The recent activity builds on significant work done during the 1990s that resulted in documents that have made large impacts on manufacturing education. This paper will summarize the goals, agendas, and results from these forums. Topics included are:

- Emerging technologies in manufacturing
- Industry needs from manufacturing graduates
- Bridging research to classroom
- Emerging methods of educational delivery
- Manufacturing topics in non-manufacturing named programs
- Manufacturing education programs; associate, baccalaureate, masters
- Integrating bio-, nano-, and electronics-manufacturing in curricula
- Manufacturing education within non-manufacturing named programs
- Pipeline development and recruiting into manufacturing careers
- Collaboration among relevant professional societies with interest in manufacturing

The two forums are part of a longer term plan for regular similar gatherings and larger, open-attendance conferences. Plans are being developed for a large conference in the summer of 2009.

## **Overview**

There has been massive change in global manufacturing professions. Many skills taught a decade ago are now obsolete and have been replaced by a number of new demands that are as yet inconsistently addressed by educators. These changes have resulted in a new urgency to keep manufacturing education healthy and forward focused as the core of the manufacturing engineering field continues to be essential to the success and growth of industries worldwide.

In the first SME meetings on manufacturing education strategies in more than a decade, invited delegates examined key issues for post-secondary learning in manufacturing for the 21st century. The Forums assessed progress and changes in manufacturing education since the landmark "Curricula 2000"<sup>1</sup> and "Curriculum 2002"<sup>2</sup> workshops held in 1989 and 1994. They had set the crucial groundwork for a) widespread improvement in both content and access and b) a future comprehensive conference on manufacturing education. Building on the assessment the group decided to move forward on expanding the discussion and formalizing the results.

The first forum "Manufacturing Education Leadership Forum: Vision for Progress" was held June 26-27, 2008 at Robert Morris University, Pittsburgh, PA<sup>3</sup> with the purpose of examining the current state of manufacturing education, and deciding what steps should follow. The next forum "Manufacturing Education Leadership Forum; Moving Forward"<sup>4</sup> was held at Farmingdale State College - SUNY, Long Island, NY, November 13-15, 2008 with the purpose of examining curricular and technology issues. From these forums has emerged the upcoming "Manufacturing Education Transformation Summit 2009"<sup>5</sup> to be held at the University of Texas - Austin, June 16-19, 2009 with the purpose of expanding the group involved in the discussions of manufacturing education. All of these activities have been tracked through a Wiki site<sup>6</sup>, that is used by the group as a focal point for activity, and a place for others to contribute and steer the process.

### **Manufacturing Education Leadership Forum: Vision for Progress**

Key objectives of this Forum were to illuminate critical linkages among manufacturing education, a vibrant industrial sector and a healthy economy, and development of guidance for vitalizing college and university manufacturing education programs. Invited keynote speakers and panelists provided perspectives and challenges for delegates to deliberate. The principal business of the Forum was conducted through a series of invited panels, discussing emerging manufacturing technologies; research-to-instruction bridging; methods of delivery; program design; curriculum content; manufacturing education for other disciplines; attracting students. The Forum resulted in the groundwork for educators, administrators, industry planners, and public policy makers.

The forum began with a review of the previous work done in the Curricula 2000 and Curriculum 2002 documents and a challenge to assess the current state of manufacturing education and set the stage to move forward. The following were designed to lead to a final set of conclusions. In brief the sessions were;

Session 1: Addressing Emerging Technologies in Manufacturing Education - The focus was manufacturing in the 21st century and identifying topics that define the manufacturing curriculum of the 21st century. Panelists explored emerging manufacturing technologies and their integration into manufacturing curricula and other disciplines in engineering and engineering technology education.

Session 2: Bridging Research-to- Classroom - Recommend ways in which research in manufacturing can be quickly and effectively transferred from research projects or industry developments into manufacturing curricula.

Session 3: Emerging Methods of Educational Delivery - Alternatives to lecture-based instruction; activity- based learning; project-based learning; case-study based learning; role of laboratories – projected changes, distance learning – Web based; distributed hybrid; role of cooperative education; internships; industry-based education; continuing education, etc.

