

PRIME – the Partnership for Regional Innovation in Manufacturing Education

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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 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^{4,5}.

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. 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 in July 1999 through a \$500,000 Manufacturing Education Plan (MEP) grant from the Education Foundation of the Society of Manufacturing Engineers (SME) with the following goals:

- Impact 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
- Serve as a replicable and portable model for competitive collaboration and regional development
- Link K-12, certificate and apprenticeship programs to a region-wide interconnected system of higher education
- Create a regional network for learning at different levels, at times and locations best suited to new and incumbent technicians and engineers
- Create and upgrade curricula and facilities at all partner institutions
- Engage the ongoing and vigorous participation of dozens of industry partners to guide and improve manufacturing education

Over the past two years the coalition partners have launched creditable degree programs, certificate programs, and options within degree programs at all sites^{6, 7}. A framework for articulation has been approved for the block transfer of credits from one participating institution to another. Along with the degree programs the coalition has seen the creation or significant enhancement of laboratory and computing facilities at partner sites. Industry partners have been instrumental in developmental efforts pertaining to the areas of experiential learning, internships, projects, and positioning of the coalition. The coalition has also been very active in the development of a comprehensive outreach program targeting middle and high school students and their communities.

At the very beginning it was recognized that the coalition would have to seek National Science Foundation (NSF) support to take the next steps in this regional initiative. The SME grant was used to launch the coalition and acquire essential equipment and instrumentation for the laboratories at the partner institutions. NSF support through the Advanced Technological Education (ATE) program is the vehicle for PRIME to develop and implement curricular activities and carry out widespread dissemination of the courseware and teaching/learning methods developed (NSF ATE Grant 0101637 dated July 2001).

II. Curricular Objectives of PRIME

The goal of the ATE project is to support the implementation of an industry-driven regional network for manufacturing education at different levels, at times and locations best suited to new and incumbent technicians and engineers. To meet this goal, the following objectives have been established for this project:

1. Establish a replicable 3-step active learning model, consisting of Exploration, Dialog, and Application steps, for engineering technology and engineering students involving conceptualization, design, implementation, and dissemination.

2. Demonstrate the ability of students to collaborate across institutional boundaries through internet-based learning and conferencing at all five partner sites.
3. Address and close the manufacturing competency gaps identified by the industry partners as described below.
4. Produce a progressive series of 20 interactive and experiential modules for the five courses specified for this project.
5. Develop and implement technical projects with industry initiative and focus within each module.
6. Demonstrate the application of common curriculum materials spanning the spectrum of technology and engineering programs at the two-year and four-year levels.
7. Establish a user-friendly, flexible delivery format for all materials developed over the course of this project.

Building on basic scientific and mathematical principles and skills, PRIME has sought to close industry-stated competencies in the manufacturing workforce. This curricular focus appears in Table I and shows areas where the institutions have common courseware needs.

Table I. Curricular Emphases of PRIME at the Partner Institutions

	Materials, Processes, and Methods in Manufacturing	Product, Tools, and Fixture Design	Metrology & Quality/ Instrumentation & Measurement	Automation, Controls, and Manufacturing Systems
RMU	◆	◆	◆	◆
PSNK	◆	◆	◆	◆
CCAC	◆		◆	◆
BCCC	◆	◆	◆	
WCCC			◆	◆

For this project, the PRIME partners decided to address the following five areas of common need:

- Engineering Materials
- Manufacturing Processes
- Quality and Measurement
- Computers Applications in Manufacturing
- Programmable Logic Controllers

III. The Learning Model

Research into adult learning has shown that having relevant hands-on activities is critical to student learning. Knowles has stated that for adult learning to be effective it must⁸:

1. Be relevant to employment or job requirements.
2. Have immediate possible application.
3. Provide actual hands-on exercises.

In addition, recent work in the physical sciences suggests that effective learning is accomplished when students are allowed to build and discover their knowledge in an interactive or active learning environment.^{9,10} PRIME proposes to adapt and implement the best practices from other NSF sponsored projects into an active learning environment. In addition to closely examining

the work done at Focus:Hope in Detroit, MI and the AIM Center in Dayton, OH, PRIME will research the work being done at the following sites and adopt modules as necessary. The framework appears in Figure 1.

