

Innovation in Manufacturing Education and Workforce Development – The PRIME Coalition

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I. Introduction

The manufacturing base of Southwestern Pennsylvania is the key to a healthy regional economy. Manufacturing is the second largest private sector employer with 166,000 jobs, and the first in annual wages with a total payroll of over \$6 billion^{1, 2}. The average manufacturing wage of \$40,000 compares very favorably to the \$28,000 average of other sectors. In southwestern Pennsylvania, the manufacturing workforce (which is 15% of the total workforce) accounts for \$56 billion of a \$139 billion economy. This is a clear indication of the impact that the relatively small number of manufacturing jobs has on the regional economy.

This essential regional economic base is being threatened by a critical shortage of skilled technicians and engineers needed to sustain and grow the region's manufacturers³. This is further complicated by the fact that the industry base in Southwestern Pennsylvania is no longer dominated by the steel industry. Manufacturers in the region now exhibit significant diversity in materials, processes, and technology thereby challenging the educational system that needs to be in place to prepare the regional workforce.

At a time when manufacturers cannot recruit a sufficient number of skilled workers, there is a segment of the region's workforce that is under-employed and often working in the service and retail sectors for much lower wages. The projected retirement attrition rate of 5% per year in the manufacturing sector further exacerbates this situation. This disconnect in the deployment of the regional workforce was the impetus for an effort targeting the recruitment and education of the kind of workforce demanded by the region's manufacturers while simultaneously providing new and rewarding career paths for the region's youth.

The challenge of transforming academic institutions into educators of highly qualified manufacturing employees that are skilled in mathematics, science and technological innovation is a critical one that has drawn national attention. In southwestern Pennsylvania, the response to this challenge has taken the form of an innovative partnership called PRIME. The Partnership for Regional Innovation in Manufacturing Education (PRIME) is an industry-driven, five-college system delivering innovative manufacturing education and career development in southwest Pennsylvania. Established in 1999, PRIME brings together Robert Morris University (RMU), Pennsylvania State New Kensington (PSNK), the Community College of Allegheny County (CCAC), Butler County Community College (BCCC) and Westmoreland County Community

College (WCCC) along with dozens of manufacturing partners in southwestern Pennsylvania. The coalition was established through an MEP grant from the Education Foundation of the Society of Manufacturing Engineers.

PRIME was launched to achieve the following objectives:

- Build regional support for the engineering industry and increase awareness of the employment opportunities in this region's manufacturing sector.
- Develop innovative manufacturing programs that emphasize real world experiences and provide students hands-on learning with industrial-grade equipment.
- Develop a feeder system for individuals who will access the seven new degree programs that will be offered by PRIME's educational partners.

Early in the process, the PRIME partners realized that the success of the coalition would depend on the implementation of a strategic plan that would address the needs of the region at various levels. Accordingly, the group adopted the integrated paradigm that appears in Figure 1 and has been working on the implementation of its components over the past two years. It is important to note that the implementation of the activities shown in the paradigm is concurrent in nature with some stagger and overlap between various activities. For example, it was considered important for the partners to establish a solid infrastructure at each site before embarking upon the development of pre-college programs for the feeder system.

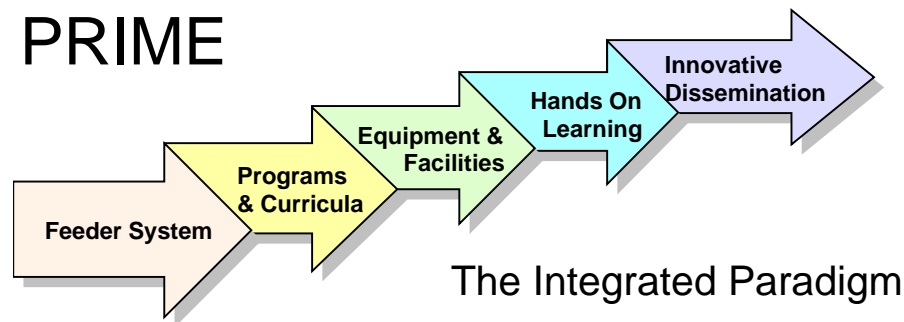


Figure 1. The Integrated Paradigm Adopted by PRIME

These are described in next three sections of this paper. The first of these describes the feeder system, the second addresses the activities at the partner institutions, and the third pertains to innovations that have recently been initiated in the area of dissemination and asynchronous learning.

