

Manufacturing Education at Syracuse University*

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This paper aims to report a model adopted and implemented at Syracuse University to foster a multidisciplinary approach to manufacturing engineering. The background and rationale behind the establishment of the Institute for Manufacturing Enterprises, a revision of the MS degree curriculum in Manufacturing Engineering, and the establishment of an alliance program with a major enterprise solution company, are explained. The institute was created with the mission of promoting learning in manufacturing enterprises through teaching, application, integration, discovery, and service. The new MS degree curriculum is a result of realizing the vision of the Institute for Manufacturing Enterprises. It provides a unique curriculum addressing discipline-specific fundamentals as well as multidisciplinary knowledge and skills by drawing courses from various units on campus. A full-scale enterprise resource planning software was adopted as a tool to realize the vision of the institute.

INTRODUCTION

THE SIZE, scope, and complexity of manufacturing in today's global economy are increasing. To stay competitive, successful manufacturers constantly analyze, redesign, and upgrade their technologies, information infrastructure, business processes, supply chains, marketing strategies, and customer relations. The challenge for manufacturing education in today's higher educational institutions is to provide students with both discipline-specific fundamentals and multidisciplinary knowledge and skills [14]. Syracuse University is responding to such a challenge in a unique way through:

- the establishment of the Institute for Manufacturing Enterprises (IME);
- the creation of a new Master's level Manufacturing Engineering curriculum; and
- the partnership with SAP's University Alliance program.

The underlying philosophy of the Manufacturing Education at Syracuse University can be found in the IME's values:

- *Connectivity*: making seamless connections within academia and between academia and industry is an essential component of learning in manufacturing enterprises;
- *Lifelong learning*: leaders in manufacturing enterprises are committed to lifelong learning, which can be fostered by accommodating a differential rate of learning,
- *Scholarship*: scholarship is a way of living,

worthy of being embraced by everyone in manufacturing enterprises,

- *Culture for excellence*: we are committed to achieving excellence through open dialogue, reflective listening, taking initiatives, respect for others, and technical innovation.

The present paper describes manufacturing engineering education and its related activities that have taken place at Syracuse University during the last few years.

BACKGROUND

A trace of manufacturing engineering education at Syracuse University goes back to 1908 when a curriculum in Industrial Engineering (IE) was established. The curriculum was the second in USA only after the first curriculum in IE at Pennsylvania State College in 1907. Despite the fact that the official name of the program was Industrial Engineering, the major theme of the IE curriculum then was Manufacturing Engineering.

It is useful to note that the IE curricula or courses in those years grew out of Mechanical Engineering and were greatly influenced by the Taylor system. At the same time, the Taylor system branched its way into the business school curriculum. In 1908, the Harvard School of Business Administration adopted the Taylor system for teaching shop management subjects. A course description in the Pennsylvania State catalog of 1909–1910 illustrates such a trend in early years [4]:

This course is intended especially to prepare for positions that deal with the side of industrial organizations that has to do with business management, works management, superintendence, purchasing and

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Table 1. The old curriculum MS in Manufacturing Engineering

Group	Courses
A Manufacturing core courses (4 courses)	MFE635 Manufacturing Systems MFE636 Materials and Processing in Manufacturing MFE639 CAD/CAM Systems MFE654 Production System Design and Control
B Management core course (1 course)	OPM864 Manufacturing Management Systems
C Manufacturing elective courses (choose 3 courses)	MFE534 Statistical Quality Control MFE548 Engineering Economics and Project Evaluation MFE634 Productivity and Quality Engineering MFE629 Modeling and Optimization Techniques MFE676 Computer Control of Machines and Processes MFE692 Design for Manufacturing MFE735 Artificial Intelligence in Manufacturing Systems
D General elective courses (choose 2 courses)	Graduate level course subject to approval by the faculty

sales. It deals largely with the application of the sciences and humanistic studies to industrial ends. It prepares for the competent handling of such subjects as the determining of costs, depreciation, statistics, proper distribution of expense, economic production, systems of remunerating labor and raising labor efficiency, the handling and records of stock and orders, sales, purchasing, corporation accounting and allied work.

For the purpose indicated, well-trained engineers are required; hence the course includes all the fundamental engineering work in mathematics, drawing, physics, chemistry, machine design, heat engineering, mechanics, hydraulics, and structures that are common to all other engineering courses. But more time should be and is given to such general studies as modern languages, English, economics, logic, and psychology and specialized work in accounting, factory management, shop time study, machine tools and methods and shop practice in general.

