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ABSTRACT

Stemming from a series of panel discussions between employers from the manufacturing sector and community college educators, this document describes the development and goals of the two-year Associate Degree in High-Performance Manufacturing and outlines 20 standards for the degree agreed upon in the discussions. Part I describes the origin of the degree, designed to represent an agreed-upon content for the two-year degree so that meaningful standards might be reached by manufacturing students and workers, and reviews the role of standards, universal competencies, and general education in the degree. Part II then describes 20 standards for manufacturing students and workers, including the competencies involved, performance requirements, and illustrative tasks that cannot be performed without the competencies. These standards include the ability to: (1) allocate time, money, material, facility, and human resources; (2) acquire and evaluate information; (3) understand and comply with legal requirements; (4) organize, maintain, interpret, and communicate information; (5) use computers; (6) engage in teamwork; (7) teach others; (8) serve clients; (9) exercise leadership; (10) negotiate; (11) work with diversity; (12) identify, describe, and work with systems; (13) understand and describe social, political, economic, and business systems in which firms function; (14) monitor and correct performance; (15) design and improve systems; (16) select and apply technology; and (17) perform maintenance and troubleshooting. Part III reviews traditional, hybrid, and modular models of curriculum design, rating each according to flexibility, articulation, integration, and distance and computer-based learning. A list of panel participants is appended. (KP)

Institute for Policy Studies
The Johns Hopkins University

AN ASSOCIATE DEGREE IN HIGH-PERFORMANCE MANUFACTURING

Arnold H. Packer
SCANS/2000 Program

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Final Report
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EXECUTIVE SUMMARY

Between the fall of 1993 and the spring of 1994 a panel of a seventeen individuals representing employers in the manufacturing sector met three times with another panel of sixteen representing educators from the nation's community colleges.[1] The National Association of Manufacturers hosted the Employer Panel which included representatives of small and large manufacturing firms, unions, and trade associations. The American Association of Community Colleges hosted the Educator Panel which included presidents and administrators of colleges and college systems. (Attachment A contains the list of panel members.)

These panels defined and agreed upon standards for a two-year *Associate Degree in High-Performance Manufacturing*. This is a single degree, with industry-specific areas of concentration, that could serve the entire manufacturing sector from aircraft to electronics to printing. They also agreed on criteria for the curricula needed to meet these standards.

An Associate Degree in High-Performance Manufacturing can contribute to meeting the nation's highest domestic priority: placing the U.S. economy firmly on a high-skill, high-wage path. It will serve the three purposes described below.

1. **Increase the options available to youngsters.**

Connecting school and work, formal and informal schooling, middle schools and high schools, high schools and community colleges, and community colleges and four-year colleges will increase the options open to young students. The connections will particularly help youngsters who are not planning to go immediately to a four-year college after high school. A well-designed development process will allow these students to prepare for a specific career without foreclosing their other options; it will allow them to choose while it avoids tracking.

Consider a four-year development system that begins at about age 16. By their 21st birthday, youngsters should be able to obtain a high school diploma, an Associate degree, and a work-based resume. These three credentials should be acceptable to a wide variety of prospective employers as evidence of the know-how required for high-performance

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[1] The work was done under a grant by the Sloan Foundation to the SCANS/2000 Program within the Johns Hopkins University Institute for Policy Studies. The assistance of Dr. Elizabeth Mathias of Anne Arundel Community College in the preparation of this Report is gratefully acknowledged.

manufacturing. The students should also be equipped to transfer to a four-year college and obtain a baccalaureate degree. The system requires:

a. Standards for work and school that are simultaneously generic enough to maintain the students' options and specific enough to help them obtain a position on a career ladder.

b. Option-rich Schooling that grounds students solidly in the workplace know-how valued in many jobs and in the academic background needed for further schooling.

c. Learning-rich Work Assignments that offer students an opportunity to practice and demonstrate the know-how needed to meet the industry skill standards (as noted in (a) above) and help them build their resumes.

d. Development Pilots that create and validate curricula, instructional materials, instructional strategies and other concepts, including pilots in high schools, community colleges, and in work-based learning.

2. **Increase the options available to experienced workers.**

The proposed degree will also expand the options open to experienced workers, whether their jobs are secure or threatened with dislocation. Almost everyone agrees on the need for more training of experienced workers. What, however, will motivate workers to expend the effort needed to continue their education and learn new skills? The incentives must include expanded job opportunities and employment security. This can be achieved by grounding workers in the know-how that manufacturing leaders have agreed on, as needed in high-performance manufacturing firms.

3. **Improve the competitiveness of American manufacturing.**

The third goal of the proposed degree is to increase the competitiveness of American manufacturing by increasing the proficiency of manufacturing workers. A nationally-recognized two-year degree, widely accepted by those who do the hiring for manufacturing firms, is a means to this end. Many institutions will offer such a degree if employers really value the education that lies behind it. Many students will seek the degree if employers hire and promote those who have it. Clearly, the first two goals are achievable only if there are employment opportunities for the graduates of the proposed degree. The premise is that increasing the number of manufacturing workers who have the skills represented by the degree will help American manufacturing retain jobs in the United States.

PART I

THE ORIGIN AND CONTEXT FOR THE PROJECT

Origins

Harry Featherstone, President of the Will-Burt Corporation in Orville, Ohio, suggested this project a few years ago. Harry is nationally known for demonstrating that training, education, and a commitment to high performance can move even a small firm like Will-Burt from imminent failure to long term viability. Harry's goal was a portable associate degree that workers in firms such as Will-Burt could acquire, knowing that it would be valued by many employers.

A second motivation came from a report issued by the Competitiveness Policy Council. The Council, established by Congress and working under the direction of Fred Bergston of the Institute for International Economics, had the task of recommending policies to enhance the nation's productivity and international competitiveness. In March of 1993, the Council reported to the new Clinton administration and the new Congress. The Council recommended developing a system for retraining dislocated workers and an improved system for school-to-work transition. A companion recommendation, directly related to this project, urged the development of a portable associate degree in manufacturing.[2]

A third impetus for this project was the legislation that had been introduced in the face of the evidence that the "learning and earning" system was not working. The majority of American youngsters who have not attained a four-year college degree, as well as older workers facing corporate downsizing, are losing ground. The percentage of full-time, year-round, workers who did not earn enough to keep a family of four above the poverty line had increased from 12% in 1979 to 18% in 1992. As the Employer and Educator Panels met, the *School-to-Work Opportunities* and *Goals 2000, Educate America* legislation were working their way through Congress. Both bills were enacted in the spring of 1994 as this project's Panels were having their final meeting. The Administration had also introduced the *Re-Employment* Act to help experienced workers adjust to economic change.

Even before any of this legislation was introduced, the Bush and Clinton administrations had encouraged private industries to define the workplace standards that their employees need to satisfy. The U.S. Departments of Education and Labor had funded 22 Pilot Skill Standards projects. The Employer Panel included representatives from five groups that were developing Pilot Standards:

1. The National Tooling and Machining Association: Standards for the metal working industries.

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[2] See *"A Competitiveness Strategy for America and Building High-Performance Workplaces," Competitiveness Policy Council*, Washington, DC, March 1993. Also see the companion report of the Training Subcouncil headed by Lynn Williams, then President of the United Steelworkers of America.