II. The Feeder System

The creation of new degree programs does not automatically lead to an influx of students – the less than favorable public perception of manufacturing makes this painfully obvious in the case of manufacturing programs. The situation is further complicated in geographic regions that have experienced a decline in traditional manufacturing – steel in the case of southwestern

Pennsylvania. Over the past year, PRIME has focussed on the development of an outreach effort with the following objectives:

- Stimulate/motivate students to pursue careers in manufacturing
- Develop student (and parents and teachers) understanding and appreciation for manufacturing and manufacturing careers
- To engage manufacturing companies and their personnel more fully in achieving the above objectives

The multi-step methodology that has been described below is being adopted by PRIME. At the time of this writing, each of the steps has been implemented to some degree.

Manufacturing Awareness: The public perception of manufacturing has been unfavorable at times and reminiscent of when manufacturing jobs were viewed as repetitive, monotonous, dirty, and in hazardous environments. This image must be rectified through an advertising campaign that highlights the high tech nature of PRIME's programs and the wealth of opportunities that are available to PRIME graduates. PRIME will also draw upon the assistance of the industry partners and resources from SME for this purpose.

Through its web site at www.primepa.org and the toll free number at (888)279-2241, PRIME will regularly inform the community about its activities and the career opportunities that are available through manufacturing education. Awareness will be emphasized through presentations at various schools in the area, career fairs, National Engineers Week celebrations, the Pittsburgh Sci-Tech Festival, the SME Student Robotic Challenge, meetings of professional and trade associations including SME, NTMA, Allegheny Career Connection, and the Pittsburgh Technology Council. These activities and the ones described in the following section on "Manufacturing World Exploration" will target the creation of a database of candidates for PRIME and its programs. With professional assistance in student and industry focus groups, copyediting, graphics design, and photography, PRIME has created three brochures. PRIME has been featured on radio shows and a program is being planned with local television stations.

Manufacturing World Exploration:

- PRIME will invite middle and high school students, teachers, and administrators to visit PRIME academic partner institutions, participate in shadowing programs, and mentor K-12 student teams for various competitions
- Industry based activities would include tours of local manufacturing organizations sponsored by SME chapters, industry steering committee members, and area industry.

Manufacturing Career Information for School Systems: The focus here is on the engagement of school systems through the following means

- Short workshops for middle and high school math and science teachers, counselors, administrators
- Manufacturing career counseling for students, the K-12 community, and families
- Manufacturing scholarships: It is important to have a counseling center that will allow students to be paired with the institution that is best suited to their needs and career aspirations. Admissions and financial aid officers from the various institutions will assist students with paperwork and counseling. Scholarship opportunities available through

federal, state, professional, and private initiatives will be aggressively pursued to offset the cost of education for the participants.

- Manufacturing jobs awareness for students, the K-12 community, and families

Manufacturing Workforce Recruitment/Preparation - Summer camps: PRIME has explored the work done through programs such as the Science Technology and Engineering Preview Summer camp for girls (STEPS), the Detroit Area Pre-College Engineering Program (DAPCEP), the Ford Academy of Manufacturing Sciences (FAMS) program, and several other initiatives. In the end, PRIME selected the Manufacturing Pathways Initiative (MPI) program – an effort by the Pittsburgh Technology Council (PTC) and Southwestern Pennsylvania Industrial Resource Center (SPIRC). As the leading change agent for Southwestern Pennsylvania's technology industry, the Pittsburgh Technology Council drives the growth, development, and retention of the region's technology-focused business and talent. Established in 1988, the Southwestern Pennsylvania Industrial Resource Center (SPIRC) helps small and medium-sized manufacturers in southwestern Pennsylvania grow their companies and improve their competitive performance. SPIRC.

