THE SECRETARY'S COMMISSION ON ACHIEVING NECESSARY SKILLS

Identifying and Describing
The Skills Required by Work

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SEPTEMBER 14, 1990

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PREPARED FOR:

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EMPLOYMENT AND TRAINING ADMINISTRATION
U.S. DEPARTMENT OF LABOR

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TABLE OF CONTENTS

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IDENTIFYING AND DESCRIBING THE SKILLS REQUIRED BY WORK

I. INTRODUCTION

Which skills are essential to effective work performance? Although this question has been asked many times throughout this century, there is no generally accepted statement of the skills required to succeed at a career in the United States. During World War II, the identification of key skills was critical to the design of training programs. After enactment of the Great Society measures of the 1960s, the specification of skills became important to the development of bias-free job testing. Today's concern about our schools' ability to prepare young people effectively for the world of work has prompted several studies of workplace skill requirements. Identification of necessary work skills has challenged psychologists, educators, analysts, employers, and lawyers.

Most attempts to characterize the skills used at work focus either on general human characteristics (e.g., intelligence, reasoning ability, reaction time) or on the characteristics of specific jobs (e.g., ability to assemble items, load ammunition, route packages). The level of detail communicated varies from the very general (e.g., ability to solve problems) to the very discrete (e.g., perform a tack weld in aluminum sheet metal). As a result, the operational implications and meaning of these lists are frequently difficult to determine. In short, they lack context. Thus they do not provide direct links to the "stuff" of schools or a sense of the work enabled by the skills identified.

The Secretary's Commission on Achieving Necessary Skills (SCANS) has an opportunity to break from this practice and, as a result, to change the nature of both schooling and work. People learn best when they are taught in a context of application--in a functional context. If teachers and students know what performance is required for success in modern work contexts, schools can organize instruction to teach the skills that support such performance--and test developers and businesses can develop reliable assessments of performance. Identifying and communicating this information constitutes a significant challenge for the Commission.

This report suggests how to respond to this challenge. It is now becoming widely recognized that the United States must choose between two futures. We can become increasingly divided into rich and poor, a nation of second-rate products and

services; or, we can continue to be a highly productive and thriving economic force. To remain the latter we must restructure our schools and workplaces and greatly increase the

skills of much of our current and future workforce--especially those of our frontline, non-college educated workers.

We need not repeat the details of our nation's skills gap here. The issues have been widely discussed, starting with the Hudson Institute's Workforce 2000 report (Johnston and Packer, 1987) and most recently by the Commission on the Skills of the American Workforce (CSAW). As Commission Chairman Brock stated in reference to the CSAW report, "The good news is that we do not have a skills gap. The bad news is that we do not have a skills gap." In other words, only if we choose the high-skill, high-wage, high-productivity road do we have a real skills gap.

In recommending the skills required for work readiness, the Commission must identify the skills required for success in a high-performing environment; its findings must speak to both the world of work and the world of schools. This report suggests a language for this message and presents an initial working inventory of necessary skills.

There are three elements of this language. The functional skills that describe what people actually do at work; the enabling skills, that is, the specific knowledge and procedures developed through the traditional teaching and learning activities of schools; and the scenario, a communication device to demonstrate the way in which work integrates these skills into a productive outcome.

The remainder of this report is organized into four sections. Section II describes how studies of the worlds of work and of learning point up the changes needed in schools. Section III discusses the language we propose that the Commission adopt in responding to its mandate and communicating to schools, corporations, and the general public. It also presents an initial "working inventory" of required skills. Section IV describes how this proposal was formulated--the specific process and events that resulted in the proposed language structure and the working inventory of skills. Section V suggests steps that should be taken next by the Commission to define workplace skill requirements.

II. CHALLENGING OUR SCHOOLS TO CHANGE WHAT THEY TEACH, HOW THEY TEACH, AND WHO THEY TEACH

Two trends pose a profound challenge to our schools: (1) changes in the kinds and levels of performances that even workers traditionally described as "less skilled" are expected to

exhibit in the workplace and (2) emerging research findings on how people learn most effectively. The two trends together imply that schools need to change what they teach, how they teach it, and to whom they teach it.