Session 4: Manufacturing Topics in Other Engineering Disciplines - Manufacturing immersed in other (non-manufacturing-named) engineering curricula (mechanical, industrial, electrical, etc.) including the essential principles and practices of manufacturing; discipline-specific aspects of manufacturing (Mechanical, Electrical, Chemical, etc.); curriculum design to ensure that all engineering graduates obtain adequate knowledge and skills in manufacturing along with their primary discipline, and; global education for manufacturing professionals.

Session 5: Enhancing the Manufacturing Career Pipeline - Increasing the intake of qualified and interested people into manufacturing education programs and manufacturing careers.

Session 6: Manufacturing Education Programs (Three parallel working group sessions in different rooms) - Developing an outline of a plan (an agenda) for revising the curriculum 2002 plan through future MER Community events including conferences, workshops, forums, webinars, etc. This included developing new strategies, replacement strategies, and definitions. The 'first-level topics' would set the basis for a more in-depth examination in the later forum.

6a. Associate degree programs in manufacturing, manufacturing engineering technicians and programs and development for non- degreed manufacturing personnel.

6b. Baccalaureate degree programs in manufacturing, manufacturing engineers and manufacturing technologists.

6c. Post-baccalaureate degree programs and research in manufacturing.

The forum concluded with a planning session to suggest and prioritize strategies. The top strategies suggested are listed below in the order of priority.

1. Conference/workshop (industry and education).
2. Develop a group of Manufacturing program leaders.
2. Form customer focus groups to obtain info and validate initiatives.
3. Secure "product design/development" theme.

- 4. Excellence in teaching (not technology).
- 4. Develop a plan based on Product Design.
- 4. Develop a Wiki.
- 4. Image/credentials improvement and expansion.
- 4. Globalize SME and MFG engineering education.

Based on the outcome the group decided to move forward quickly to set up a following forum to do more planning and set the stage for a following conference (the Summit).

### **Second Manufacturing Leadership Forum: Moving Forward**

The forum hosted representatives from manufacturing industry, government, educational community and the Society of Manufacturing Engineers. A total of about 60 people participated in the forum over three days. The objectives of the forum were:

- Build on the earlier curricular development work that resulted in “manufacturing curricula 2002” document.
- Make substantial contribution to Curricula 2015.
- Expand on the work done at the 1<sup>st</sup> Manufacturing Leadership Forum at the Robert Morris University, Pittsburgh in June 2008.
- Explore the role of advanced technologies in the manufacturing curricula.
- Identify competencies and skills needed for nano/bio/electronics/energy and other advanced technology based manufacturing industries.
- Specify curricular elements needed to address the competency requirements of nano/bio/electronics/ energy manufacturing.
- Explore the means to enhance the inflow of students to manufacturing programs.
- Engage industry in enhancing the scope of manufacturing education.
- Consider the impact of “globalization” on the future of manufacturing education.
- Lay the foundation for a larger manufacturing conference in 2009.

The forum included two workshops, three key note addresses, three sessions on the integration of advanced manufacturing technologies, and two working group sessions on manufacturing education and strategies for future. The workshops covered the following topics: a) nanotechnology and b) dental manufacturing. The keynote addresses discussed the following issues: a) Measurements, instruments and standards for nanotechnology, b) Concepts in Energy Manufacturing, and c) Globalization: A Vision of a New World. The sessions on the integration of advanced manufacturing technologies covered the following topics: a) Biotechnology and Manufacturing, b) Nanomanufacturing and c) Electronics Manufacturing. The two working

group sessions covered the following subjects: a) strategies for outreach to K-12 student population, and b) curricular models for manufacturing.

The workshops provided an insight into the recent developments in nanotechnology and dental manufacturing. The nanotechnology workshop presented the scientific and engineering foundations needed to work with nanomaterials, nanomanufacturing processes, and nanometrology. It also presented the issues pertaining to product design, manufacturing processes, and the forces that will drive the use of nanotechnology in the future. The workshop on dental manufacturing presented the nature of the industry and its evolution, a study of the materials used to create dental structures, an overview of fabrication technologies employed in creating dental structures, the relationship that exists between traditional manufacturing techniques and the biocompatible material processing, and the challenges that exist in dealing with dental manufacturing at the macro, micro and nanoscale level. This workshop also included a tour of an engineering facility dedicated for dental manufacturing.