The strategic partnership between PRIME and PTC/SPIRC is a logical one and an ideal vehicle for the delivery of the 180-hour MPI program. 60 hours of this program will be spent in classroom and laboratory activities (covering manufacturing processes and systems, problem solving, communications, teamwork, and project management) while 120 hours will be spent at an industry partner's site working on a paid internship. The instructors for the program will be recruited from the PRIME colleges and universities while mentors for the internships will be located from area industry. A pilot MPI program was conducted in Summer 2001 at a single site in one county with 25 students from 4 different high schools. In the Summer of 2002, ten sites are planned with 25 students at each site – the program will impact the ten counties surrounding Pittsburgh. The MPI program targets high school students –the coalition will explore summer programs at the middle school level at a future date.

Manufacturing Workforce Recruitment/Preparation - In School Component: In 2000 and 2001, the SME Student Robotic Challenge was hosted by Robert Morris in Pittsburgh. Following this event, SME personnel were instrumental in the creation of an event that is currently called the Pittsburgh Adventures in Technology. The event will be piloted in the Spring of 2002 and will have its full-scale rollout in the Fall of 2002. The purpose of this event is to engage the school systems that were cited in the earlier component of the outreach program (and others) over the course of the academic year. The need for such a program was experienced during the pilot test of the MPI program and offers another avenue for partnership between PRIME and PTC/SPIRC.

At the high school level, this event would focus on developing a new or revised product from concept through the development of manufacturing, production systems, assessment of market, and costing to evaluate commercial viability. Student teams would develop presentation materials and present their results at a regional showcase such as the Sci Tech Festival. At the middle school level, the event would seek to inform students/parents and teachers about careers in manufacturing, including starting and lifetime earning potentials, and advancement/promotion potentials. Students would identify entry -level skill requirements for the career path and sources to obtain those skills in southwestern Pennsylvania through high school programs, post

secondary offerings of universities, community colleges, technical centers, and industry training. Students would identify number of positions in this career field and the current number of openings available.

Recent meetings in Pittsburgh with various constituencies have been very successful and stakeholders at various levels have expressed a high level of interest in participating in the program. An added advantage is the development of closer relations between PRIME academic partners, area industry, and area K-12 systems.

III. PRIME Activities

The creation of the PRIME partnership has involved activities at each institution as well as those that have been undertaken as a coalition. Each partner institution has undertaken work in the following common areas:

- Developed or modified curricula and facilities to address the competency gaps identified by industry^{4,5}
- Transformed industry advisory committees into joint faculty-industry steering committees to guide and continuously improve the curriculum
- Developed articulation agreements amongst themselves. Figure 2 depicts the flow that is currently possible due to the block articulation frameworks that have been created between the various academic partners and the creditable programs^{6,7}
- Improved relationships with industry to offer time- and place-appropriate, highly relevant, industry specific, real-world learning experiences for students through internships and projects

