AC 2012-3751: CURRICULA 2015: AN UPDATE FOR 2012

Dr. Hugh Jack P.Eng., Grand Valley State University

Hugh Jack is a professor of product design and manufacturing engineering at Grand Valley State University in Grand Rapids, Mich. His specialties include automation, design projects, and internet application development.

Prof. Robert L. Mott, University of Dayton

Robert L. Mott, P.E., is Professor Emeritus of engineering technology at the University of Dayton. He serves the Society of Manufacturing Engineers through the Manufacturing Education & Research Community and the SME Center for Education, and he is a recipient of the SME Education Award. He has authored four textbooks: Applied Fluid Mechanics, 6th ed.; Applied Strength of Materials, 5th ed.; Statics and Strength of Materials, 1st ed.; and Machine Elements in Mechanical Design, 5rd ed., all published by Pearson/Prentice-Hall. He also works with the NSF-sponsored National Center for Manufacturing Education at Sinclair Community College in Dayton, Ohio. He is a Fellow of the American Society for Engineering Education (ASEE) and the recipient of the James H. McGraw Award, the Frederick J. Berger Award, and the Archie Higdon Distinguished Mechanics Educator Award from ASEE. He is also a member of ASME. His degrees are the B.S.M.E. from General Motors Institute (now Kettering University) and the M.S.M.E. from Purdue University.

Mr. Mark J. Stratton, Society of Manufacturing Engineers
Dr. Phil Waldrop, Georgia Southern University

Phil Waldrop retired in 2011 as professor, mechanical and electrical engineering, Georgia Southern University, where he taught manufacturing and industrial management courses. He had previously worked as a manager of R&D in the aerospace/defense industry. He currently serves SME as a member of the Manufacturing Education & Research Community Steering Committee and as a liaison to ATMAE concerning accreditation. He is a graduate of Ball State and Purdue universities.

Prof. Karen Wosczyna-Birch, CT College of Technology

Curricula 2015; An update for 2012

Abstract

Between 2008 and 2011 the Curricula 2015 (C2015) initiative was undertaken by hundreds of professionals from industry, academia, and service groups. The goal was to examine the state of manufacturing education and develop a plan for revising manufacturing education. The preliminary content was well received and multiple groups are currently working on various recommendations and action items. This paper describes the progress of the work.

Introduction

The developments in the economy, globalization, and technology made the last decade difficult for manufacturers. Many companies were caught trying to make rapid changes to remain competitive[1]. The major problem was the shortage of appropriately educated employees [2]. Likewise, education has been the subject of major budget reductions, fewer students choosing manufacturing, and lower resources to develop new curriculum. The number of manufacturing engineering programs was growing until 2001 when the number of programs began to shrink[6]. The growth before 2000 could be attributed to a great deal of planning and support[6] for manufacturing education[3,4,5].

In 2006 the Manufacturing Education and Research Community of the Society of Manufacturing Engineers (SME) recognized and prioritized the issues permeating manufacturing education. In response a number of events were developed including two forums[7,8], one summit[9], strategic meetings, and joint authorship of the Curricula 2015 report[10]. These efforts involved hundreds of individuals representing many of the sectors and interest areas of manufacturing industry and education. The Curricula 2015 document was created to capture all of the details, plans, and recommendations from these events. The purpose of this paper is to describe the recommendation areas and progress to date.

What follows is a recast of the recommendations in the Curricula 2015 initiative into major action areas. Some groups such as the National Center for Manufacturing Education (NCME) have already to begun to take action on the recommendations.

The Four Pillars of Manufacturing Engineering

The recommendations related to the Four Pillars of Manufacturing Engineering are listed in Table 1. The Four Pillars of Manufacturing Engineering model in Figure 1 is already being used by many in academia and industry for describing manufacturing curricula. The initial model was formed using the details from the SME Certified Manufacturing Technologist (CMfT) and Certified Manufacturing Engineer (CMfE) Body of Knowledge. The Body of Knowledge topics are aligned with the ABET Inc. program criteria for Manufacturing Engineering programs. In simple terms the model is meant to be descriptive, defining the body of manufacturing knowledge coupled with the manufacturing program criteria to create a model useful for describing manufacturing education. The model has been embraced for updating the ABET accreditation program criteria for Manufacturing Engineering and is expected to be reflected in the upcoming revision of Manufacturing Engineering Technology program criteria. In addition the model will be used to identify gaps in the current curricula content and resources so that educators will be supported in endeavors to fill the gaps. It is expected that the model will evolve over the next few years as it expands to incorporate other types of programs with different industry foci.