Workplaces Changes

Changes in the workplace have particular implications for what schools teach and, to whom they teach it, as well as for the performance standards they set for students.

Changes in the Workplace Have Altered What Workers Do, How They Do It, and With Whom They Work

Changes in what workers do. One of the most profound implications of computers in the workplace is that they replace learning based on visual observation with learning acquired primarily through symbols, whether verbal or mathematical (Zuboff, 1988; Scribner, 1988). For example, in textiles, semiliterate operators used to be able to move into technician jobs because they literally could see how textile machines functioned. Today, many machines have microprocessors and other electronic components that are not observable. To understand, diagnose, and fix the new machines, technicians now have to be able to represent their structures and processes symbolically in their heads by decoding complicated manuals, diagrams, and updates provided by the manufacturers (Bailey, 1988). Literacy requirements have accordingly increased.

One hallmark of successful competition in today's market-place is flexibility in service and manufacturing industries. "Total customer service" and "total quality management" are the bywords of high-performance business organizations. The variations in product and service associated with this flexibility multiply the number of workplace decisions that must be made. In more productive companies these decisions are being made at lower and lower levels in the corporate structure, requiring both higher- and lower-skill workers to think critically and regulate their own performance.

The ability of organizations to compress the time between product design and marketplace delivery has become a major competitive weapon in both manufacturing and service industries (Stalk, 1988; Bailey, 1989). Companies can no longer afford to buck decisions up and down the management ladder; decisions must be made right at the point of production or point of service. As a result, frontline workers have to deal with the unfamiliar,

atypical, and irregular. In order to make the decisions that previously were made by others, these workers must understand their firm's market environment and organizational context. To minimize work stoppage by generating initial hypotheses about the source of equipment breakdown for maintenance technicians, frontline workers must stay on top of the latest technologies. As one personnel manager for a plant noted, "Our operations change too fast to be able to spell everything out. Operators have to be better able to figure things out for themselves" (Bailey, 1988).

Changes in how they work. Not only must workers do multiple tasks, they must do them well. As a trainer at Motorola Corporation said, "Now that the new technologies can be easily bought, the real edge is in how well you use them. We are in a situation that is like the International Race of Champions, where everyone has the same cars, and these cars are traded between races. The prize goes to the most skilled driver" (Berryman, 1990).

Changes in those with whom they work. Increasingly, workers have to work in teams*--within the same function, across functions, across hierarchical levels, and within supplier-producer-customer networks--and in a multicultural environment. These features of the work environment generate the need for skills in both interpersonal communication and conflict resolution.

The workplace will continue to change. In the past decade, shifting international markets and sources of comparative advantage, fickle customers, and rapid innovations in products and processes have forced fundamental changes in corporate strategies. The speed with which new products are being introduced suggests that technologies and markets will <u>not</u> stabilize. Ongoing change generates the need for a continuous adaptation of employee skills.

Implications for Schooling

Changes in the workplace have consequences for the skills that students must learn, for the ways in which they are taught and for the performance standards to which they are held. For

* Work teams are the basic organizational unit at plants in the Motorola Corporation, IBM, Ford Motor Company, Goodyear Tire and Rubber, and numerous other major modern corporations.

example, facing a life of continuous learning, they need to learn how to learn. The emphasis on teamwork in more and more workplaces means that instructional approaches must also emphasize learning collaboratively not just individually. The need for high-quality work performance means that students must be held to, and come to hold themselves to, high standards of careful and best effort performances.

These changes also have consequences for who learns. As job content changes rapidly, narrow, specific skills have become less important, and broader, more generic skills more important. The generic skills required (i.e., metacognitive skills--the ability to think about what one is doing and its consequences for the work goal) have become more similar across higher- and lower-skill jobs. This blurring of historical skill differences between occupations implies a change in who gets taught what. It raises serious questions about our distinct educational traditions of elite education and mass education (Resnick, 1987a), as usually embodied in "academic" versus "vocational" tracks.

Cognitive Science and Learning

Cognitive science is a multimethod, multidisciplinary field that studies how knowledge is acquired and used. For all types and levels of schooling and training, the field's emerging research findings challenge what we teach and when and how we teach it.