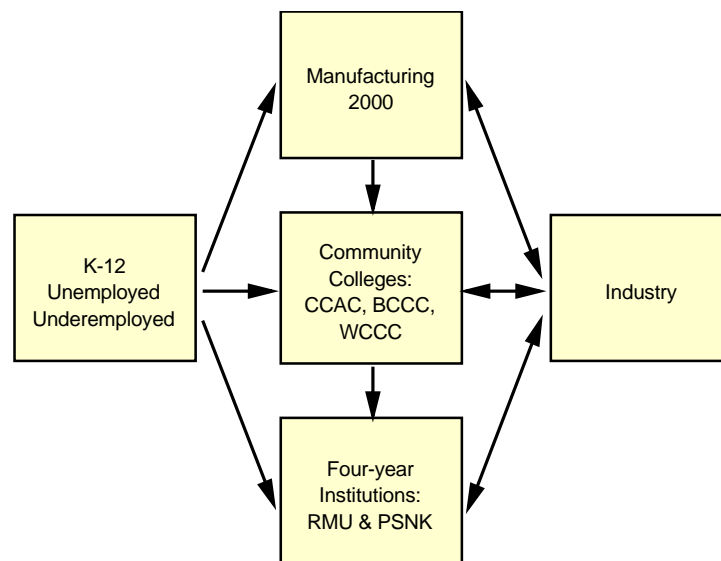


Figure 2. PRIME Partnership

In addition to these common needs, each institution has a niche resulting from its strategic position and industry needs specific to that part of the region. At Robert Morris University this has taken the form of the Computer Integrated Engineering Enterprise – the Learning Factory. The mission of this learning factory is to support the B.S. in Manufacturing Engineering and educational programs college-wide, serve as a test bed for research and development activities, support College outreach and recruitment activities, and provide an environment for lifelong learning. The College has dedicated 7,500 square feet to the facility that features materials characterization, analysis, and testing, sensor-equipped automated machining, robotic assembly/inspection, rapid prototyping, metrology, plastics injection molding, materials handling, automatic identification systems, and systems integration. When complete, this laboratory will constitute a full production system that will allow students to take a product all the way from concept through design and on to final manufacture. This facility will support all engineering courses and will also support business, science, and mathematics courses by providing actual production data and system for analysis, control, and integration in near real time.

At Penn State New Kensington, certificate program and options within existing technology programs have preceded the Associates and Baccalaureate degrees in Manufacturing Engineering Technology – the later are currently undergoing scrutiny for approval. The focus is on tool and die manufacturing, electro-optics, and general manufacturing. Students will also have access to programs in plastics manufacturing at the Behrend campus and nano-fabrication at the State College campus. In addition to laboratories on campus, students may work at the nearby Manufacturing Assistance Center operated by the University of Pittsburgh.

The Associates degree in Manufacturing Technology offered by the Community College of Allegheny County and the three-year bridge program to Robert Morris University focuses on the areas of controls, automation, metrology, and quality. The CCAC vision for this degree program is based in the control of the manufacturing process through automation. This involves computer-based data acquisition and the analysis of the acquired information using techniques such as Statistical Process Control. In addition to space available on campus, CCAC leases space at the nearby Steel Center Area Vo-Tech. The long-term plans are to create and house an Advanced Manufacturing Academy on the CCAC campus.

The Associates degree in Manufacturing Technology offered by the Butler County Community College focuses on tool and die manufacturing and plastics manufacturing. Building on strong existing programs in design and metrology, the new program emphasizes team skills, project management, international relations, and business skills in the context of these manufacturing focus areas specified earlier. The new Manufacturing Technology degree and manufacturing option in the General Engineering transfer program are supported through the use of existing facilities and the development of a new building, a portion of which is dedicated to the Manufacturing Processes Lab. This new facility will allow the college to update and expand its current lab space. BCCC has also formed a partnership with Penn United Technology, Inc. whereby BCCC uses Penn United's training facility for a number of tool and die courses.

The Associates degree in Manufacturing Technology offered by the Westmoreland County Community College has allowed the institution to consolidate and reorganize its offerings in

manufacturing. WCCC current offers options in Chemical Processes, Manufacturing Processes, Manufacturing Maintenance Apprenticeship, and Nano-fabrication under the umbrella of a Manufacturing Technology degree program. The new Manufacturing Technology degree features a common first-year curriculum, consisting of basic skill courses in math, electronics and manufacturing, and other core requirements with area-specific specialization in the second year. The process of consolidation has extended to physical facilities in that all of these options have been co-located for purposes of cohesion. The result is a blend of theoretical and experiential learning and is also structured to focus on team skills.

At the coalition level, PRIME works on various activities to create a world-class environment for manufacturing in southwestern Pennsylvania. These include:

- Benchmarking and sharing the best in class that each institution has to offer by facilitating the adaptation of curriculum modules developed in one institution for use by the others.
- Open access to each other's facilities and seek opportunities to engage students in shared learning experiences.
- Organize an annual academic-industry forum to foster peer learning among faculty, students, and industry and to provide opportunities for students to demonstrate mastery of technical, teamwork and communication skills in a professional setting.
- A system of governance to better manage the academic/industry relationships and position the involved institutions to deal with issues of portability, growth, standards, and shared measures of excellence.
- A structure that will facilitate interface between PRIME and K-12 programs as described in the earlier section.