2. The Graphic Arts Technical Foundation who are working on standards for the printing industry.

3. The Foundation for Industrial Modernization: Standards for Computer Assisted Drafting and Design (CADD).

4. The Foundation for Industrial Modernization: Standards for Advanced Manufacturing.

5. The American Electronics Association: Standards for the electronics industry.

Harry Featherstone's question was acquiring a larger urgency. The nation was moving to encourage all youngsters to acquire some post-secondary education and all firms to become high-performance organizations. Skill standards were being developed. Everyone understood that industry skill standards are not an end in themselves. They are but a means to helping workers meet the standards. The goal is workers who produce goods and services that are internationally competitive, and who receive decent wages, job stability and adequate benefits and who are able to keep abreast of developing technologies and evolving market demands.

Post-secondary education faced a key question: Could it deliver what was going to be expected of it? Could community colleges prepare youngsters and dislocated workers for a high-performance future? The future would not be certain and flexibility was required. No youngster could be assured that a career choice made at 18 could be maintained for a decade. Unfortunately, the same could be said for that youngster's parents. No one could predict with certainty who their employer would be, what part of the country they would be working in, or even the narrowly-defined part of the industry that would be employing them. The degree had to be portable.

A degree in "high-performance manufacturing" that was accepted and valued by a large number of manufacturing firms would help solve Harry's problem. If respected representatives of the entire manufacturing sector could agree on the content of a two-year "community college" associate degree then meaningful standards could be reached by all students and workers interested in a career within manufacturing. While there would be room for specialization in electronics, or steel fabrication, or printing, or chemical processing, the core of the degree would be constant across all of the community colleges offering the degree.

A successful degree will help students gain access to a career path in a high-performance firm. It should help students who want a portable and flexible passport to multiple career possibilities. It should help employers who want to know what skills a graduate has without extensive testing of the applicant. It should help community colleges who want to deliver a coherent program cost-effectively.

These benefits cannot be achieved unless employers and educators agree on three things:

1. What a graduate should know and be able to do.

2. How well should he or she be able to do it.

3. What course work could meet these needs.

The agreement must satisfy the line managers' need for specific skills to meet his or her immediate requirements and the students' need for immediate job placement after graduation. But these short-run requirements should not sacrifice the CEOs' and students' long-run need for a broad education. These are some of the criteria that the Panels had to satisfy as they began their deliberations.

This understanding provided the framework for the panels' deliberations. There was a series of questions for the employer panel. Could employers, coming from various industries in the manufacturing sector, agree on "standards" for this associate degree? Could those who have been working on industry standards be part of this agreement? There were also questions for the educators. Could educators from a diversity of institutions agree with this set of standards? Could they agree on a way, or more likely, multiple ways, to provide the instruction to grant such a degree? Could the colleges reconcile this goal with their mission to provide the general education courses that broaden the student's knowledge of the world around him or her?

Standards in The Current Policy Context

The *Goals 2000 Educate America* Act established the National Skills Standards Board (NSSB) to develop a system of voluntary industry standards. The NSSB will presumably build on the work of the 22 Pilot projects, including the five noted above, to construct a comprehensive and cohesive standards system.

Many of the industry associations are aware of the dangers of excessive fragmentation and of standards that are too narrow. Some of these Pilots have taken place within very small industries; for example, industrial laundering. If becoming a certified industrial launderer is of little value outside that industry then it will hardly pay most people to spend much energy earning that certificate. The industrial launderers, however, see their effort as applying to all production workers and maintenance technicians in the textile industries. If the skills apply to a significant number of good jobs, then acquiring a certificate in these competencies will be worth the effort of many.

The *School-to-Work Opportunities* Act encourages all youngsters to choose a career field no later than at the 11th grade. However, few young people know what they want to do at sixteen or even twenty-one. Even those who do choose take a great risk if they are narrowly trained. Job and career changes are too common to decide about a lifelong occupation at an early age. And experienced workers dislocated by economic restructuring know too well the dangers of limiting their education to narrowly defined skills and, thereby, being unprepared for change.

Meeting too many diverse skill standards is also a difficult challenge for the education system. Where can a college obtain qualified teachers, current textbooks, and instructional materials? How can it maintain standards over so many different degree programs? Besides, it is unnecessary to proliferate courses and degrees. For example, consider a single course in **working in teams,** a competency identified by all employers. If this skill is important for the electronics industry as well as the industrial launderers then the same accredited course should suffice for both industries.

Thus, the design challenge faced by the Panels was to reconcile a broad education with the training required for a specific job. This tension was expiored at the first meeting. The Panels agreed that there are general skills that are needed throughout the manufacturing sector (and perhaps other sectors as well). **Working in teams** is an example of a universal skill that is required in almost all jobs and is easily transferred among industries. (By the word "industry" we mean steel or electronics or chemicals. The manufacturing sector includes all manufacturing industries.)

The Panels also agreed that some skills take on a particular form shaped by the context of the specific manufacturing industry. **Scheduling**, for example, is a quasi-universal skill that takes one form in manufacturing discrete products, such as autos, and another in a continuous manufacturing process, such as chemical production.

Finally, the Panels recognized that industry-specific **technology** skills are needed to enter a particular manufacturing industry which have little applicability elsewhere in the manufacturing sector. For example, the technology of printing and metal working are too different to be included in a single course. (Although there are principles of technology that are common among these industries.) The accuracy of the table shown on the next page will determine whether a single degree, with industry-specific majors, is possible.

The Panels were very well aware of the work published by the Secretary's Commission on Achieving Necessary Skills (SCANS).[3] The Commission had developed a set of five universal competencies that it said would be required of all workers. Moreover, there were indications that many of the industry skill standards would employ or directly refer to these SCANS competencies.[4] The SCANS competencies are used to define the standards in Part II of this report.

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[3] See *Learning a Living*, the U.S. Department of Labor, Washington DC, 1992. The Principle Investigator for this project was the Executive Director of the Commission. Jim Burge of Motorola was both a member of the Employer Panel and a SCANS Commissioner. Ken Lay of IBM was also a member of the Employer Panel and had been involved in the Commission's activities.

[4] At this writing, two standards that have been published, those for workers in the electronics industry and for CADD, explicitly assume the SCANS competencies as pre-requisites. See *Setting the Standards,* a report of the American Electronics Association, p. 39, and *National Occupational Skills Standards, CADD,* a report of the Foundation for Industrial Modernization, pp. 24, 27.

The Panels had to answer the following question: **Can a universal set of competencies, such as those developed by SCANS, be made specific enough to meet industry requirements?** The Panels gave a clear cut and positive answer to the question. Employers and educators could agree on the standards for an associate degree in high-performance manufacturing. The agreed upon standards are contained in Part II of this report.

UNIVERSALITY OF SCANS COMPETENCIES

SCANS COMPETENCY	DOES COMPETENCY APPLY THROUGHOUT THE MANUFACTURING SECTOR?
Interpersonal Skills: Teamwork, negotiate, teach, serve customers, intercultural.	Yes. Competency is universal and transcends manufacturing to other sectors of the economy.
Information: acquire, evaluate, organize, interpret and communicate.	Yes. Competency is universal although the kinds of information used in manufacturing may differ from that in other sectors.
Allocating Resources: time, money, staff, and space.	Yes. Competency is universal, although types of schedules and budgets will vary among specific manufacturing industries.
Systems: understand, monitor, correct, improve and design organizational and technological systems.	Yes. Competency is universal, although the systems will differ among specific manufacturing industries.
Technology: select, use, maintain and troubleshoot.	No. Although basic principles will be common, the actual equipment is industry specific.