Table 1 – Four Pillars Of Manufacturing Engineering

C2015 Category	C2015 Recommendations
Curriculum Revision and Development	6. Develop the Four Pillars structure and content
	7. Encourage the use of the Four Pillars for curriculum design
	8. Augment traditional required courses with Manufacturing
Financial	7. Use the Four Pillars in funding and activity planning
Education Standards	2. Improve industry-academic cooperation with curriculum standards
	3. Help ABET and ATMAE support Manufacturing education
	4. Develop more consistent manufacturing education curriculum
	5. Textbooks should be developed for manufacturing curricula
	6. Find champions for the topics within the Four Pillars
	7. Educators in specialties need to coordinate curriculum
	8. Use the Four Pillars for employee education mapping

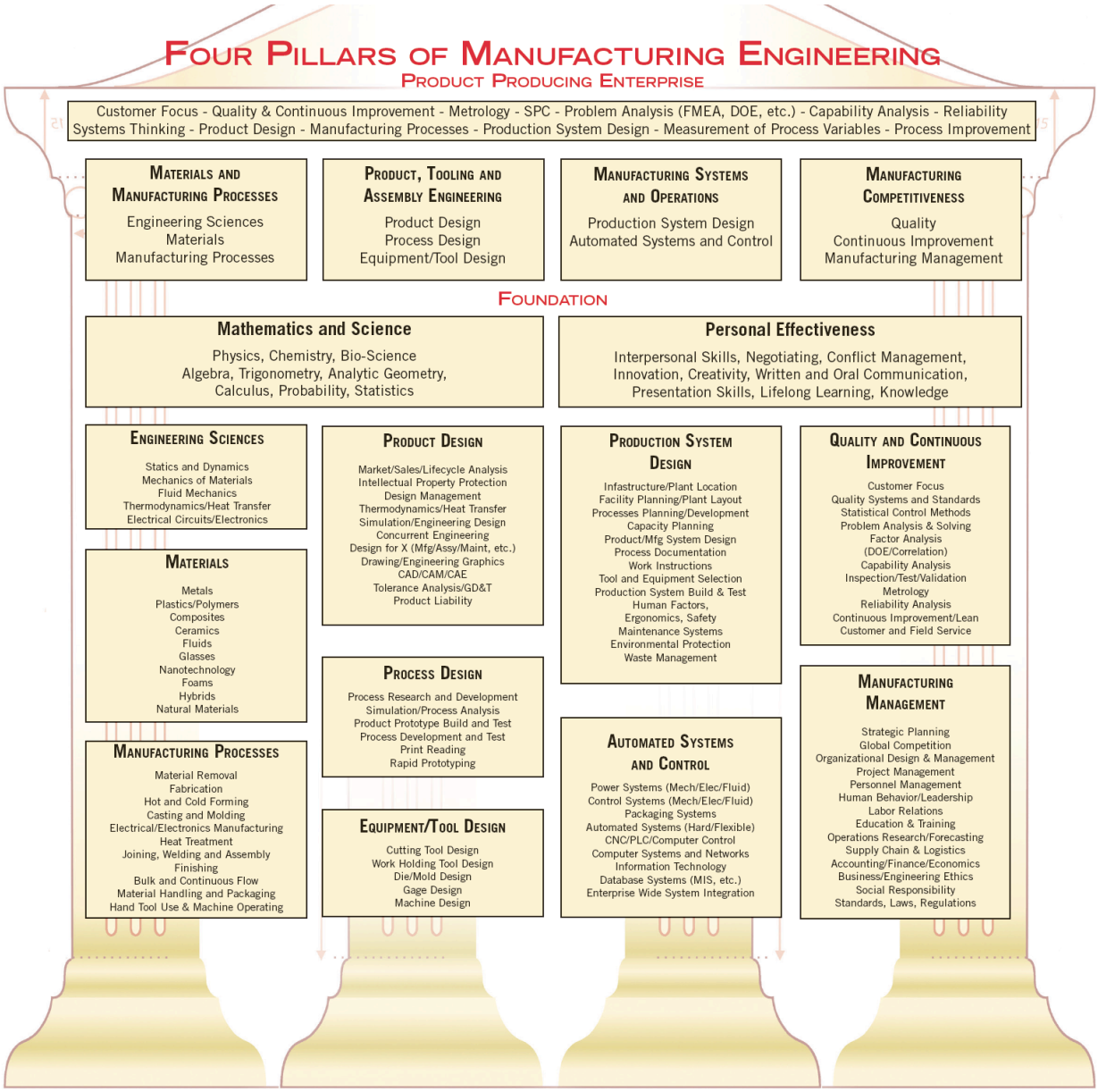

Figure 1 – The Four Pillars of Manufacturing Engineering

Communication Between Industry and Academics

Academia and Industry have much different cultures. A stereotypical model of industry culture is a group of professionals working together to meet a defined corporate goal. They look for a manager who can 'make things happen'. They are willing to spend time and money if they can achieve a tangible result. A stereotypical model of academic culture is a collection of individuals self-organizing to select individual work goals and work cooperatively. When academics collaborate they look for interesting problems they can pursue. Academics have very limited budgets and effectively no way to find money for non-research projects. When academia and industry meet these conflicting approaches often result in frustration with

academics thinking industries only wants vocational training, and companies thinking that the academics are not interested in changing the curriculum to solve industrial problems. Luckily these cultural issues can be overcome when industry and academics spend more time together.