Although this original program at Syracuse University was discontinued, the university later revived an active IE program. Following a general trend in engineering education in USA after the middle of the last century, the emphasis of the IE program at Syracuse University shifted to providing a foundation in engineering science as opposed to providing practical skills and knowledge that could be applied immediately in the field. Until mid-1980s, the IE program at Syracuse University was oriented toward Operations Research.

Syracuse University established a new MS degree program in Manufacturing Engineering in 1985 while discontinuing the earlier IE program. Even though there have been minor modifications in the curriculum, the main structure and components remained the same until 2002. The old curriculum in MS in Manufacturing Engineering is presented in Table 1. Like many traditional curricula, this one was to be carried out by the manufacturing engineering

faculty and self-contained within the Department of Mechanical and Aerospace Engineering.

This MS program has been graduating between 10 and 20 students per year and the typical enrollment in a manufacturing engineering graduate course has been between 15–30 since students majoring in other disciplines have also taken manufacturing engineering courses.

THE INSTITUTE FOR MANUFACTURING ENTERPRISES (IME)

The Institute for Manufacturing Enterprises was created in 2000 at Syracuse University with the mission of promoting learning in manufacturing enterprises through teaching, application, integration, discovery, and service. The IME is a multidisciplinary research and education center partnering with manufacturing companies [7] as well as the College of Engineering and Computer Science, the School of Management, the School of Information Studies, the University College, and other schools and colleges at Syracuse University.

The creation of the IME was prompted by the recognition that Manufacturing Education is multidisciplinary in nature and cannot be successful without meaningful interaction with manufacturing industry. Some of the IME activities include:

- *Non-traditional educational opportunities.* The IME offers a variety of opportunities for life-long learning through short courses, certificate programs and graduate level courses on non-matriculated basis. For example, one-day courses on 'Lean Manufacturing,' 'Robust Product Design,' and 'Survey of Manufacturing Processes' have been offered to practicing engineers and managers. A certificate program on 'Enterprise Resource Planning System' was developed jointly with University College.

Table 2. The new curriculum in MS in Manufacturing Engineering

Category	Courses	Concentrations
Foundational Courses (3 courses)	<ul style="list-style-type: none"> • ECS526 (Statistics for Engineers) • MFE636 (Materials and Processing in Manufacturing) • A course in Financial or Managerial Accounting 	
Core Courses (choose 2 Courses)	<ul style="list-style-type: none"> • MFE635 (Manufacturing Systems) • MFE654 (Production System Design and Control) • MFE692 (Design for Manufacturing) 	
Elective Courses from a Concentration (choose 5 courses in a concentration)		<ul style="list-style-type: none"> • <i>Manufacturing information systems</i> • <i>Manufacturing system design</i> • <i>Product development</i> • <i>e-Manufacturing</i> • <i>Supply chain management</i>

- *Deliverable research projects.* The IME identifies relevant manufacturing research problems to a cross section of partner companies. The company provides the problems, possibly along with a project manager who will work with students and the IME personnel. The IME ensures that successful completion of the project as well as its transfer to the sponsoring company.
- *A regional conduit.* The IME serves as a local interface with a group of academics and others interested in improving the manufacturing enterprise. The IME established strategic partnership with a number of regional groups such as the Manufacturers Association of Central New York (MACNY) and the Lean Manufacturing Institute at Onondaga Community College.

The establishment of the IME is in line with Syracuse University's recent emphasis on multidisciplinary research and education. In 2001, a new academic plan was proposed under the name of 'A Strategic Partnership for Innovative Research and Education.' The plan is to leverage the strengths of Syracuse University by fostering multidisciplinary interactions among diverse academic units. As a result of the planning process, the following four focus areas were identified. It turned out to be that the first three of these four areas are directly related to manufacturing. Following are the excerpts from Syracuse University's strategic plan:

- Information Management and Technology
- Environmental Systems and Quality
- Collaborative Design
- Citizenship and Governance

THE NEW MS CURRICULUM IN MANUFACTURING ENGINEERING

The design of new curriculum in MS. degree in Manufacturing Engineering began in 2000 [3]. With

the newly established IME, the motivation was to provide truly multidisciplinary opportunities in manufacturing education with a substantial interaction with industry. A curriculum committee consisted of faculty members from three different schools and colleges at Syracuse University. The committee members were director of Manufacturing Engineering and director of Engineering Management from the College of Engineering and Computer Science, director of Information Management from the School of Information Studies, and a faculty member representing the School of Management.