The keynote address on Measurements, Instruments and Standards for Nanotechnology made a strong case for the application of metrology in developing and implementing nanotechnology. It discussed the ramifications of establishing standards and developing measuring instruments on manufacturing at the macro, micro and nano scale. It also discussed the evolution in microscopy that has resulted the current measuring devices and the standards for nano scale products. The keynote address on energy manufacturing dealt with the use renewable energy sources and the technologies available to harness those. The address focused on the use of algae to produce biofuel. It presented the scientific principles and the process used to manufacture the fuel. Algae need water, sunlight and carbon dioxide to grow. The oil they produce can then be harvested and converted into biodiesel. The algae's carbohydrate content can be fermented into ethanol. Both are considered to be cleaner-burning fuels than petroleum-based diesel or gas. The keynote address on globalization dealt with the challenges and opportunities for manufacturing. It made a case for exploiting the opportunities and strengthening manufacturing.

The sessions on the integration of advanced manufacturing technologies presented the current and future needs for skills and competencies in the areas of bio, nano and electronics manufacturing, and the role of education in preparing graduates to meet those needs. Specifically, the following were the recommendations from the three areas:

a. Bio-manufacturing technologies

- develop skills in process design, validation, metrology, upstream processing, downstream processing, quality control microbiology, quality control biochemistry, quality assurance, facilities, environmental health and safety
- create a global biomanufacturing curriculum and develop instructional material repository that will be accessible to anyone, anywhere
- leverage the current regional / national biomanufacturing infrastructure to develop skills needed in industry

b. Nanomanufacturing technologies

- Areas of skills requirements to be met:
  - Nanomaterials
  - Passive and active nanostructures
  - Multi-state nanomachines
  - Nanomanufacturing processes
  - Nano-enhanced products
  - Bio-nano-info convergence
  - Applications in consumer / food, transportation, information technology, industrial/construction, energy/utilities, healthcare
  - Technology driver issues: performance, size, cost and applications

c. Electronics manufacturing technologies

- Electronics manufacturing engineering requirements in industry:
  - Human Machine Interactions
  - Diagnosis and Prognosis
  - Intelligent Automation
  - Intelligent Transportation System
  - Manufacturing Execution Systems
  - Networked Embedded Controllers
  - Machine-to-Machine interface
  - Condition Based Maintenance
  - Multi-Agent Systems
  - Use of sensory inputs
  - Increase in computing power and speed
  - Artificial Intelligence
  - Smaller, Faster, Lighter Products
  - High level of performance
  - High density packaging
  - Superior thermal management
  - Low cost material sets

- Improved reliability
- skills needed of engineering personnel in the electronics manufacturing industry:
  - Process knowledge
  - Product quality
  - Talent / people management
  - Cost management
  - Equipment uptime
  - Inventory management
  - Product changeovers
  - Time to Market
  - Lean – manufacturing, development....
  - International operations – for all sizes of companies
  - International communications

The working group discussions resulted in recommendations on strategies for outreach to K-12 student population, and curricular contents The following are some of the recommendations and conclusions:

- a. Procedures for outreach to K-12 students
  - The need for outreach
  - Target age for outreach
  - Attributes of a good outreach program
  - SME's current approach to outreach
  - [SWOT of outreach efforts](#)
  - [Benchmarking of SME's outreach program](#)
  - [Metrics for success](#)
  - [Long term tracking](#)
  - Steps to be taken to implement outreach program
- b. Topics to become part the manufacturing curricula
  - Biomanufacturing
  - Nanotechnologies
  - Electronics



- Manufacturing decision making
- Integration of lean manufacturing
- Business and leadership skills
- Green / sustainable energy
- Product engineering
- Systems and organizational engineering

### **Manufacturing Education Transformation Summit 2009**

The purpose of this summit is to attract a broader audience than the previous forums. Issues that must be addressed in this summit from a strategic position are;

- Why is transformation necessary in manufacturing education?
- What kind of transformation is necessary?
- Who has the power/responsibility for effecting the transformation?
- How can the transformation be accomplished?