Curriculum Breadth and General Education

Bringing students to the agreed upon standards was the subject of the Panels' final meeting. Would colleges agree to provide the education if there were sufficient jobs for the graduates and if there were adequate resources to develop the curriculum and the needed staff? The answer was enthusiastically affirmative.

Determining an appropriate educational design is as challenging as arriving at common standards. Fortunately, a representative of the Boeing Aircraft Corporation attended the third Panel meeting[5]. Boeing, located in Seattle, and other employers in the state of Washington are heavily involved in a state-wide effort to create a manufacturing degree. Washington's employers and state community colleges are further along, on a state basis, than this project is on its national degree. Interestingly, the Washington standards are quite compatible with the standards described in Part II of this report. Even more interesting is their view of the breadth needed for that degree.

Boeing, a unionized firm, thinks it important that all students learn the history of the labor movement. The view is shared by the other employers in Washington state. The employers also think that students should understand the history of environmental, health and similar regulation. This project's Educator and Employer panels agreed with the State of Washington's view on the breadth of education that is required for true high performance.

The breadth issue is joined when considering whether to include the so-called "general education" courses in the high-performance manufacturing degree. These courses -- history, English, etc. -- serve other than vocational purposes. In addition to broadening students' perspective, they prepare community college students to transfer to four-year colleges for a baccalaureate degree.

General education is not something that should be set aside as separate from the "real" preparation for work. High-performance demands an understanding of the larger world in which the individual and the firm acts. While it is true that education is about more than earning a pay check, it is also true that high performance is about breaking down the barriers that create "silos" or "boxes" that separate public and private activities. Students need a foundation in general education to understand how values are formed, to appreciate the benefits of diversity and to know something about entrepreneurship. The need courses in mathematics (including statistics) and the sciences (including physics) if they are to communicate with engineers at their workplaces.

[5] Conversation with Dr. Carver C. Gayton, Boeing Commercial Airplane Group.

The choice between education for a career and education for broader purposes is becoming a false choice. High-performance careers require an understanding of good citizenship. General education courses should integrate, rather than be separate from, the courses that impart more job-specific skills. This suggests that general education courses be cross-disciplinary and that students understand how those lessons are applied in their lives outside of college. Realizing these changes will require a considerable investment in teacher education.

Part III of this document describes the results of the final Panel meeting on curriculum issues.

Curriculum Issues and Next Steps

Employers and educators agreeing on standards will only have meaning if, some time soon, students are graduating with the ability to perform well in high-performance manufacturing firms. Making that happen requires changing students' educational experience. The relevant questions that were discussed but not answered during this project are:

What steps must be taken before colleges can award a portable and well-respected associate degree in High- Performance Manufacturing?

What must be done over the next five years to have some students graduate with such a degree by the year 2000 and many more by 2010?

The Panels rejected the idea that mere publication of the standards would lead to widespread granting of the appropriate degrees. While they would welcome entrepreneurial colleges proceeding on their own with curriculum development and other parts of the agenda, they did not think this would occur without outside assistance. They urged colleges to form consortia, seek funding through or with an umbrella group, and use the funding to develop and pilot curricula in a few colleges.

Questions of curriculum design, teaching strategies, and assessment both at school and at the job will have to be answered in development pilot projects (as called for on page 3), with real faculty, real students, and real employers. College administrators and faculty will have to decide whether to create new courses or change old ones to meet the standards. Community colleges and other educational institutions will have to re-organize to help students learn what they need to know and be able to do to meet the standards. Colleges will have to find ways to assess students and grant them a degree that certifies that the students meet the standards. Administrative support and faculty development are the keys to successful implementation.

The Educator and Employer Panels see no reason to dictate an approach to any institution. Every community college has its own procedures and clientele and should choose the path best suited to it. The Panels, however, do recommend that institutions avoid developing a unique and separate Manufacturing Curriculum to meet the challenge. They think it preferable that colleges

use the new standards as an opportunity to make changes that are desirable on their own throughout the curriculum.

The Panels recommend that educational institutions think through four considerations as they design their programs:

1. **Flexibility** in serving diverse populations, from youngsters enrolled in tech-prep to dislocated older workers.

2. **Articulation** with the curricula of high schools and of four-year colleges.

3. **Integration** of the program with the rest of the college.

4. Capacity to use **distance and computer-based learning** in delivering instruction.

Finally, participants in the Educator Panel emphasized how important it would be for employers and employer organizations to **formally endorse** the standards that are described in the next section. Without this endorsement neither funders nor colleges can afford the risk of investing in the needed changes. The issue of accreditation was not directly addressed. No one wants a lengthy process that would slow progress, yet students do want some assurance that their course of study will lead to a career ladder. Endorsement by employers will provide some of the needed assurance.

PART II

STANDARDS for the ASSOCIATE DEGREE in HIGH-PERFORMANCE MANUFACTURING

These standards were developed over a period of seven months by two national panels: one of employers and employer associations and another of educators and educator associations. (See Attachment A.) The two panels drew on a number of sources: the reports of the Secretary's Commission on Achieving Necessary Skills (SCANS), a set of tasks from an existing DACUM (Developing A Curriculum) exercise, and a set of tasks produced by the skills standards efforts of the electronics industry.[6] Additional input was received from a group of Maryland educators and employers (see Attachment B).

A standard is defined by a competency accompanied by a series of illustrative tasks that cannot be satisfactorily performed without that competency.

The tasks that help define the standards are exemplars of what associate degree holders should be able to do after about 90 days of company-specific training. In all cases, a clear set of corporate policies and guidelines is assumed along with competent supervision. Often, the tasks are performed by a team. The holder of the Associate Degree in High-Performance Manufacturing should be a contributing member of the team.

In most cases, more than a single competency is required to perform the task. The tasks, however, are associated with only a single (the most important) competency. The tasks are not specific job descriptions. The task, not the job title, is important. The context of each task, for any particular student, will depend on the student's major or area of interest (e.g., electronics, printing, metal-working, and so on).

This report should be seen in the context of the national effort to develop skill standards as contemplated in the recently enacted *Goals 2000 Educate America Act*. That Act established a National Skills Standards Board (NSSB) to develop industry standards. This standards development benefited from the work of four standards projects related to manufacturing: electronics, metal working, printing, and CADD. In addition, the American College Testing is undertaking a National Job Task Analysis (NJTA) as part of their effort to develop assessment tools for generic workplace skills such as those described in the SCANS reports. As industry groups develop additional skill standards and the NJTA is completed, more and more such tasks will be available. These standards are somewhat different from the other efforts because these

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[6] See *"Learning a Living,"* Secretary's Commission on Achieving Necessary Skills, U.S. Department of Labor, Washington, DC 1992, and *"Setting the Standards,"* American Electronics Association, 1994.

standards are tied to a level of education (i.e., the associate degree), rather than a specific job (e.g., electronics technician). These standards also address a large field -- manufacturing -- rather than a single manufacturing industry. The goal is a *portable* degree, where portability has both a geographic and industrial dimension; that is the degree should be valued by employers across the country and in any manufacturing industry. Although students may major in an industry such as electronics or printing, the core courses that teach resource allocation or other competencies should be sufficiently broad as to provide this portability.[7]

[7] At the suggestion of the Panels, draft copies of this report were sent to organizations that are developing industry skill standards and their comments, if any, were incorporated. The goal is consistency in all competencies.