The revision process coincided with the major revisions taking place in the MBA program and the MS in Information Management. As a result, a provision for dual degree options between Manufacturing Engineering and three other degree programs (MBA, MS in Information Management, and MS in Engineering Management) was naturally accomplished.

The multidisciplinary program draws courses and faculty from Syracuse University's College of Engineering and Computer Science, School of Management, School of Information Studies, and other schools and colleges at the University. Besides, the program is also reaching them out proactively. The Manufacturing Engineering program hosts SAP's University Alliance program as described later. In addition to providing a unique set of tools and community to realize the new curriculum's vision, the SAP program became a catalyst for connecting other programs on campus.

The new curriculum requires 30 credits of coursework and an optional project and is presented in Table 2.

An example set of elective courses under 'Manufacturing Information Systems' is given in Table 3.

The unique features of the new curriculum include:

Table 3. An example concentration on 'Manufacturing Information Systems'

CSE 581 (Introduction to Database Management Systems)
CSE 682 (Software Engineering)
ELE 558 (Data Networks: Basic Principles)
IST 552 (Information Systems Analysis: Concepts and Practice)
IST 555 (Distributed Computing for Information Professionals)
IST 575 (Managing Information Systems Projects)
IST 642 (Electronic Commerce)
IST 653 (Introduction to Telecommunications and Network Management)
IST 656 (Telecommunication and Information Network Technology)
IST 659 (Data Administration Concepts and Database Management)
MEE 850 (Advanced Topics in Manufacturing)
MFE 534 (Statistical Quality Control)
MFE 629 (Modeling and Optimization Techniques)
MFE 635 (Manufacturing Systems)
MFE 639 (CAD/CAM Systems)
MFE 654 (Production System Design and Control)
MFE 690 (Independent Study: Manufacturing Practicum)
MFE 997 (Master's Thesis)
MIS 545 (Decision Support Systems)
MIS 635 (The MIS Data Base)
SCM 701 (Introduction to Supply Chain Management)

- Emphasis on multidisciplinary nature of manufacturing engineering, drawing relevant courses from other colleges and schools across the campus.
- Incorporation of the input from manufacturing industry and other constituents such as:
 - Society of Manufacturing Engineers (SME);
 - Institute for Manufacturing Enterprises (IME) advisory board.
- Incorporation of feedback from other faculty:
 - Incorporation of business perspective outlook and suggestions from the faculty of the School of Management;
 - Incorporation of IT perspective suggestions from the faculty of the School of Information Studies to enable e-manufacturing.
- Provision for in-depth study on an area of concentration.
- Provision for expansion of areas of concentration.
- Provision for Dual-Degree options in:
 - MFE & EM (Manufacturing Engineering & Engineering Management);
 - MFE & IM (Manufacturing Engineering & Information Management);
 - MFE & MBA (Manufacturing Engineering & Master of Business Administration).

During the academic year 2001/2002, the new MS in Manufacturing Engineering program has replaced the old curriculum.

THE INTERNSHIP PROGRAM

Over the last 20 years, the Manufacturing Engineering program has developed a regional graduate internship program to address both the

immediate and long-term needs of Central New York manufacturing and high-technology firms. The first company that pioneered the internship program was New Venture Gear (NVG) in 1988. Over more than 10 years, NVG typically has supported 6 or 7 students in the program each year. In 1994, the program was significantly expanded with a four-year federal grant through the Technology Reinvestment Program (TRP) [8]. Since then, the State of New York has provided matching funds to support the internship program under 'Renaissance Internships' grant. As a result, more firms, particularly small and medium sized companies, were able to participate in the internship program.

The organization structure for operating the internship program is described in Fig. 1.

Distinguishing elements of the internship program include:

- To be eligible for the internship program, applicants must have an undergraduate degree in engineering. In addition, previous work experience is strongly preferred.
- Interns work 20 hours per week on site at a local company, assisting full-time employees in addressing tasks critical to the immediate needs of the firm, including product development and manufacturing productivity improvements.
- Syracuse University faculty members assist in the supervision of student work assignments, ensuring that the students apply state-of-the-art techniques learned in the classroom to their work assignments.
- Participants earn a master's degree in engineering, engineering management, or business administration.

The IME developed a partnership with the Manufacturers Association of Central New York (MACNY) and Lean Manufacturing Institute at Onondaga Community College. Through the partnership the internship program is expected to grow with the participation of more companies.