- Johns Hopkins University in training manufacturing faculty to teach technicians workplace competencies
- Cuesta College and the CREATE consortium for preparing technicians in high tech manufacturing
- Cleveland State University and the TEAM project in bringing industry projects into the classroom
- University of New Mexico and their work in cross-training technicians and engineers
- Oklahoma State University for bringing industry projects into the classroom
- University of Illinois-Chicago for the technological competency program for adults
- Westark College for its work in vertical integration in manufacturing education

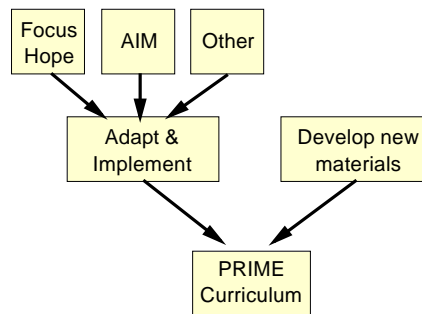


Figure 1. Development of PRIME Curricula

This process of integrating the pedagogy of other projects will allow PRIME to benefit from the work that has already been done in the field of manufacturing, technical, and science education. PRIME will develop modules for a series of courses that are common to the programs of the five schools presently in the consortium.

For each course a series of four modules will be developed. Each module will represent one month of activity for a typical college class. Each of these modules will further break down into four weeklong sections. The modular approach to curriculum development allows materials developed to be used over a broad range of academic levels. PRIME materials will be usable at the Industrial Technology, Engineering Technology and Engineering Science levels of manufacturing education. Dr. Cunningham, a Co-PI in this project, has experience with this type of modular development through his involvement with the Introductory College Physics for the 21st Century Project (DUE # 9553665). A similar curriculum model is being proposed for application to manufacturing education. Dr. Erevelles, a co-PI and Director for this project has had extensive experience, including 4 NSF ILI projects, where industry input was used to design and implement learning laboratories in manufacturing engineering at Kettering University.

IV. The Learning Cycle

Each module will begin with an industrial situation that must be resolved or understood. The Industrial Steering Committee (ISC) will provide these industrial problems. Each section of the module will move the student toward both an understanding of the concepts and technology important to the situation and to a solution to the problem. Subject experts at the PRIME schools will write the modules. The modules will have a consistent style and educational approach. The learning cycle (Figure 2) that will be used has three essential steps:

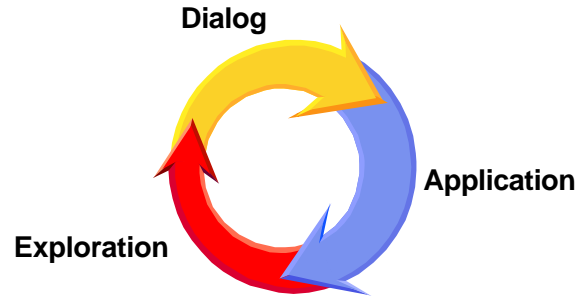


Figure 2. Learning Cycle

- 1) Exploration Phase – In this portion of the module the students will carry out short experiments to demonstrate or discover the basic concepts of the physical phenomena or technology being studied. Students will be required to communicate their results in both written and spoken form.
- 2) Dialog Phase – This portion of the module will provide discussion of relevant theory or details of specific techniques that are appropriate to the solution of the problem. Techniques of problem solving, or information presentation would be found in this portion of the module.
- 3) Application Phase – In this portion of the module the student will be presented with a problem or series of problems for solution with the ideas and techniques studied. These problems may be of a pencil-paper nature or actual hands-on project experiments. All problems will be derived from the industries represented by the ISC.

