

Innovations in Manufacturing Engineering Education: The Southern California Coalition

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Five participating universities in Southern California and forty-one industries, in cooperation with the California Engineering Foundation (an industry association), the California Manufacturing Technology Center, and the Los Angeles County Economic Development Corporation, have formed the Southern California Coalition for Education in Manufacturing Engineering (SCCEME, pronounced "scheme") to develop outstanding, well-integrated, practice-oriented, ABET-accredited programs in manufacturing engineering, to infuse manufacturing know-how into all engineering and engineering technology curricula, and to provide on-site training in Southern California. SCCEME brings together the respective strengths and resources of a major public research university (UCLA), a major private research university (USC), three practice-oriented primarily undergraduate universities (CSULB, CSULA, CSUF), and large and small industrial partners to offer degrees, degree options, and certificate programs that integrate the precepts of modern engineering practice including technology for affordability, integrated product and process development, total quality management, continuous process improvement, and agile manufacturing. Through a diverse spectrum of accessible, high-quality, practice-oriented programs, SCCEME is meeting the needs of area industries for skilled engineers and engineering technologists. This project is supported by National Science Foundation Cooperative Agreement #EEC-9405262 with Technology Reinvestment Project Funding of \$3,980,000 for the period of April 1, 1994 - March 31, 1996.

Progress to date includes development of a new degree (B.S. in Manufacturing Engineering) and new degree options, development of multimedia-based course modules in manufacturing, networking the universities and industries in the Coalition, teleconferencing of manufacturing courses among campuses and area industries (including hands-on rapid prototyping and integrated product development), on-site delivery of manufacturing-related training to 823 defense workers, and securing \$3,079,108 in matching support (\$1,383,436 State + \$1,695,645 industry) and additional commitments for the second year.

Historically, industry has supported engineering schools through sponsored research, advisory councils, general financial contributions, donated equipment, and part-time faculty. However, industry has not been actively

involved in curricula development. Minimum standards for course and program content are established through the accreditation process under the auspices of the national voluntary organization called the *Accreditation Board for Engineering and Technology (ABET)*. These criteria are translated into the specific curricula for the different disciplines of engineering through faculty committees in the academic institutions. Industry involvement in the accreditation process has been limited to participation in campus program reviews, but this has not been a high priority activity in most companies' agendas. It does not affect the "bottom line this quarter" - a crucial paradigm in business survival.

Industrial leaders have been vocal about the need for engineers to have additional skills. Those skills most mentioned by keynote speakers in national engineering conferences are: communication arts (written, spoken, and nonverbal), human resources management, marketing science, product design, technology, finance, legal, industrial processes, intellectual property, total quality management, and environmental quality regulations and management.

The title of manufacturing engineer evolved in the industry over many decades. The field was once populated with upwardly mobile individuals, usually from the design/drafting group, who had acquired experience working with the "shop" people (machinists) translating drawings into hardware. Rare was the situation where a graduate engineer in any engineering discipline became a "manufacturing engineer". In fact, many major firms had separate chains of command for the engineering side of the company and manufacturing operations. The process is different in many Japanese firms where the design engineer manages the product through the innovation and production process.

The situation in American industry is now changing as manufacturing systems become more complex. In the past, a manufacturing engineer would discuss a drawing with a machinist who would produce a component. Now, a design engineer produces a computer-aided design and provides the manufacturing engineer the software to operate a five axis, numerically controlled milling machine. Total quality management philosophy is applied, and the component is produced "just in time" to facilitate an automated assembly process.

The California State University, Long Beach, (CSULB); The California State University, Fullerton (CSUF); The California State University, Los Angeles (CSULA); The University of Southern California (USC); and The University of California, Los Angeles (UCLA), in cooperation with Southern California industries, the NIST California Manufacturing Technology Center (CMTC), the Los Angeles County Economic Development Corporation (EDC), and the California Engineering Foundation (CEF), have formed the Southern California Coalition for Education in Manufacturing Engineering (SCCEME, pronounced "scheme"), with funding by the Technology Reinvestment Project through the National Science Foundation Division of Engineering Education and Centers (NSF/EEC) and additional funding from State agencies and area industries. The Coalition brings together the respective strengths of a major public research university, a major private research university, three primarily undergraduate comprehensive universities, large and small manufacturing industries, CMTC, EDC, and CEF to create an educational infrastructure that is creating new and enhancing existing manufacturing-related ABET-accredited baccalaureate engineering and engineering technology degree programs in the Los Angeles area. By combining their resources, these universities offer degrees, degree options, and certificate and training programs that integrate the precepts of modern engineering practice including technology for affordability, integrated product development, total quality management, continuous process improvement, and agile manufacturing. The Coalition is focused on the Los Angeles basin and is playing a significant role in reindustrializing the Los Angeles area. If Flexible Manufacturing Systems (FMS) and Computer Integrated Manufacturing (CIM) were viewed as the industrial battleground of the 1970s and 80s, respectively, then life-cycle design/manufacturing is the battleground of the 1990s.