Ultimately manufacturing engineering programs are designed to educate individuals who can contribute to society through manufacturing. In this endeavor educators and practitioners are partners. If academia and industry communicate, education will be more relevant to practice, and industry will be able to use the knowledge the graduates possess. Table 2 shows ways that industry and academics could use to develop a better understanding of individual and mutual needs. Building these relationships will benefit everybody at all levels from the K-12 system to post-graduate education.

Table 2 – Industry-Academic Ties

C2015 Category	C2015 Recommendations
Curriculum Revision and Development	1. Hold round table discussions between educators and industry
	3. Include large, medium, and small companies in education planning
	5. Create education-industry consortia for global competitiveness
	12. Accept that curricula change is a zero sum game
	13. Educators should address the industry problems of today
Faculty Development	1. Develop industry relationships for continuous improvement
	4. Industry needs to reach out to academic researchers
	5. The scholarship of corporate research projects should be recognized
	9. Invite industry to participate in the academic processes
	10. Provide faculty with employment incentives to work with industry
	11. Industry must manage the education supply chain
	12. Relationships should be brokered between industry and academics by service groups such as SME and others
	13. Get academia involved in industry education programs.
	16. Industry needs to tell educators what they value
Reaching Out to Other Disciplines and Employees	3. Create win-win opportunities and activities
	4. Develop certification plans for degreed manufacturing professionals
	5. Use certifications to empower employees and careers
Financial	5. Make programs relevant to industry to encourage more funding
	8. Industry must support educators who want to teach new technologies
Pipeline	10. Industries should preferentially hire manufacturing graduates
	13. Support career pathways that do not include college

Many of these goals are less about developing new initiatives and more about taking advantage of efforts that already exist. Some of the successes to date are listed below.