Cognitive science finds that intelligence and expertise are built out of interaction with the environment, not in isolation from it. These results challenge our traditional distinctions between:

- head and hand,
- academic and vocational education,
- knowing and doing,
- abstract and applied knowledge,
- education and training; and
- school-based and work-based learning.

Mistakes in Education and Training

Cognitive science research reveals several persistent mistakes in education and training. These mistakes must be kept

in mind as this Commission chooses how to select, describe, and communicate skill requirements to schools and corporations.

- Most K-12 education and work-based training operate on the false assumption that skills are like building blocks. But people need not "learn the basics" or "first things first" before they learn specific technical or problem-solving skills. For example, in training production workers to handle a new production process, we often assume that they need to learn discrete facts about the process before they can begin to deal with the more complex problems surrounding it. But human beings--even small children--are quint-essentially sense-making, problem-solving animals. By not involving the learners' sense-making inclinations in early learning, we not only miss opportunities to begin refining their problem-solving skills in the domain that we are trying to teach, but we create barriers to learning itself.

- Although learners are often depicted as resembling blank slates, learners bring their own conceptions to the learning situation. For example, individuals have their own conceptions of natural phenomena, such as light, heat and temperature, or electricity. These ideas are personal--constructed from their interpreta-tions of naive experience, coherent in their own terms, and resistant to change through traditional training. Traditional curriculum design usually is based on an analysis of the subject matter that ignores what is already in learners' heads, with the result that students can play back memorized knowledge and conceptions but return to their own ideas when confronted with unfamiliar questions or nonroutine problems. College physics students can solve "book" problems in Newtonian mechanics by rote application of formulas. When faced with an unfamiliar problem to which their formal instruction is in fact relevant, however, they revert to naive pre-Newtonian explanations of common physical situations.

- Educators often depict learners as passive receptacles into which knowledge may be "poured." But learning actually occurs when the learner constructs, invents, and solves problems.

- Skills are often taught in isolation; learners get little practice in applying and combining skills. Studies reveal a surprising lack of transfer of

theoretical principles, processes, or skills learned in classes to practice. For example, research shows that extensive training in electronics and trouble-shooting theories provides very little knowledge and fewer skills directly applicable to performing electronics trouble-shooting.

- Although "learning to know," "learning to do," and their "application" are often separated, there is no effective learning or understanding of one kind without the other two. As Resnick (1987b) points out, most school learning is symbol-based. When symbolic activities become detached from meaningful context, school learning becomes a matter of learning rules and saying or writing things according to the rules. Outside school, actions are intimately connected with things and events. When people are engaged with things and situations that make sense, they do not forget what their calculations or what their reasonings are about. Their mental activities make sense in terms of immediate effects, and their actions are grounded in the logic of immediate situations.

- Knowledge and skills are often taught in ways that do not replicate the settings in which the work must be performed. This teaching out of context impedes the transfer of training to new settings. For example, both traditional classroom education and corporate training activities usually require individual performance, but increasingly work occurs within the context of teams. What one person is able to do depends fundamentally on what others do, and "successful" functioning depends on the mesh of several individuals' mental and physical performances. Similarly, work is intimately involved with tools and resources of all kinds--from production technologies to computerized data bases. Competence requires the expert use of tools and other resources. Too often educational and training situations do not replicate the team-like nature of work or include the resources that workers are expected to be able to use in the conduct of their work.

Implications for Schools

Cognitive science strongly implies that people learn best when they are taught in the context of situations, activities,

and problems (Sticht, 1984, 1986, 1987; Resnick, 1987b; Lave, 1988). Learning in context provides meaning and therefore motivation to learn. It helps to break down the separation between knowledge (knowing what) and practice (knowing how and when) that has resulted from the formal approach to instruction in schools and the resulting mismatch between school and work.

Appropriate contexts for learning should be designed to--

- o require the integration of knowledge, procedures, and their application;
- o engage the sense-making efforts of the student;
- o require active construction and invention;
- o engage multiple skills of different types and require students to integrate these in a performance; and
- o include the social interactions and resources and tools typical of non-school situations.