E-MANUFACTURING CONCENTRATION

In order to address emerging issues in applying Information Technology to manufacturing operations, e-Manufacturing concentration has been developed. The concentration includes two new courses (MFE 600 and MFE 700) from ECS, one course in Distributed Computing, one course in Database Technology, and one course in Context for e-Manufacturing Applications.

e-Manufacturing project (mfe 600)

This course is a project-oriented course integrating manufacturing equipment, data collection system, data communication system, programmable controllers, manufacturing execution system, enterprise resource planning system, supply chain management system, business warehouse, etc.

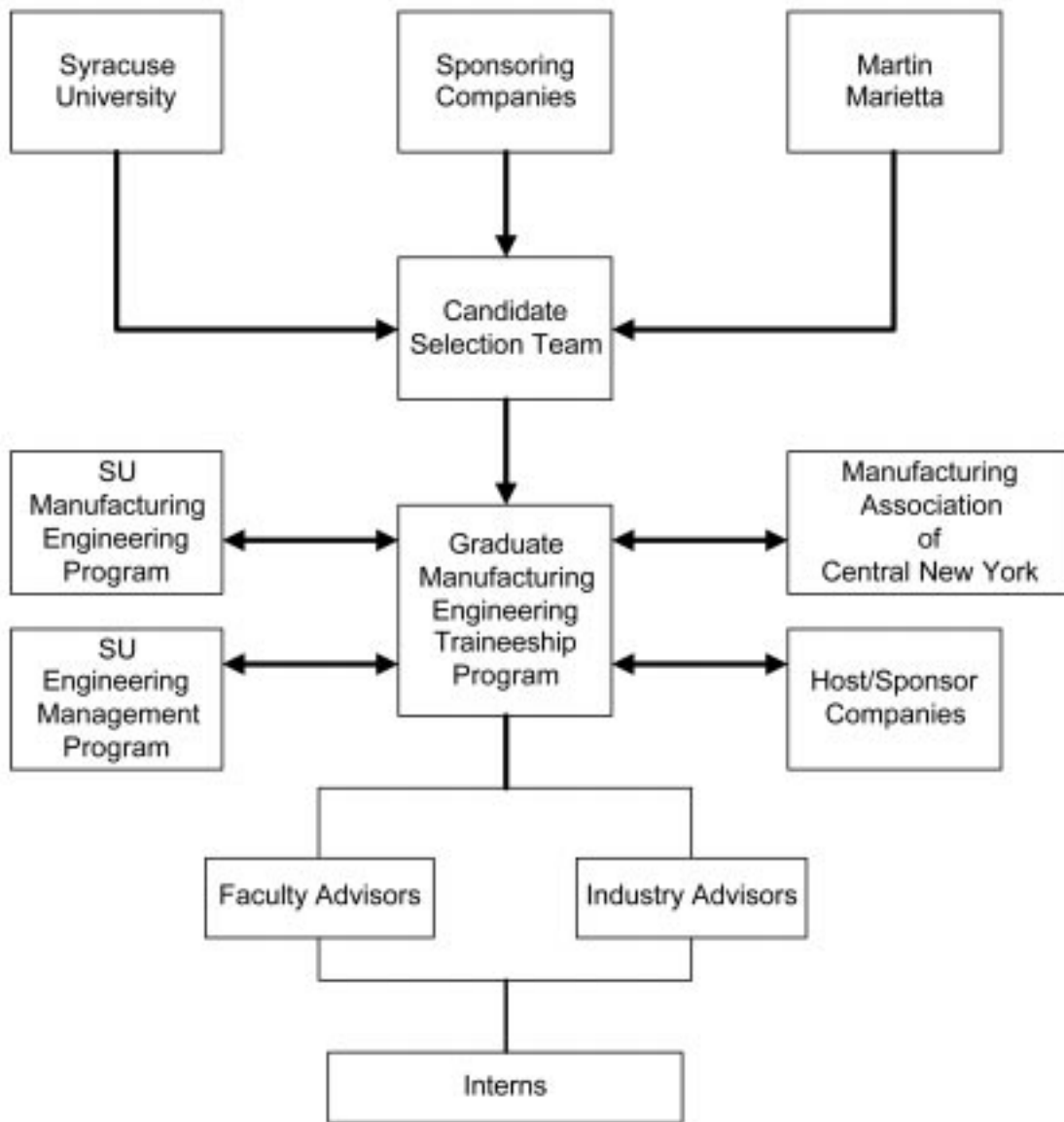


Fig. 1. Organization structure.