- Recently the (US) President, in response to recommendations in a report from the President's Council of Advisors on Science and Technology (PCAST), launched the Advanced Manufacturing Partnership (AMP) program [11]. The AMP is a national effort bringing together the Federal government, industry, universities, and other stakeholders to identify and invest in emerging technologies with the potential to create high-quality domestic manufacturing jobs and enhance the global competitiveness of the United States.
- A National Strategic Plan for Advanced Manufacturing was released in February 2011. It is a strategic plan to guide Federal programs and activities in support of advanced-manufacturing research and development.
- The ASME has an initiative entitled "Vision 2030" that concludes among a number of things, that there is a design and manufacturing gap. Surveys of early career mechanical engineers and their supervisors find agreement that curricula and preparation were weak in practical experience (how things are made) indicating the need for more practical education in manufacturing in mechanical engineering programs.
- A member of the SME Board of Directors was named to direct manufacturing industry-related issues for the National Institute for Science and Technology (NIST).

Curriculum Revision, Delivery, and Education Methods

Curriculum revision is a normal part of an academic's duties. However the resources, encouragement, and motivations can vary significantly between faculty and institutions. The recommendations in Table 3 are directed to helping these faculty set personal priorities when developing new courses, revising programs, adding new programs, developing new laboratories, adopting new teaching methods, and adding new topics.

Table 3 – Curriculum Revision

C2015 Category	C2015 Recommendations
Curriculum Revision and Development	3. Develop stronger ties between research and the classroom
	4. Identify and teach new technologies
	7. Encourage students to pursue global travels and projects
	9. Create programs, options, and courses for new technologies
	10. Incorporate topics and courses that support global manufacturing
	11. Address the current demand for Lean Manufacturing
	14. Use teaching methods that engage students
	15. Encourage educators to teach workplace skills
	16. Manufacturing Engineering education needs a systems approach
Faculty Development	7. Educators need incentives to create critical teaching materials
	15. Continuous improvement of teaching is vital for student interest
Reaching Out to Other Disciplines and Employees	9. Continue developing online education and similar innovations
Pipeline	9. Build confidence and promote an understanding of economics

Revision of the education process can be encouraged by setting priorities in departments, recognizing the value of development, and providing support for these activities. Although these activities do already happen it would be beneficial if they would happen at a faster pace over more of the curriculum. Efforts that are helping to achieve the goals include;

- The President's Advance Manufacturing Partnership Initiative [11].
- The number of academic papers including those presented at the ASEE annual conference and submitted to academic journals.
- Further development of resources and examples based on the Four Pillars of Manufacturing in a matrix to assist in curriculum review and assessment.
- National calls for improved workforce development for advanced manufacturing from organizations such as NAM, NACFAM, and NDIA.
- NSF-sponsored projects and centers focused on advanced manufacturing and materials.
- More items in popular media favoring the enhancement of manufacturing industries and recognition of the quality of manufacturing careers.

Outreach By Education and Industry

These recommendations focus on including more students in manufacturing education as they move through a number of academic pathways. This includes adding manufacturing topics to augment other education programs and attracting more students into manufacturing programs and courses.

Table 4 – Expanding the Pool of Manufacturing Professionals

C2015 Category	C2015 Recommendations
Faculty Development	8. Work with other disciplines to build service courses for manufacturing
	14. Support the K-12 teachers doing Manufacturing related education
Reaching Out to Other Disciplines and Employees	2. Communicate that Manufacturing is essential for all disciplines
	6. Non-manufacturing programs should include manufacturing content
	8. Faculty must promote manufacturing knowledge in other programs
Financial	1. Political education priorities need to be discussed publicly
Pipeline	1. Communicate that Manufacturing is the largest economic catalyst
	2. Be Guides on the path to Manufacturing careers
	3. Good news! Share the stories of success and growth
	4. Develop a press kit for manufacturing and education
	5. Send the message that Manufacturing Engineers design products
	6. Develop a simple image of Manufacturing for the public
	7. Appealing! Attracting! Engaging! Enabling! Joining!
	8. Give motivation and support for students already in manufacturing
	11. Provide activities to attract K-12 students to study technical subjects
	12. Reverse the loss of technical programs in the K-12 system

To expand the manufacturing knowledge base it is necessary to reach out to employees with continuous learning opportunities, to increase manufacturing knowledge in non-manufacturing-titled programs, and to encourage more students to pursue education that includes manufacturing content.