Within a section of the module, the learning cycle will be repeated several times in a spiral fashion. Each cycle will develop more deeply the overall concept of the module. Each section will end with a hands-on project experiment. This approach will satisfy the three tenets of adult education. By using industry relevant activities provided by the Industry Steering Committees, PRIME uses cases, examples and problems that are relevant to job requirement. Secondly, explorations and applications emphasize hands-on activities that are applied immediately to the problem at hand. Finally, the project-based approach gives students a deeper understanding of the module under study through hands-on involvement by the students.

V. Delivery Format

All module materials will be developed for delivery in an electronic format. The World Wide Web and a CD-ROM will both be used as the delivery media. The CD-ROM will contain the module in three formats. First, the web-enabled version will be included on the CD-ROM. This will allow interactive work with the materials. Second, a portable document format (pdf) version will be provided for faculty wishing to use the materials with no changes. And, third, the original Word documents will be provided to allow faculty to modify or change the materials in response to local needs. Use of the CD-ROM will carry a site license to make as many printed copies as are needed for the course. Faculty wishing to use only a section of the modules need

only duplicate that portion. Additionally, on the web site a “Faculty Desk” will be maintained with current information on using the materials, drawings of equipment, equipment lists, vendors, and user comments.

PRIME will hold the copyright on all materials developed by the individual schools. The five PRIME partners will be granted full site license to the modules developed under this project. PRIME is currently exploring the possibility of marketing the CD-ROM through SME and has started discussions with their Conferencing Division.

VI. Web Conferencing

Among the skill-gaps identified by industry were collaboration and communication skills. For students to develop these abilities, classroom activities must allow time and opportunity to practice them. Further, with today’s information age the collaborative team may not always be located in the same place. To facilitate these experiences, three of the courses will have a collaboration component where student teams will be built from multiple schools. These teams will tackle a project around a manufacturing problem in the Programmable Logic course, and the Metrology course. Students from partner schools will “meet” on-line using tools such as Net Meeting to discuss possible problem solutions and divide the tasks among the team members. The mechanism of web conferencing was chosen because:

- 1) Students are familiar with browser technology.
- 2) Cost is essentially zero to students as opposed to travel expenses for face-to-face meetings at the schools.
- 3) The web is available at the schools at any time of the day and for any size team.
- 4) It enhances the vital interaction with industry partners who provide the problems and whose assistance will be needed from time to time.

The themes of commonality and Internet connectivity also extend to the equipment selected for this project. Each school will have identical equipment available at their sites and PRIME has entered negotiations with the vendors to build partnerships and secure significant discounts to maximize the NSF investment and enhance the learning process. For the programmable logic course, an Allen Bradley SLC 5/05 Internet-connected PLC will allow students from one school to control the machine and read results from machines or systems located at a different school. This will require the students to communicate and collaborate on the design and implementation of the project.

In the Metrology course a computer-controlled coordinate measurement machine (CMM), either a Mitutoyo Brite Series or a Brown & Sharp Gage 2000 will be available. Data and inspection routines from a CMM at one location may be easily shared with students at a different location. Students will share the information, activities and results over the Internet. These cross college collaborations will allow students from different academic levels to work together as they must in industry. For example, the BS Engineering students may design a PLC program to operate a machine for which the AS Engineering Technology students have developed and implemented interfaces for control.

In the computer applications course one of the modules will contain a section on using the Internet in collaborative work environments. In addition to these two common pieces of equipment, each school has a series of specialized equipment that the collaborative process can make available for wider group projects. For example, all five schools have laboratories dedicated to computer-aided drafting and design with common software at each school. Computational software, such as MathCAD, and simulation software such as Electronic Workbench is also available at all schools to allow students to share work on common projects. PRIME feels that the introduction of Internet based collaborative projects will motivate the students and provide them with global prospective about their work.

VII. Status and Expected Impact of the Coalition

At the time of this paper, all of the above activities are in process. The progress made by each of the partners and the coalition as a whole is consistent with the timeline established for the first twelve months of the project. The infusion of funds by NSF through DUE-0101637, the time invested by the industry partners, equipment donations from industry, and the relationships cultivated with the industry vendors have allowed the partners to quickly progress towards the goals set for this project. Assessment practices established for the coalition will be expanded to include a national visiting committee for program and project assessment¹¹. 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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