STANDARD #1: ALLOCATE TIME

Competency: Identify relevant, goal-related activities, rank them in order of importance, allocate time to activities, and understand, prepare, and follow schedules.

Competent performance requires:

- understanding sequencing -- properly identifying tasks in order of importance;
- developing and following an effective, workable schedule based on accurate estimates of importance of tasks, time to complete tasks, time available for completion, and task deadlines;
- avoiding wasting time;
- evaluating and adjusting a schedule.

Illustrative Tasks

1. **Review and schedule orders for production within a specified time:** receive copies of order requests daily; evaluate orders to determine priority requirements; check inventory to ensure that the raw material to fill standard and custom orders is available; order raw materials, if necessary; schedule job/order for production; satisfy the requirements of manufacturing and fill various product orders to meet customer deadlines.

2. **Work in a team to estimate the amount of time required to write a computer program:** break down the program writing task into major components; estimate the time required to complete each component; develop a timeline (a graphical aid to display actual progress against initial deadlines); identify problem areas and areas that went better than expected, and identify solutions to problem areas.

3. **Work in a team to establish a time schedule for a graphic design job:** construct a chart which allocates time for each component of the job; contact vendors to set up a schedule for completion of the components for which they are responsible; check periodically to ensure that all components are on schedule; allow enough time to assemble and fine-tune the project before it is delivered to the client.

4. **Prepare a schedule to unload trucks:** receive a call from the terminal manager specifying which delivery trucks to expect; prepare a daily schedule for truck deliveries; estimate the number of workers required to unload the trucks; modify schedule to accommodate truck delivery cancellations or truck breakdowns; and ensure that specific required deliveries are worked into the schedule.

5. **Manage schedules, activities and events to achieve objectives:** produce and manage schedules; schedule and monitor workload; arrange, coordinate, and support meetings, events, and activities; plan and coordinate travel arrangements.

STANDARD #2: ALLOCATE MONEY

Competency: Use or prepare budgets, help to make cost and revenue forecasts, keep detailed records to track budget performance, and make appropriate adjustments.

Competent performance requires:

- preparing a budget according to the firm's accounting method and policies;
- projecting costs and revenues;
- tracking the extent to which actual costs and revenues differ from the estimated budget;
- taking actions to adjust to budget overruns.

Illustrative Tasks

1. Work in a team to receive and review a purchasing budget: consult with the merchandise manager to discuss the budget and goods to be purchased, analyze sales records to identify goods in demand; select and order merchandise based on market trends, customer tastes and buying habits, current inventory levels, and price and delivery arrangements of vendors; maintain records on goods purchased, costs, inventories, and product performance.

Note: The product or service being purchased is standard and part of the team's usual mission; that is, the agent is buying widgets, not a particle accelerator. Also, the firm or organization has a well-defined procurement procedure.

STANDARD #3: ALLOCATE MATERIAL AND FACILITY RESOURCES

Competency: Acquire, store, and distribute materials, supplies, parts, equipment, space, or final products in order to make the best use of them.

Competent performance requires:

- planning the steps involved in the acquisition, storage, and distribution of resources;
- acquiring, transporting, or storing resources safely and efficiently;
- maintaining resources in good condition;
- distributing resources to the end user.

Note: Frequently requires spatial thinking.

Illustrative Tasks

1. Identify machine use and operation, determine availability of supplies and materials, order and receive stock, inventory supplies and materials.

2. Develop a plan to recycle scrap metal, chips, shavings, trash and waste materials.

3. Perform layout for precision machine work using layout instructions.

STANDARD #4: ALLOCATE HUMAN RESOURCES

Competency: Work with a team to identify and assess knowledge and skills and distribute work accordingly, evaluate performance and provide feedback.

Competent performance requires:

- assessing people's knowledge, skills, and abilities;
- identifying present and future workload;
- making effective matches between individual talents and workload;
- monitoring performance and providing feedback.

Illustrative Tasks

1. **Help to supervise a large and diverse work crew:** schedule and assign the workers according to their abilities. Understand the motivation of the members of the team.

2. **Use human resources to manage workflow:** Work with a team to identify and plan for human resource requirements; assess and meet training and development needs, assess and provide feedback on performance; facilitate a discussion about reward, reassignment, and removal recommendations based on company standards.

STANDARD #5: ACQUIRE AND EVALUATE INFORMATION

Competency: Identify need for data, obtain them from existing sources or create them, and evaluate their relevance and accuracy.

Competent performance requires:

- asking analytic questions to determine specific information need;
- selecting possible information and evaluating its appropriateness;
- determining when new information must be created.

Illustrative Tasks

1. **Use written resources to identify strengths of given metals:** be familiar with safety standards and enforce them; understand chemical configurations and identify possible hazards.

2. **Acquire data to justify a cost improvement project:** implement a process change and determine the effect on yield of the change; retrieve documentation or information that details yields; evaluate data to determine trends, such as improvement in yield; prepare documentation that details the cost improvement process; submit documentation for approval; and prepare/revise batch records.

3. **Acquire input from the user to implement a new (and relatively small) electronic data system:** prepare and distribute a graphic layout of the old system; send out requests to users for analysis reports; review responses from users; verify the findings by scanning the source code of the current system; discuss the findings with the users and the applications programmers; evaluate the validity of the findings; disseminate the results for final approval.

4. **Identify customers and their needs:** identify potential customers; identify sources of information about customer needs; obtain information about customer needs; document and process customer order.

5. **Plan work activities and strategy to accomplish administrative/information support work.**

6. **Acquire a working knowledge of machine shop procedures and policies and develop materials for a presentation.**

STANDARD #5A: UNDERSTAND AND COMPLY WITH LEGAL REQUIREMENTS

Competency: Be aware of regulations that apply to a specific firm/industry and be alert for situations may be covered by these regulations.

Competent performance requires:

- understanding purposes and applicability of legal requirements;
- collecting relevant data;
- communicating concerns.

Illustrative Tasks

1. **Consult with a corporate attorney or similar expert to ensure that product and process meet business requirements:** integrate improvement processes into each critical function; follow health, safety, and legal requirements with regard to processes, products, and people; select, set up, and perform diagnostic tests; analyze and interpret test data for problems that require corrective actions and for compliance with specifications.

2. **Function as a team member that is aware of legal, health and safety requirements.**

3. **Research safety rules for a manufacturing process and, under supervision, post rules.**

4. **Write an inspection report on compliance with ADA and OSHA rules.**

STANDARD #6: ORGANIZE AND MAINTAIN INFORMATION

Competency: Work with a team to systematically organize, process, and maintain written or computerized records and other forms of information.

Competent performance requires:

- understanding information from computer, oral, and physical sources in accessible formats;
- transforming data into different formats in order to organize them by sorting, classifying, or more formal methods.

Note: For many, data becomes information only after it is processed or interpreted.

Illustrative Tasks

1. **Maintain customer electronic data files:** set up a file for every site; determine what information is to be maintained in each file; set up a system among engineers to update files; set up future planning for sites; locate storage space for files; and design a method for retrieving information that can be used by those not familiar with the system.

2. **Complete quality control case file:** gather and complete all required documents; extrapolate information from field notes and put it into appropriate places on the forms; relate the obtained information to photographs; complete the case file; and organize the on-file information for effective use in meeting legal obligations, information maintenance, and presentations to officials.