Role of Industry and Other External Constituents: Each institution has established Industry Steering Committees that are co-chaired by an industry representative and the co-PI's for this proposal. These Steering Committees are working groups with a major role in curriculum and laboratory development, internships, development of problem-solving opportunities using teams, and sponsored projects. These committees are responsible for monitoring the deliverables established for the coalition and ensuring that elements of each institution's proposed programs are being kept on schedule and on track⁸.

PRIME originally envisioned the formation of an oversight committee to plan and set priorities for the coalition. A steering group that has met on a monthly basis absorbed this activity for the past two years. With the continued growth of PRIME, it is recognized that there is an arena of activity at the state and national level in which PRIME should be engaged. A National Advisory/Visiting Committee will be formed to facilitate the establishment of relationships with similar efforts, elevate PRIME's profile, for assessment, and similar efforts. PRIME works closely with a local organization called WIN – World Class Industrial Network for building government relations and consulting in the area of fundraising.

V. Impact of PRIME To Date

PRIME is dedicated to the creation of the integrated educational system needed to meet industry, student/trainee, and regional economic needs southwestern Pennsylvania. PRIME builds on

basic scientific and mathematical principles and skills to establish workforce competencies in manufacturing. To date, PRIME has served the region in the following ways:

- Closed the competency gaps cited by regional industry through new and upgraded curricula and facilities at all partner institutions. These gaps include *Business Knowledge Skills, Communication Skills, Manufacturing Processes, International Perspective, Manufacturing Process Controls, Manufacturing Systems and Principles, Quality, Problem-solving, Project Management, Teamwork, Materials, and Engineering Fundamentals*;
- Impacted students seeking pre-employment education or a skills upgrade for career advancement through a combination of traditional (full-time), non-traditional (part-time), and industry-based certificate instruction;
- Served as a replicable and portable model for competitive collaboration and regional development;
- Linked K-12 and certificate and apprenticeship programs to a region-wide articulated system of higher education;
- Created a regional network for learning at different levels, at times and locations best suited to new and incumbent technicians and engineers (work in process); and
- Engaged the vigorous and in-depth participation of over fifty industry partners to guide and continuously improve regional and national manufacturing education.

IV. Innovative Dissemination

PRIME has been invited to present at various forums over the last two years – each co-PI has been very active in disseminating the activities of the coalition. Most recently this has taken the form of funded work in the area of asynchronous learning. The National Science Foundation recently awarded PRIME a three-year Advanced Technological Education (ATE) grant towards the implementation of this comprehensive approach to manufacturing education.

Highlights of the ATE project include:

- The creation of 20 learning modules in five areas of study - Engineering Materials, Manufacturing Processes, Quality and Metrology, Computer Applications in Manufacturing, and Programmable Logic Controllers with projects from industry partners.
- The implementation of an active learning model consisting of Exploration, Dialog, and Application steps for engineering technology and engineering students.
- The creation of a web-based conferencing system to network the five campuses and industry partners in order to enhance the learning process and facilitate collaborative learning.
- The implementation of materials common to both two- and four-year institutions.
- The creation of a flexible, user-friendly, and supportive delivery system.

Work on this project has begun and will allow the coalition to reach a wider audience with greater flexibility. This extends to the access and sharing of laboratory and technical facilities within the coalition, between coalition members and area industry, and finally between teams of students who may be located at various partner institutions. Additional work in this area is being showcased in the 2002 NSF Grantees poster session and in a DELOS session.

V. Summary

The PRIME coalition is now in its second year of existence. The progress made by each of the partners and the coalition as a whole is consistent with the timeline established for the project. In addition to the SME funds, the coalition has been funded by the Heinz Endowments, the National Science Foundation, the Alcoa Foundation, and the USX Foundation. The coalition has submitted proposals to the U.S. Department of Labor (in partnership with various regional efforts) and various local foundations to support its activities.

The infusion of funds, the time invested by the industry partners, equipment donations from industry, and the relationships cultivated with the middle and high school systems have allowed the partners to make significant progress towards the goals set for this coalition. The process of growing the talent pool for the manufacturing sector in the region is an ongoing one. As the project matures, the number of students drawn into programs and careers in manufacturing will increase significantly. This will further strengthen the existing manufacturing base in the region, and the increased technical workforce will attract new businesses to the region

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