Few schools today routinely follow these precepts in the education of all the students they teach.

III. GETTING SCHOOLS TO CHANGE: THE COMMISSION'S OPPORTUNITY

The Commission has several opportunities to change American schools:

1. Educators generally do not understand the skill demands of high-performance work, especially the skills needed for what they think of as "less skilled" jobs. For example, they may read that leading-edge companies want production workers who can identify and solve problems, but they have no context for understanding what these abstract terms mean. **This Commission can define skill requirements in ways that put these terms into context and give meaning to them.**

2. Employers send different messages about the skills that they need (Commission on the Skills of the American Workforce, 1990). Some of the variation is probably related to company size, but much of it has to do with whether companies have high- or low-performance ways of organizing the work they perform. Different messages (e.g. concerning the need for minimum standards verses

high levels of performance or for broadly educated students verses students prepared for a specific, discrete job) are confusing to educators and to the public officials who have power to make policy for schools. Because these variations are reflected in corporate hiring standards, they also muddy the message to students. **This Commission can identify skills that reflect high performance work and obtain corporate consensus that these are the critical skills for the workplace.**

3. The skill assessments that states, schools, and the nation use only rarely evaluate student performance in meaningful contexts. Today's assessment usually consists of paper and pencil, norm-referenced, multiple-choice tests. These tests show how individuals perform relative to the population against which the test is benchmarked. However, we do not know how they perform relative to some criterion or performance standard that is socially valued and understood. Multiple choice tests also do not model the performance demands or resources of non-school settings. They preclude display of problem-solving and other high-level skills, implicitly presuming that "competence" is the ability to retrieve the "right" fact from a warehouse of facts. They thus encourage routine drill in bits and pieces and militate against the development of intelligent judgment. Finally, because they are paper and pencil tests, they do not show how well students can use other tools and resources in the performance of tasks.

   This Commission can identify skills and communicate them in ways that imply major changes in assessment strategies. Rethinking assessments is one lever for restructuring the educational enterprise. As Resnick and Resnick (in press) observe, public, comparative assessment results that affect the reputations of schools, teachers, principals, and school graduates also powerfully affect curriculum and pedagogy. What we measure and how we measure it gets taught and is reflected in instructional practice; what we do not measure does not get taught.

4. Schools do not routinely teach skills in contexts that have meaning for and motivate students. Yet cognitive science teaches that people learn skills best when they are taught in meaningful contexts and that people are

more likely to use knowledge appropriately in applied settings if they acquire it in such settings. **This Commission can define skill requirements in terms of what people actually do at work and thus give schools the information they need to use functional context instructional techniques.**

IV. DEVELOPING A NEW LANGUAGE FOR SKILLS

The opportunities just described have implications for how the Commission conceives of "necessary skills," what skills it selects as "necessary," and how it communicates this understanding to the corporate and educational communities. We suggest the following language: **functional skills**, which reflect what people in a wide range of jobs actually do at work; **enabling skills**, which underlie the performance of functional skills; and **workplace scenarios**, which describe skills in the context of real work activities.

Functional Skills

Functional skills reflect what people in a wide range of jobs actually do at work. These skills are exhibited at many different levels and in different proportions, depending on the job, but with enough common aspects of content and cognitive and behavioral performance to constitute a "skill."

The commonality of functional skills among jobs and their relationship to the acquisition of other skills make them key to many career opportunities. For example, being the leader of a work team in a company may call for supervisory skills similar to those required of a plant manager, even though they may be a few times removed.

The functional skills are different from a person's "technical" or "domain-specific" knowledge and skills. For example, the functional skills of accountants and manufacturing technicians in a manufacturing facility may be much more similar than their "technical skills" but equally important.

Functional skills that are selected must be--

- Keyed to effective performance in a broad range of jobs;

- Limited in number to between 20 and 40, so they can be widely understood;
- Representative of the complexities of work;
- Inclusive of a wide range of the enabling skills typically taught in school;
- Open-ended, that is, capable of being defined for students ranging in ability from below average to the graduates of four-year and professional schools;
- Explicit enough to permit the development of instruments to assess the level of performance; and
- Capable of being taught.