- The NCME has expanded its outreach in Ohio through the Project Lead The Way (PLTW) [12] with an expanded CIM module that was developed with support of the SME Education Foundation.
- The SME Education Foundation launched a PRIME schools initiative. The PRIME model creates strong partnerships between organizations, businesses, and exemplary schools to provide a comprehensive community-based approach to manufacturing education. This new program, launched in six model sites nationwide in the fall, 2011 brings industry and organization partners into the classroom, insuring a relevant connection between the curriculum and the real world. The six selected schools were chosen based on a set of select criteria: exemplary manufacturing curriculum, skilled and dedicated instructors, engaged and active students and connectivity to the local manufacturing base or an SME membership group. Each of the six model schools received a $10,000 grant from the SME Education Foundation that will be used to update their manufacturing equipment, CAD/CAM software, or for instructor training. In additional each school will receive $5,000 to launch and build a summer camp program to insure the pipeline of students interested in manufacturing continues to be filled. The first six PRIME schools are: Kettering Fairmont High School - Dayton, OH; Walker Career Center - Indianapolis, IN; Summit Technology Academy - Kansas City, MO; Wheeling High School - Chicago, IL; Francis Tuttle Technology Center - Oklahoma City, OK; and Hawthorne High School - Los Angeles, CA. Additional PRIME schools are expected to be nominated and connecting with the instructors and students at PRIME schools can help facilitate mentoring, student, curriculum and faculty development to enhance the image and pipeline for students to be attracted to and continue their education in manufacturing.
- The SME Foundation has established a partnership with the Edge Factor, a film project advancing the image of manufacturing with an eye toward attracting young people to the field. A series of Edge Factor videos and a Reality Redesigned competition are currently available with additional educational resources as well as community building anticipated.
- The CIM course in the Project Lead the Way high school curriculum has high quality of content and is educating more students who are knowledgeable about manufacturing industry and potential careers in manufacturing.

Strategy Setting and Leadership

Those in leadership positions have the unique opportunity to make minor decisions that support manufacturing education. It goes without saying that financial constraints are the greatest challenge to manufacturing education. Recent developments such as the new National Strategic Plan for Advanced Manufacturing and the Advanced Manufacturing Partnership initiated by the federal government indicates the political priority of manufacturing and workforce development and education.

Table 5 – Leadership and Strategy for Manufacturing Engineering Education

C2015 Category	C2015 Recommendations
Curriculum Revision and Development	2. Enhance Graduate Manufacturing education leadership
Faculty Development	2. Appoint Fire Keepers for the history of Manufacturing Education
	5. Remember the history of manufacturing education
Financial	2. Examine the education funding allocation and use it to lobby for more
	3. Metrics should be used for assessment and strategic funding
	4. The funding for manufacturing programs should increase
	6. Money is the limiting factor for expansion and relevancy of education
Pipeline	1. Scholarships are needed to attract students
Education Standards	1. Charge the SME Center for Education with the role of coordinator.

Those recommendations specific to SME are being considered by the SME Manufacturing Education and Research Community and the SME Center for Education. At the June 5, 2011 Education Forum at the SME Annual Conference the Curricula 2015 report was first released, there were presentations, and numerous discussions about the key issues. The report was presented to the SME Board of Directors at their November 13, 2011 meeting and they requested that a position paper be developed summarizing the key recommendations for addressing the challenges to manufacturing education for public dissemination. The position paper was submitted in February 2012 and further editing was requested, which is in process for resubmission along with a communications plan for disseminating the position paper.

Conclusions

The plans for manufacturing education are moving forwards and will be reviewed in 2013 and updated in 2015. With a new U. S. national strategic plan for manufacturing released in February[11] and the Advanced Manufacturing Partnership report due in March, manufacturing is becoming more visible as a priority and becoming more important in engineering and technology education programs. This portends an increase in resources and support for manufacturing research, education, and training along with the need for furthering collaboration and partnerships among all of those whose aim is to enhance manufacturing.

Some of the opportunities for contributions include taking up action on items in the tables both individually and collectively through groups such as the SME Manufacturing Education and Research Community.