3. **Study a pending personnel situation and decide what documentation is needed to reinforce the company's position:** gather information and documentation from various sources such as personnel files stored in computer, hardcopy files, and written reports and memos; input the information gathered from all sources into computerized files.

4. **Help operate and maintain office systems:** maintain material resources; track financial resources; contribute to management of workgroup resources.

5. **Generate and maintain documents and information:** gather data; draft, review, and finalize documents and information; duplicate and distribute documents and information; establish and maintain document and information storage and retrieval systems.

STANDARD #7: INTERPRET AND COMMUNICATE INFORMATION

Competency: Select and analyze information and communicate the results to others using oral, written, graphic, or multimedia methods.

Competent performance requires:

- determining information to be communicated;
- identifying the best methods to format and present information;
- conveying information to others through a variety of means including oral presentation, written communication, etc.

Illustrative Tasks

1. **Examine dimensions of parts from blueprint, calculate stock utilizations:** determine material strength; calculate amount of material needed, machine speeds; and convert measurements from British/American to metric units. This will require machine handbooks, charts and tables.

2. **Make presentations and generate reports to management.** Working with a team, at least one of whose members understands the applicable tax provisions, analyze leasing versus purchasing options; gather pertinent data; organize the data in order to resolve the problem; assimilate information and present it in a clear and concise manner summarizing technical information for management; write a report; give an oral presentation using visual aids; respond to questions.

3. **Analyze customer information and communicate ideas graphically:** review customer information and determine the best methods for meeting the customer's needs; identify the best method for presenting the information, complete a rough draft of the ideas; discuss interpretation with the customer, make revisions incorporating customer's feedback, prepare final sketches.

4. **Prepare a proposal for a customer:** collect records of the customer's past bills, compare the competitor's past bills with the estimated cost for the same services from your company to illustrate the benefits of changing vendors, graph the information in order to visually display potential savings and orally present the results of this research to the customer, and send written documentation of the research to the customer.

5. **Determine what data is needed by the business staff** by asking them about their reporting requirements, retrieve the needed financial data and format the output into a readable report, and provide data to the business staff, both in hard copy and electronically.

STANDARD #7: INTERPRET AND COMMUNICATE INFORMATION (CONT'D)

6. **Develop options to meet customer needs for a manufactured product:** interpret and clarify specifications prepared by others; communicate with customers to establish their requirements; identify and select internal and external resources and materials; prepare and evaluate options, develop short- and long-term plans to satisfy customer needs.

7. **Propose solutions that solve a customer's problem:** present range of options to customer; negotiate the solution and acceptance criteria with the customer; document and disseminate the customer agreement.

8. **Initiate and sustain communication process and procedures within a manufacturing environment:** create and enhance effective, productive relationships within the workgroup; manage communication beyond the workgroup.

9. **Initiate and facilitate administrative/information services support:** receive and transmit information using telephone and electronic communications; create and maintain effective and productive work relationships; and provide support and service.

STANDARD #8: USE COMPUTERS TO PROCESS INFORMATION

Competency: Use computers to acquire, organize, analyze, and communicate information.

Competent performance requires:

- entering, modifying, retrieving, storing, and verifying data and other information;
- choosing format for display (e.g., line graphs, bar graphs, tables, pie charts, narrative);
- converting information into the chosen format.

Illustrative Tasks

1. **With guidance, use a computer to resolve an application malfunction:** log onto the mainframe computer to determine the problem; retrieve the necessary information to identify the problem; transmit data from various computer systems to help with identification; arrive at a solution; transmit corrective software back to the production system; and monitor the new application to verify the solution.

2. **With guidance, create and present solutions for graphic design problems:** enter the relevant design information into the computer, using desktop publishing software and/or computer-assisted design; create a design to meet the needs of the client; present design ideas to the client for feedback and approval; refine the design and present the finished product to the client.

3. **Classify type of personnel information to be retained:** decide which of three computer systems to use; input information; choose software package; load the software into the computer and begin input; edit input to eliminate errors.

4. **Issue a purchase order**; input the vendor code to access an account file, determine bid requests that need to be completed; check the file listing to identify qualified suppliers; check quotes in the computer and retrieve data on potential suppliers; retrieve the purchase order form and issue a purchase order; and enter appropriate codes and special conditions.

5. **Demonstrate basic uses of CAD, CAM, CAPP, CIM, CNC, LNC, and computer-aided testing.**

6. **Create a document using a word processor.**

STANDARD #9: PARTICIPATE AS A MEMBER OF A TEAM

Competency: Work cooperatively with others and contribute to the group with ideas, suggestions, and effort.

Competent performance requires:

- doing own share of tasks necessary to complete a project;
- encouraging team members by listening and responding appropriately to their contribution;
- building on individual team member's strengths;
- resolving differences for the benefit of the team;
- taking personal responsibility for accomplishing goals;
- challenging existing procedures, policies, or authorities in a responsible way.

Illustrative Tasks

1. Participate as a member of J.I.T. (Just In Time) project management team to increase the yield of a particular product: after receiving an assignment to represent the production department on a yield improvement project, meet with group members weekly to discuss objectives, participate in the decision making process, communicate objectives of the J.I.T. team to the department, prepare written instructions and submit them to the processing staff to implement recommended changes, and provide feedback from processing to the J.I.T. team members.

2. Determine client's needs for graphic design through meetings with the accounting department, brainstorm with copywriters to generate ideas and obtain writer's suggestions; coordinate purchases with production department.

3. Employ a team to solve a problem with an offset lithographic press; relay information about the problem to the programmer; test new tools.

4. Verify that all members of a team understand the goals and objectives.

STANDARD #10: TEACH OTHERS

Competency: Help others to learn.

Competent performance requires:

- identifying training needs;
- helping others to apply job information, concepts, and theories to tasks;
- assessing performance to provide constructive feedback/reinforcement.

Illustrative Tasks

1. **Help train new employees in production line job tasks:** identify and conduct training required for specific tasks; acquaint the employees with the overall company operation, explain company's policies and procedures; help assign new employees to production line personnel for-on-the job training of job tasks and equipment operation; monitor new employees during on-the-job training period, assist personnel, as needed, with individualized training; help evaluate new employees at three-, six-, and twelve-month intervals to measure performance; document performance for personnel files.

2. **Teach new representatives and others** about the industry, the company's competitors, and the company's products and services -- answer questions about a product or issue, provide lunch sessions and memos on a specific topic to help representatives to become knowledgeable and informed; monitor new employees' telephone calls and offer them information and feedback in order to coach them through calls, offer assistance to new representatives in the refinement of their opening sales pitch.

3. **Cross-train** so other team members can perform one's own job.

STANDARD #11: SERVE CLIENTS/CUSTOMERS

Competency: Work and communicate with clients and customers to satisfy their expectations.

Competent performance requires:

- identifying clients' needs and efficiently obtaining additional resources to solve their problem;
- listening actively to customers to avoid misunderstandings;
- communicating in a positive manner especially when handling complaints or conflict.

Note: Clients can be internal or external to the firm.

Illustrative Tasks

1. **Listen** to customer complaint; identify and present possible solutions; negotiate resolution.