Enterprise Systems Modeling and Configuration (MFE 700)

This course addresses modeling enterprise system and actual configuration of the system. Enterprise modeling architectures such as CIMOSA, ARIS, GRAI, and the Purdue enterprise reference architecture are studied. Issues with existing architectures and tools are discussed. Students configure a model enterprise integrating various functions such as finance, controlling, materials management, production planning, sales and distribution. An industry-scale ERP system is adopted for the configuration exercises. A pre-configured environment is used to demonstrate the configuration and creation of (i) organizational structures, (ii) master data, and (iii) transaction data. Each student is responsible for configuring and validating an operating company based on an enterprise model.

Distributed computing

Choose one course from the following list:

- Object-Oriented Programming in C++ (CIS 554)
- Internet Programming (CSE 686)
- Software Modeling and Analysis (CSE 681)
- Object Oriented Design (CSE 687)
- Distributed Objects (CSE 775)

Database technology

Choose one course from the following list:

- Introduction to Database Management Systems (CSE 581)
- Data Base Management Systems (CSE 781)
- Data Administration Concepts and Database Management (IST 659)

Context for e-manufacturing applications

Choose one course from the following list:

- Electronic Commerce (IST 642)
- Introduction to Supply Chain Management (SCM 701)
- Manufacturing Management Systems (OPM 864)

THE SAP UNIVERSITY ALLIANCE PROGRAM

Manufacturing enterprise is an integrated entity. Students who will work and contribute to the organization should be equipped with not only a solid technical background but also an integrated perspective on the operation. The faculty in the business school has been devising ways to address operations related issues [5]. Manufacturing education community concurred and acted as well

[11]. In the new curriculum, these issues were addressed by incorporating a full scale Enterprise Resource Planning (ERP) system.

According to a recent survey by AMR Research [1], 88% of companies surveyed are using, implementing, or evaluating ERP systems. This means that ERP systems have become an essential backbone of information infrastructure for most companies [6,10]. Even though there are alternate suggestions for educating students for ERP related technologies using a scaled-down ERP tool [13], there are unique merits for using a full-scale ERP system [2].

As a leading ERP software company, SAP established the SAP University Alliance program in 1997 [12] through which a full scale ERP system, R/3 is available for research and instructional use. The SAP University Alliance Program provides a unique set of tools and community to realize the IME's vision and advance the IME's mission. Syracuse University began the preparation to