- Engage high schools that offer the CIM program, especially the PRIME schools recognized by the SME Education Foundation, to show support, to participate in advisory committees, to provide mentoring for students, to explain higher education opportunities

to students and their teachers, and to have current college students in manufacturing interact with high school students.

- Support the use of the careerME.org website nationally by helping the National Center for Manufacturing Education (NCME) to establish collaborations with regional industry associations throughout the U.S. and Canada.
- Use the Four Pillars of Manufacturing Engineering to help constituents understand the nature of the manufacturing engineering field, to refine curricula in manufacturing and related disciplines, and to communicate with industry and external publics about the importance of manufacturing education.

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Appendix – Recommendation Areas from the Curricula 2015 Report

Curriculum Revision and Development

Reason: Educators are always looking for new content, methods, and technologies to improve their effectiveness in education. These recommendations address elements that faculty can consider when dealing with specific course design, and institution specific curriculum. These will also be of great value when considering the general manufacturing body of knowledge.

Objective: Programs will continually improve to prepare students for present and future needs.

Metrics: The results of these efforts can be assessed through journal publications and conference presentations. Effort is required to track improvements and alignment with industry and academic needs.

Faculty Development

Reason: Faculty are a critical part of the education process. If they do not interact with industry and keep abreast of new developments it becomes very easy for their teachable knowledge to become stale. Various avenues exist for faculty growth including learning new topics, participating in fundamental research, and doing industrial projects.

Objective: Develop faculty who can deliver a world class manufacturing education.

Metrics: There are multiple methods for tracking faculty development. On one end we can look at the funding requested for teaching development and research from groups such as the NSF and SME-EF. The other valuable metric is the number of manufacturing publications.

Reaching Out to Other Disciplines and Employees

Reason: It is recognized that the number of students in manufacturing programs is relatively small, but the demand for manufacturing knowledge is very high. Similarly many manufacturing employees do not have formal education for aspects of their work. To have a significant impact we must reach students in other programs and working professionals with education needs.

Objectives: These recommendations are directed to spreading manufacturing knowledge beyond the manufacturing dedicated programs.

Metrics: The success of these efforts can be measured by the number of students and professionals receiving manufacturing education. Manufacturing education for other disciplines can be assessed using surveys of manufacturing programs to obtain student head-counts in manufacturing service courses and life-long learners. The registration for SME professional events would be an approximate indicator of professional training and education.

Financial

Reason: Resources for supporting education are critically low and inhibiting growth an innovation. The resources that are available must be deployed more strategically. General approaches that will produce results are i) focusing support on students in the pipeline, ii) providing support for needed curriculum revisions, and iii) making manufacturing education a public funding priority.

Objective: Short term objectives need adequate funding to keep programs operating. Long term funding should permit education innovation.

Metrics: Financial support for program development can be estimated using publicly funded curriculum development and research, as well as private project funding. These can be obtained as a combination of survey results of programs, grants at the federal and state levels, and groups such as the Society of Manufacturing Engineers Education Foundation.

Pipeline

Reason: Manufacturing professionals and educators are focusing on how the discipline is perceived and how that influences the public interest and support for manufacturing. The primary, but not only, tool in use now is K-12 education and motivation.

Objective: To this end there is work towards i) improving the image of manufacturing careers and education, ii) encouraging K-16 students to study manufacturing topics, iii) finding common ground to work together, iv) rally political support.

Metrics: The success of these efforts can be assessed by survey of students in manufacturing and related disciplines to determine what programs they have been exposed to, as well as the extent of influence on their choice of studies.

Education Standards

Reason: Presently there is a substantial variation in the understanding of what constitutes a manufacturing program. The goal of these recommendations is to help unify programs, provide consistent accreditation guidelines, and aid in the development of course materials. These recommendations provide possible avenues for uniting the manufacturing knowledge base for both completeness and consistency.

Objective: A better defined curriculum for manufacturing and other disciplines.

Metrics: The results of these efforts can be assessed using surveys of the books and education resources available for manufacturing education programs directly, and education content in materials for other disciplines. Groups such as the National Center for Manufacturing Education (NCME) will be able provide useful statistics based on resource registrations.