2. **Work and communicate with the client to satisfy his or her expectations for a graphic design:** actively listen to the customer's ideas and take notes, determine the feasibility of completing the project, communicate ideas to the customer with an estimate of the cost of the project; complete a rough draft of ideas, review rough drafts with the customers to get their input regarding revisions and approval to proceed; and communicate regularly with the customer until the final draft drawings are completed and sent to the printer.

3. **Help install computer systems:** call the customer to coordinate installation and logistics activities (where to stay, directions to the site); confirm that the hardware is on site with the field engineer; install the software; schedule and conduct customer training (for getting information from the old system onto the new system); document the proficiency of customer training and request evaluations while on site; troubleshoot the problems that occur on "live day" (when a system becomes operational); and write a trip report.

4. **Promote improved customer service and satisfaction:** monitor and improve service activity and solutions provided; provide ongoing customer service and support; and identify new customer needs.

5. **Make a modification in a machine shop product to provide customer with a special feature that he/she wants.**

STANDARD #12: EXERCISE LEADERSHIP

Competency: Communicate thoughts, feelings, and ideas to justify a position; encourage, persuade, convince, or otherwise motivate an individual or groups.

Competent performance requires:

- responsibly challenging existing procedures, policies, or authority;
- differentiating between leading and managing;
- making positive use of the rules/values followed by others;
- justifying a position logically and appropriately;
- establishing credibility through competence and integrity;
- taking minority viewpoints into consideration.

Note: Requires self-esteem, discipline, and integrity. Will often depend on the maturity and experience of the individual. "Leadership is the courage to admit mistakes, the vision to welcome change, the enthusiasm to motivate others, and the confidence to stay out of step when everyone else is marching to the wrong tune" (E.M. Estes, Former President of General Motors).

Illustrative Tasks

1. **Serve as team leader:** distribute work to other team members; motivate other team members; coordinate communication among team members; answer questions from team members.

2. **Present a graphic design proposal to the client in a positive and persuasive manner**; convince the client to be open to new and different concepts; motivate clients, staff and vendors to the best job possible.

3. **Explain concept of working as a team**; interview job candidates, understand group dynamics.

STANDARD #13: NEGOTIATE TO ARRIVE AT A DECISION

Competency: Work toward an agreement, with customers (internal as well as external), vendors, or co-workers that may involve exchanging specific resources or resolving divergent interests.

Competent performance requires:

- researching opposition and the history of the conflict;
- understanding motivations of all sides of conflict;
- setting realistic and attainable goals;
- presenting facts and arguments;
- listening to and reflecting on what has been said;
- clarifying problems and resolving conflicts;
- adjusting quickly to new facts/ideas;
- proposing and examining possible options;
- making reasonable compromises.

Note: Usually requires openness. This competency is part of facilitating solutions. Includes understanding the difference between win-win outcomes and win-lose outcomes.

Illustrative Tasks

1. Participate in a team effort to resolve an issue between the company and the supplier so that both parties are satisfied with the decision: listen to a supplier who insists that the blueprints submitted by the company are in error and that the part cannot be made to strength using the blueprints submitted; look at the blueprints showing how the part is to be built to ascertain where the supplier is having problems and how to explain to the departments involved what and where the specific problem is; contact manufacturing and engineering departments, who are insistent in their views regarding the blueprints and the part; inform them of the supplier's problem with the blueprint specifications; listen to manufacturing and engineering viewpoints; negotiate with all parties to come up with changes (i.e. change blueprint) that both sides can agree upon without compromising quality.

2. Work with a team to negotiate with vendors to obtain the best merchandise available at the lowest possible cost: compile and analyze industry sales data to identify goods in demand; select vendors to interview based on that information; interview vendors to learn about products, prices, and their ability to meet the needs of the company; and negotiate with vendors to obtain contract terms that best meet these needs.

STANDARD #14: WORK WITH DIVERSITY

Competency: Work well with men and women of different ages and with a variety of ethnic, social, or educational backgrounds.

Competent performance requires:

- understanding one's own culture and those of others and how they differ;
- respecting the rights of others while helping make cultural adjustments where necessary;
- basing impressions on individual performance and contributions to the work effort, not on stereotypes;
- understanding concerns of members of other ethnic and gender groups;
- recognizing the cultural variations in the international marketplace.

Note: Requires empathy and an understanding and respect for differences.

Illustrative Tasks

1. Communicate with different ethnic/language groups where there may be a barrier to understanding: recognize that it is not always possible to make a situation understood over the telephone and identify when he or she may have to meet the other party in person. During a safety inspection, identify safety violations; communicate them to workers in a manner they will understand (taking into account language and vocabulary considerations as well as previous experiences); negotiate with workers to rectify safety violations; motivate workers to enact this plan.

Note: This requires an understanding that differences in lifestyle may affect an individual's understanding of the safety regulations and thus also affect his or her actions. For instance, many immigrants have worked with dangerous materials before entering the United States and do not understand either the problem with doing this or the need for regulations. Must be aware that there are cultural differences and adjust expectations for them.

STANDARD #15: IDENTIFY, DESCRIBE, AND WORK WITH SYSTEMS

Competency: Know how social, organizational, and technological systems work and operate effectively within them.

Competent performance requires:

- knowing how system's structures relate to goals;
- responding to demands of the system/organization;
- learning the right people to ask for information and resources;
- functioning within the formal and informal codes of the social/organizational system;
- understanding how a firm operates in the larger economic and social system.

Note: Requires logical thinking combined with an ability to look beyond the immediate situation.

Illustrative Tasks

1. Understand a customer's organization and its procurement process after working on the account over a period of time: determine who the organization's decision makers are; what computer systems are currently in use; how the technician's organization relates to those systems; what the customer's procurement process is; what the customer plans in the area of systems development; and where the systems engineers of the technician's organization can be of service.

2. Understand production system and perform welding or assembly operations in that system.

3. Follow up on product control standards to improve quality.

4. Use computer-integrated manufacturing (CIM).

5. Describe the industry in which the firm works: identify major markets, competitors, and vendors and understand the firm's relationships with them; present this information to others.

STANDARD 15A: UNDERSTAND AND DESCRIBE THE LARGER SOCIAL, POLITICAL, ECONOMIC, AND BUSINESS SYSTEMS IN WHICH THE EMPLOYEE AND THE FIRM FUNCTION

Competency: Understand the values that underlie business and personal ethics, government regulation, union-management relationships, environmental and equity concerns, and relationships with the community and its institutions.

Competent performance requires:

- understanding history, economics, politics, and philosophical concepts;
- understanding how to examine a situation from these multiple perspectives.

Illustrative Tasks

1. Can undertake appropriate civic and professional duties and represent the company and him or her self in a positive way.

2. Can be counted on to perform ethically with regard to abiding by government regulation, environmental and equity concerns, and community values.

3. Understand the entrepreneurial motivation and mode of operation.

4. Understand the industry and how it relates to other industries.

5. Understand the relationship between workers and management and the role of unions in the industry.

STANDARD #16: MONITOR AND CORRECT PERFORMANCE

Competency: Distinguish trends, predict impact of actions on system operations, diagnose deviations in the function of a system/organization, and take necessary action to correct performance.

Competent performance requires:

- applying statistical quality control;
- gathering information about how the system is intended to function, detecting deviations from system's intended purpose;
- determining root causes of the deviations, troubleshooting the system, and making changes to rectify system functioning and ensure quality.

Note: One should understand the idea of "building quality in", rather than "inspecting quality of".