Life-cycle design/manufacturing requires that all life-cycle phases of a product or process (design, development, manufacturing, marketing, distribution, usage and disposal/ recycling) must be considered simultaneously. The success of manufacturing enterprises in the 1990s and beyond will depend largely on how well they can horizontally integrate design, manufacturing, marketing, quality and environmental functions to produce globally-competitive products. SCCEME focuses on the long-term, systematic reform of undergraduate manufacturing engineering education across the curricula, enhancing existing manufacturing-related baccalaureate degree programs and creating new degree programs and degree options, and training programs for industrial employees, related to manufacturing that emphasize this integrated approach, known as Integrated Product and Process Development (IPPD). These efforts include curricula modernization, development of closer ties with industry, exchanges of instructors, utilization of active professionals working in industry to teach classes and provide lectures, use of industry facilities, university/industry team teaching,

industrial internships, increased knowledge transfer from industry to academia, teleconferencing of courses among campuses and industrial sites, sharing of faculty and facilities, and greater awareness of manufacturing engineering as a challenging and rewarding discipline. Since no single academic program can meet all the needs of all manufacturers for the many different types of highly-skilled, well-educated manufacturing engineers that industry needs, SCCEME provides a diverse spectrum of accessible, high-quality, practice-oriented undergraduate curricula that meet the needs of all types of manufacturers. Quality is emphasized as a key element throughout each program. Quality in the conduct and administration of the academic programs and quality (TQM and CPI) concepts integrated throughout the curricula.

The conversion of defense industries to achieve diversification, commercialization and dual-use, and the reindustrialization of the Los Angeles area in this era of rapid technological change and increasing global competitiveness, require that manufacturers have access to manufacturing engineers of all specializations. The discipline of Manufacturing Engineering has long been neglected by educational institutions throughout the United States. This neglect has led to a scarcity of manufacturing-oriented technical professionals with the practical expertise that is necessary for American industry to compete in the global marketplace. SCCEME addresses this scarcity by creating an educational infrastructure offering new and enhancing existing manufacturing-related baccalaureate engineering degree programs in the Los Angeles area, infusing manufacturing knowhow into all engineering curricula on the five campuses, and providing high-demand training programs to industry. Special efforts are made to attract individuals from underrepresented groups into these programs. The Coalition is much stronger than the sum of its parts because it combines the complimentary strengths of its members. For example, UCLA has outstanding CAD labs, the CSU campuses have excellent manufacturing labs, CSULA — a Title III Minority Institution (MI) and Title III Hispanic-Serving Institution (HSI) — is nationally renowned for developing outstanding minority and outreach programs, and USC has excellent facilities in computer vision, sensor-based robotics, and instructional television. Yet, none of these universities currently offer a baccalaureate degree in manufacturing engineering. By combining their resources they can and will offer degrees and degree options in manufacturing that integrate the precepts of modern engineering practice including technology for affordability, integrated product development, and agile manufacturing throughout all their engineering degree programs. Each SCCEME member is a comprehensive university committed to providing high quality education to students in Southern California. Each has a long history of excellence in undergraduate engineering education, and each offers a variety of ABET-accredited baccalaureate degree programs.

SCCEME combines their respective strengths and create mutually-reinforcing and jointly-offered programs in the diverse disciplines of manufacturing engineering that are superior to the programs any single campus can offer alone. NIST/CMTC, EDC, CEF and area manufacturing industries bring additional strengths to the Coalition.

SCCEME has made certain that industry personnel are actively involved in the Coalition. Each curriculum development task group has industry employees as members. Manufacturing-related classes are being taught or team-taught by highly qualified engineers from industry, and industrial facilities are being utilized by SCCEME. The proposal for the new Bachelor of Science in Manufacturing Engineering program that has been approved by the CSULB faculty and administration requires a summer internship with area industries, and similar cooperative degree programs leading to degrees and degree options in manufacturing are being developed on the other four campuses. All these new degree programs are supported by multi-campus course offerings that are teleconferenced between and among the campuses.

New courses include Introduction to Modern Manufacturing, Simulation of Discrete Systems in Manufacturing, Introduction to Geometric Modeling, Assembly and Parts Feeding in Manufacturing, Production Methods for Aerospace Manufacturing, Metal Working, Theory and Applications, Advanced Composite Materials, Special Topics in Aerospace Manufacturing, Materials for Electronics Manufacturing, Materials Purification Processes, Materials Purification Processes, Advanced Manufacturing Processes, Industrial Applications of Electronic Circuits, Industrial Applications of Electronic Circuits Laboratory, Fundamentals of Manufacturing Processes, Tooling and Fixtures Design, Quality and Productivity Tools, Manufacturing Processes, Manufacturing Process Control & Instrumentation, Management of Manufacturing Enterprises and Cost Analysis, Electronics Packaging Manufacturing, Manufacturing Resource Planning, Computer Integrated Manufacturing, Logistics Principles and Practice, Material Removal and Tool Selection, Manufacturing Forming and Failure Analysis, Manufacturing of Plastics and Composites, Advanced Robotics, Rapid Product Development, Advanced Robotics, Principles of Systems Engineering. Many of these courses are shared among the campuses by 2-way video teleconferencing.

Thus, by working together and sharing resources, the SCCEME universities are making new manufacturing courses and programs available to students in the Los Angeles area. These courses and programs are being developed by teams of faculty from multiple campuses, rather than faculty on a single campus alone.