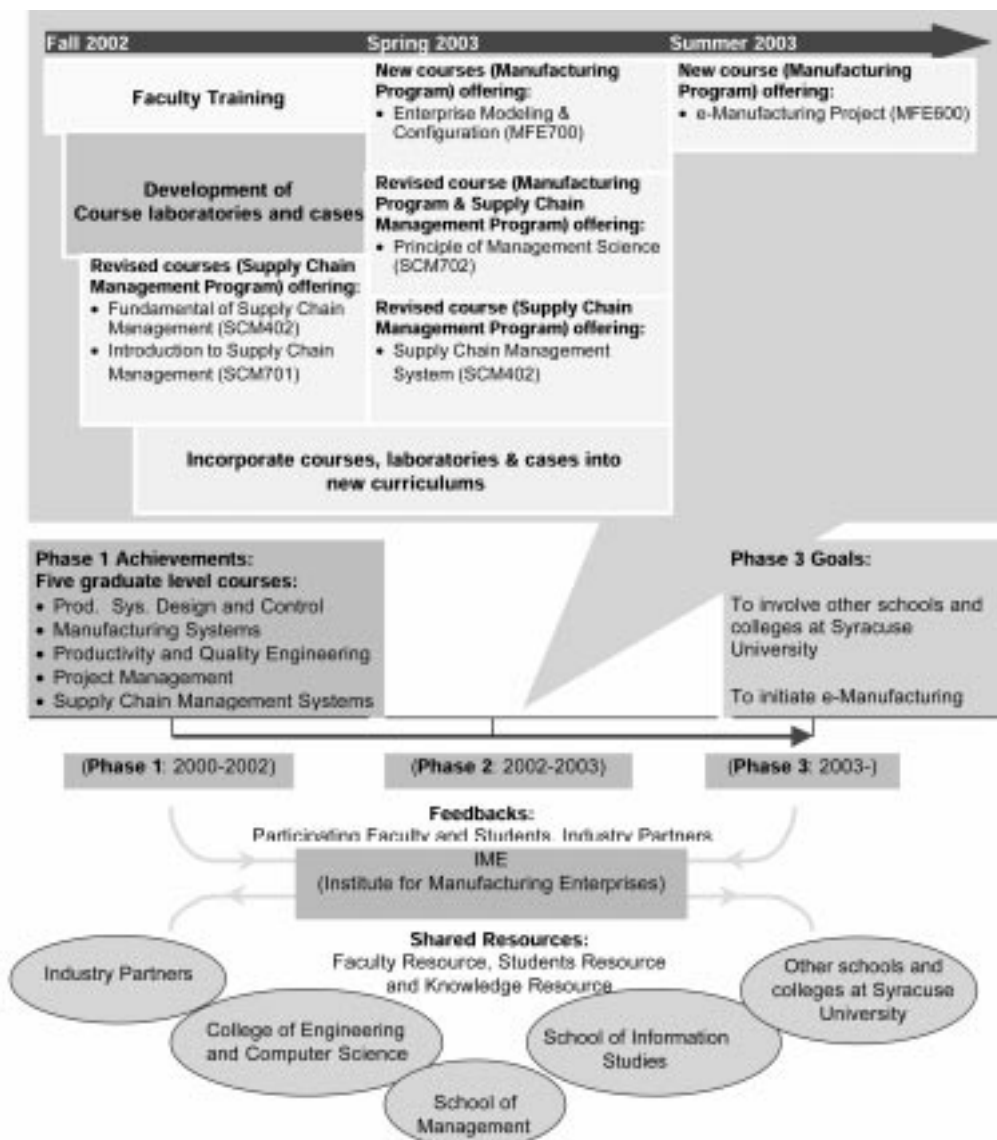


Fig. 2. SAP University Alliance Program at Syracuse University.

become a University Alliance member in 1999. Officially, the alliance program was launched in 2000 as a joint effort between the College of Engineering and Computer Science (ECS) and the University College (UC) at Syracuse University.

Despite UC's withdrawal from this program due to low enrollment from part-time students, Phase 1 (2000–2002) of SAP alliance program at Syracuse University has been successfully completed and produced five graduate level courses with significant SAP contents. These five courses are either core course or popular elective course for three graduate programs in the IME:

- M.S. in Manufacturing Engineering;
- M.S. in Engineering Management (on-campus version);
- M.S. in Engineering Management (distance-learning version).

The SAP alliance program at Syracuse University is entering Phase 2 (2002–2003) with objectives of:

1. developing an 'e-Manufacturing' concentration in the Manufacturing Engineering program
2. expanding into the undergraduate and MBA programs at the School of Management.

The success of Phase 2 will lead to Phase 3 (2003–2004), which has plans to involve more schools and colleges at Syracuse University and institutions outside of Syracuse University and industry involvement. With preliminary and growing interest already expressed from these units, Phase 3 will result in more comprehensive and innovative educational and research programs as envisioned in the IME. A future plan for this program is illustrated in Fig. 2.

Recently Syracuse University is announced as a recipient of SAP's prestigious curriculum renewal award recognizing its strategic and long-term objectives in manufacturing education.

CONCLUSION

Syracuse University has responded to today's challenge of manufacturing education by establishing a multidisciplinary research center—the Institute for Manufacturing Enterprises, developing a new M.S. curriculum in Manufacturing Engineering drawing courses from various academic units on campus, and utilizing SAP's Enterprise Resource Planning solution as a tool to realize the vision of the Institute for Manufacturing Enterprises. This manufacturing initiative has a potential for synergy with the new strategic plans for the University, particularly with 'Information Management and Technology,' 'Environmental Systems and Quality,' and 'Collaborative Design'.

Some positive evidences are emerging due to the above initiatives in manufacturing education at Syracuse University. Students' interests in manufacturing subjects are increasing, particularly in information technology related courses. Manufacturing courses are well subscribed not only by manufacturing majors but also by other students completing degrees in MBA, Information Management, Bio-Engineering, Mechanical Engineering, Engineering Management and Public Administration. A diverse group of students creates an environment where the multidisciplinary nature of manufacturing is appreciated and experienced. Class projects are comprehensive and complex enabled by students representing various disciplines. SAP honored Syracuse University's Alliance program centered on manufacturing engineering.

Multidisciplinary activities have inherent risks in an environment where basic units are discipline-specific departments. However, manufacturing education is multidisciplinary in nature and desirable in such an environment.

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