Illustrative Tasks

1. Monitor in-house production flow to determine when system is out of compliance with statistical process control; take remedial action. Includes analyzing and evaluating work processes and procedures.

2. Monitor vendor performance and determine if vendor's operation has departed from quality standards.

3. Create and use statistical process control (SPC) charts to monitor performance.

STANDARD #17: IMPROVE AND DESIGN SYSTEMS

Competency: Suggest modifications to existing systems to improve products or services and develop new or alternative systems.

Competent performance requires:

- making suggestions for improving the functioning of the system/organization;
- recommending alternative system designs based on relevant feedback;
- challenging, in a responsible way, the status quo to benefit the larger system.

Note: Usually requires creativity, curiosity, and working with a team.

Illustrative Tasks

1. Implement an enhancement to the current computer system: develop an enhancement to the current system; locate the source code needed for the enhancement; set up a test job and create test data from the other companies, if necessary; run the test job with the required data; compare the results before and after the change; and note differences.

2. Using knowledge of at least one CAD package, design a part or workspace, that will enhance system performance.

3. Work on a team to design a quality control system which uses both the human and mechanical components of the organization: ascertain what quality control measures are now in effect; determine what portions of the system should be changed to improve quality; design an improved system for quality control using new methods of recordkeeping and increased personal responsibility; and check periodically to ensure that the new system is being used as designed and that the method is effective.

4. Write a proposal to automate job filling process: recognize an inconsistency in yields between different kinds of drying equipment due to the manual filling process; consult with the engineering department staff to determine new technology available to accurately measure volume; review recommendations from the engineering department and consider limitations of the new technology, test the recommended equipment; and write a proposal to automate filling process, using the test results as justification.

5. Suggest a change in department policy that benefits the company as a whole: recognize a deficiency in department policy that limits buyer options and inhibits performance/productivity; meet with a supervisor to express concerns and recommend solutions; prepare a written version of his or her concerns and recommendations for submission to upper management by the supervisor; attend meeting with the supervisor and upper management to discuss the possible policy change.

STANDARD #17: IMPROVE AND DESIGN SYSTEMS (CONT'D)

6. Recommend peripheral devices needed for a new system (e.g., printers, tape drives, disk drives), set up the new system (hook up machines); work with vendors to ensure that the hardware peripherals are compatible and function correctly; install most recent version of the operating system, transfer data from the old system to the new system; thoroughly test all programs on the new system; debug programs that are not running correctly; set interactive limits (to ensure that the system will operate with specified number of users); and open system to new users (i.e., give users new phone numbers and let them know that the new system is available).

7. Help to implement performance improvement: coordinate internal and external resources and materials to implement and deliver solution; provide information and training to customer upon installation and use of solution; deliver solution and obtain customer acceptance.

8. Work on team to make products that exceed customer specifications: receive and communicate process flow instructions and delivery schedules; locate and retrieve production materials; prepare resources for production; maintain production according to instructions; and pack and ship product to internal/external customer.

9. Help develop, implement, and evaluate administrative processes and procedures: design and develop administrative/information services support; coordinate and implement administrative processes and procedures.

STANDARD #18: SELECT TECHNOLOGY

Competency: Contribute to a team judgement about a set of procedures, tools, or machines, (including computers and their programs), that will produce desired results.

Competent performance requires:

- determining desired outcomes and applicable constraints;
- visualizing the necessary methods and applicable technology;
- evaluating specifications;
- judging which machine or tool will produce the desired results.

Note: Team may be required to compare technology to a recognized industry benchmark.

Illustrative Tasks

1. Help user define hardware and software requirements for database application: determine the size of the database in order to define the requirements of the storage hardware (i.e., size of the hard drive); determine how many users will need to access the system simultaneously; determine how quickly data need to be retrieved; choose the hardware, operating system and database software.

2. Work on a team to select the appropriate filter/dryer to increase the capacity of a product line: examine product literature and attend vendor presentations to observe equipment in operation; meet with the engineering department staff, area equipment operators, and quality control staff to decide on the best equipment and to select a vendor; install the equipment to run test; compile data from the results and prepare slides/ transparencies and charts for a visual presentation; present recommendations to management for approval; write cost justification for the equipment, including data on labor savings impact; submit the cost justification to the engineering department for a capital expenditures request; upon approval, install the equipment; and write operating procedures.

3. Help determine which tools could best accomplish the work required to meet the goals of a graphic design project: review the customer's ideas; evaluate the methods/tools to be used to accomplish the project; choose particular tool or method to be used to produce rough drafts; look at the customer's project, rough drafts, and alternate printing methods; and determine which method would best accommodate the project.

STANDARD #19: APPLY TECHNOLOGY TO TASK

Competency: Understand the overall intent and perform the proper procedures for setting and operating machines, including computers and their programming systems.

Competent performance requires:

- understanding how different parts of machines interact and how machines interact with broader production systems;
- installing machines, including computers;
- setting up machines or systems of machines efficiently to get desired results;
- interpreting machine output;
- detecting errors from program output;
- using machines safely and effectively.

Illustrative Tasks

1. **Check a machine that is a suspected source of quality problems:** explore whether the system meets regulations; if the system is in violation, apply relevant technology to deal with violation. Requires understanding of how the different systems (mechanical, electrical, hydraulic) of a machine work and how they interact to cause a machine to work.

2. **Integrate a newly developed computer project into the production system:** complete documentation for the operator; revise jobs based on recommendations; log into the production machine and validate the transmittal of jobs; verify the installation of the online software; monitor jobs running under the new software; and correct application where necessary.

3. **Safely and efficiently perform bench work, process metals, operate equipment such as a drill press, grinding machine, operating lathe, and milling machine.**

4. **Program, set up, and operate a CNC machine and a CAM system.**

5. **Use a variety of tools.**

STANDARD #20: MAINTAIN AND TROUBLESHOOT TECHNOLOGY

Competency: Prevent, identify or solve problems in machines, computers, and other tools.

Competent performance requires:

- identifying, understanding, and performing routine preventative maintenance and service on technology;
- detecting more serious problems;
- generating workable solutions to correct deviations;
- recognizing when to get additional help.

Illustrative Tasks

1. As a team member, test a new release of an information management system: study the differences between the new release and the old system, define testing requirements based on the differences; create test data to cover all of the possible outcomes; run the test jobs; identify discrepancies between the test results and the trace findings; obtain additional help from database administrator, if necessary; and publish results.

Note: We are talking about a skilled technician, not a junior engineer.

2. Help identify a safety problem with an elevator and ascertain how critical the problem is to continued operation of the equipment: assess an elevator and notice a defect in a portion of the equipment (e.g., the top car control device, which enables one to control the elevator); determine whether the problem is critical to safe operation and suggest possible solutions for fixing the problem.

3. Inspect and clean the work area for a safe working environment: inspect, change, remove, replace, adjust, clean, and lubricate various machines and tools.

PART III

CONSIDERATIONS OF CURRICULUM DESIGN FOR AN ASSOCIATE DEGREE IN HIGH-PERFORMANCE MANUFACTURING

As indicated in Part I, curricula will have to be designed and teaching strategies developed if community colleges are to bring students to the standards described in Part II. Administrators and faculty will have to decide whether to create new courses or change old ones to meet the standards. The Panels thought it would be better to change existing programs and courses than to develop new ones. Scheduling, for example, should be not taught in a new planning course when it can be integrated into the standard mathematics curriculum. It would be better to integrate quality control into a science or technology course than to develop new courses. The Panels did believe in the need to provide professional development opportunities for administrators and faculty for this program. These should include an opportunity for instructional staff (and students) to have a meaningful work experience.