A program-driven summit is planned, presenting a mix of invited speakers, contributed peer reviewed presentations, and panel discussions. Participants from outside academia are an integral part of these activities in helping to identify new problems and opportunities that shape the direction of the transformation. The summit is structured to build upon the forums, encourage additional discussion and interaction, and empower decision makers to implement improvements in manufacturing education. The key themes of the summit are;

#### 1. Pipeline, imaging and marketing issues in manufacturing education

Goal: A Collective plan for recruitment and attraction of new entrants to our industry as Students, Skilled Workers, and Retrainees.

#### 2. Strategic policy issues and partnering for manufacturing education.

Goal: To develop a set of strategies and policies to be used to further manufacturing education by summit participants and other stakeholders.

#### 3. Emerging technologies, techniques, and pedagogy and how to integrate them into manufacturing education

Goal: Shared knowledge that will allow educators to redesign and update their curriculum.

The summit will provide a select number of presentations and keynote addresses to inspire and charge the summit participants for action. Within the summit and through follow-on efforts, prepare, present, and promulgate a designed interdisciplinary road-map to guide manufacturing education stakeholders to meet the post-secondary workforce needs of the global enterprises of the future. Stakeholders include society-at-large, industry, academia, government, economic development groups, professional societies, and industry associations.

The Summit is expected to engage a broad group of manufacturing educators and professionals and senior managers from industry and government who want to enhance manufacturing education globally. Activities will explicitly examine the needs of industry and integrate those needs into educational programs. The conference invites individuals who are in positions to make an impact on manufacturing and education. Expected attendees and stakeholders are from academia, industry, government, professional organizations. It is expected that several professional societies having an interest in manufacturing education will be represented among the attendees.

## Conclusion

The manufacturing forums have helped energize the membership base. They have also helped focus on issues that are important for the near and long term future of manufacturing education. The following have become the key issues for those involved in manufacturing education and research: building the student pipeline, strategies to recruit students at the K-12 level, strengthening the involvement of industry, integration of new technologies, increased collaboration with professional societies that are interested in manufacturing education, and increased attention to accreditation of manufacturing education. At this point the work of the group continues in the areas identified and is expected to become part of the Curriculum 2015 document <sup>7</sup>.

## Bibliography

1. Arther, A. A., Wells, D., Demers, P.J. (editors), "[Ideal Models in Manufacturing Education: Curricula 2000 Workshop Proceedings](#)", Society of Manufacturing Engineers, 1990. (<http://www.sme.org/cgi-bin/get-event.pl?--001779-000007-home--SME->)
2. Wells, D. (editor), "[Manufacturing Education for the 21st Century – Volume I: Curricula 2002 Report](#)", SME, 1995. (<http://www.sme.org/cgi-bin/get-event.pl?--001779-000007-home--SME->)
3. Jack, H. (editor), "[Manufacturing Education Leadership Forum: Vision for Progress](#)", Society of Manufacturing Engineers, 2008. (<http://claymore.engineer.gvsu.edu/~jackh/sme/pittsburgh08/Program.html>)
4. Jack, H. (editor), "[Manufacturing Education Leadership Forum; Moving Forward](#)", Society of Manufacturing Engineers, 2008. ([http://www.merconline.net/wiki/index.php?title=Farmingdale\\_Forum\\_Program](http://www.merconline.net/wiki/index.php?title=Farmingdale_Forum_Program))
5. Jack, H. (editor), "Manufacturing Education Transformation Summit 2009", Society of Manufacturing Engineers, 2009.
6. "[Manufacturing Education & Research Community Wiki](#)" (<http://www.merconline.net/wiki>)
7. "[Curriculum 2015](#)", Society of Manufacturing Engineers, (to be completed) 2009. ([http://www.merconline.net/wiki/index.php?title=Curriculum\\_2015](http://www.merconline.net/wiki/index.php?title=Curriculum_2015))