Three Academic Models

Three possible academic models -- traditional, modular, and hybrid -- are discussed below. The Panels do not recommend the modular approach but it is included to complete the discussion.

The traditional program departs as little as possible from current practice. At least half of the courses are likely to be in traditional mathematics, English (communication), social science, and physical science. These are the subjects that community colleges label as general education or what others might call liberal education. A few courses may be given in such "high-performance" topics as Total Quality Management (TQM), although even this subject may be part of the Principles of Technology course. Elective courses will be available in specialties such as electronics, for those who will major in high-performance electronics manufacturing.

The challenge, in this traditional model, is two-fold: integrating the standards into the general education courses and integrating general education with the high performance and elective subjects. The mathematics course, for example, would have to be stripped of topics that are little used outside of academic settings. No longer would students be asked to solve quadratic equations or algebra problems about paddling canoes upstream; nor would they be required to take the integral of trigonometric functions or prove geometric theorems. Instead, math students will learn the statistics needed in the TQM course, the spreadsheet techniques used in cost analysis, and the math needed to use the scheduling software so that they can schedule a production line.

The social science course would teach students how to use information, to understand the regulatory environment, and how to understand the business culture of other nations. The

physical science courses might become Principles of Technology. Students would learn how to evaluate technology and how to understand, monitor, and improve manufacturing systems. Communications would include making presentations or writing an instruction manual. All courses would stress working in teams and other interpersonal skills.

Teachers in all courses would have to accept responsibility to bring students to the standards for an associate degree in High-Performance Manufacturing. The college would have to see to it that courses or parts of courses that were not directed to these standards would have a lower priority than those that do. Thus, even if the traditional model appears on the surface to mean business as usual it does require substantial change from the practice at many (although not all) community colleges.

The modular or competency-based model, in contrast, does away with courses as they generally are known. Each of the standards is approached as a unit or module. Students who know the material move on quickly. Those whose background is weak may spend a lot of time on the basics before they can meet the standards. If, while developing a schedule, it becomes clear that finding the number of minutes between 2:30 PM and 4:00 AM for a heat-treating process is beyond the student's capacity then time is spent on the basics of subtraction to determine elapsed time.

There are many challenges in this model. It requires a different technology of teaching, one that allows students to proceed at their own pace. It will require that much of the instruction is computer-based. It may be difficult to develop coherent courses and avoid fragmentation. Students as well as teachers may have to be retrained for the modular approach to work. And it may be a difficult transition to and from other schools; that is, articulation may be difficult (although, as discussed below, it may be easier for some older students).

The hybrid model is a combination of the other two approaches. Recognized courses still exist although some courses may be combined. For example, Communications 101 may be eliminated as a separate course while the techniques of writing and presenting are integrated into other courses. Less common, Mathematics I might disappear only to reappear as a component in the Social Sciences 101 and Principles of Technology II. Courses would have modules that teach to specific competencies. While courses remain recognizable, the time any student spends on any module would depend on how long it takes to reach the standard. The requirements for the degree would be specified in terms of meeting the standards, rather than of seat time in the classroom.

The challenges with the hybrid model are also formidable. Courses need to be redesigned, teachers re-educated, and technology-based modules acquired. While the problems of articulation would be less severe than for the modular model, they would still remain.

Four Criteria

How well do each of the three education models fare on the four criteria noted below:

Flexibility. Community colleges serve a diverse student body: youngsters straight out of high school, women re-entering the workforce after a period of years as a home-maker, experienced workers now unemployed because of economic change, and full-time workers seeking to upgrade or change their basket of skills. Except for the youngsters, some of the others will have had college experience. Indeed, some community college students may already have a baccalaureate degree and are returning for a more "practical" certificate of competency in a specific skill.

Youngsters, especially those who have come from a tech-prep program in high school and who want the option of easily transferring to a four-year college, may prefer the traditional program because it raises the fewest articulation issues. They are accustomed to 13-week semesters, classes of 30, and a traditional teaching strategy. Dislocated workers may prefer the flexibility of the modular approach. Long past their high school years, they may find that a modular approach better accounts for their learning since high school because the traditional approach assumes knowledge that they never received or have long since forgotten. Employed workers may also prefer the logistic flexibility of the modular approach where courses can be scheduled at the convenience of the student rather than the faculty.

Articulation. Youngsters involved in a 2+2+2 program, where the middle "2" is a community college, will want the associate degree to fit easily into this sequence from high school to community college to four-year college. Clearly recognized courses frequently make this process easier. On the other hand, students coming from elsewhere or who did their high school work a long time ago may find that three-credit course descriptions are too rigid. What if they know all the math except spreadsheets, do they then have to take the entire course over?

Integration with Other Programs and with Work. Youngsters change their minds often. If Nursing requires English 101 and the HP Manufacturing program does not, then it is difficult to switch back and forth. Scheduling, staffing and facilities are made much easier for the college if everyone takes English 101. On these grounds the traditional model is the easiest to cope with and the modular model most difficult.

For some institutions the challenge that the modular model brings would be welcomed, giving them an excuse to re-engineer their entire operation. It will force teaching staff to abandon their isolated disciplines and concentrate on helping students learn rather than teaching subjects. Cross-disciplinary activities and other educational innovations must be built into the modular approach. The traditional approach, as the name implies, is more lenient of maintaining academic traditions.

Although the traditional model allows for the easiest integration with on-going activities on campus, the modular approach allows for easier integration with apprenticeship and other

work-based learning experiences. Siemens, for example, maintains apprenticeship programs with a number of community colleges. A master teacher gives students hands-on experience during a 20-hour work week. Integrating these work-based lessons with the 12-hour college academic load that the apprentice carries is not easy with a traditional model. A modular, competency-based model would more easily accommodate the apprenticeship approach to the school-to-work transition.

The hybrid model may be able to garner most of the advantages of the modular approach without the wrenching changes that a fully modular program requires. The Educator Panel felt that the modular approach would not work with a single manufacturing program if the rest of the college retained its traditional models.

Distance and Computer-based Learning There are many who think that the day of students sitting in classes of thirty before a lecturing teacher is inconsistent with high performance. Some believe this model will go the way of the one-room school house in the next 20 years. The future in this view, will have teacher as coach, cooperative learning with peer-to-peer teaching as part of group problem-solving, lectures provided via distance learning, and other information provided on CD-ROM, and computers as a tool for problem solving. While this approach would fit all three models it is almost mandatory in the modular model.

The following table summarizes the relationship of each model to the four criteria. As discussed before, the only way to find out what really works is to begin pilot programs that will introduce reality into these considerations. The Panels encourage potential funders and colleges to work together to make such pilots occur as soon as possible.

MODEL

CRITERIA	TRADITIONAL Identifiable Courses based on Fixed Semesters	HYBRID Competencies within Recognized Courses	MODULAR Competency-based, Recognized Courses Disappear
Flexibility	Easiest for recent HS graduates	Middle ground	Easiest for older students
Articulation	Easiest for recent HS graduates	" "	Easiest for older students
Integration	Easiest for other college programs	" "	Easiest for work-based learning or apprenticeship
Distance and Computer-based Learning	Useful but not required	" "	Almost mandatory

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