Using these criteria, a group of experts in workplace performance developed a working inventory of 27 functional skills for the Commission's review (see Exhibit 1). (Section V describes the procedures by which this set of functional skills was identified.) The skills are grouped into five classes of activity performed in most work settings: (1) resource management; (2) information management; (3) social interaction; (4) understanding of systems behavior and performance; and (5) human and technology interaction. A sixth class of skills, the affective domain that pertains to personal attitudes and characteristics such as motivation and integrity, were identified as needed, but the experts did not attempt to specify which particular items should be included.

The specific skills identified were assumed to have generic properties. They represent performances required in a variety of jobs and at a variety of levels of skill and application. This

working inventory is not presumed to be complete, but, it is presented as a well-grounded starting point for the Commission to develop a final statement of the functional skills necessary for effective work performance. (Section VI discusses the next steps required to complete the skills inventory).

Enabling Skills

Enabling skills are skills that underlie the performance of functional skills. They include reading and writing, mathematics and computer skills, listening and speaking, and other areas. A major task for this Commission is to work out the enabling skills implied in the functional skills of Exhibit 1. Enabling skills relate to the basic knowledge a person must have to develop functional skills, such as a core vocabulary required for discourse in many contexts or the basic arithmetical procedures required to compute at different levels.

Workplace Scenarios

The traditional solution to the mandate given this Commission is to develop a list of skills. Lists have a long history, although they vary in several ways, including whether the list describes skills as properties of individuals or of jobs.

Depending solely on a list, however, poses at least three problems: First, skills on a list are abstracted from the work contexts in which they have meaning. When skills are described without context, their meaning is left unanchored, and they imply instruction without context. However, we know that learning occurs most effectively in contexts that are meaningful to the individual.

Second, skills on a list, whether they are properties of jobs or of the person, do not reflect the individual's interaction with the environment. The distinction between a static list of skills versus a dynamic performance is important for how we think about "good" performance. A static approach inclines schools and educators toward "one right way" and "one right answer" performances. However, empirical observations of how real people perform real tasks in real situations show that there are many ways to skin a cat, and often more than one "good" resolution to a problem.

Third, skills on a list do not capture the integration of multiple skills that any real performance requires. Again, this Commission can convey to educators the nature of real work, which requires that students not only develop individual skills, but

also learn to integrate them appropriately in the act of performing work.

EXHIBIT 1

Functional Skills Needed for Effective Work Performance

I. Resource Management: Identifies, organizes, plans, and allocates resources

- A. Time: Understands, follows, and prepares a schedule
- B. Money: Prepares and follows a budget
- C. Material: Allocates material resources
- D. People: Allocates personnel resources

II. Information Management: Acquires and uses necessary information

- A. Identifies, finds, and selects necessary information
- B. Assimilates and integrates information from multiple sources
- C. Represents, conveys, and communicates information to others effectively
- D. Converts information from one form to another
- E. Prepares, interprets, and maintains quantitative and nonquantitative records and information, including visual displays

III. Social Interaction

- A. Participates as an effective member of a team
- B. Facilitates group learning
- C. Teaches others new skills
- D. Serves clients/customers
- E. Influences (informs, explains, persuades, convinces) an individual or group
- F. Negotiates to arrive at a decision
- G. Works well with all kinds of people
- H. Understands how the social/organizational system works

IV. Systems Behavior and Performance

- A. Understands how system components interact to achieve goals
- B. Identifies, anticipates, and manages consequences
- C. Monitors and corrects performance, identifies trends and anomalies
- D. Links symbolic representations to real-world phenomena
- E. Integrates multiple displays

V. Human and Technology Interaction

- A. Selects and uses appropriate technologies
- B. Visualizes operations and programs machines to perform work
- C. Employs computers for input, presentation, and analysis
- D. Troubleshoots and maintains technologies
- E. Designs systems to perform complex tasks efficiently

VI. Affective Skills: Attitudes, motivation, and values

Appendix A gives several examples of workplace scenarios, which are important companion pieces to any list of skills. The scenarios contain empirically based synopses (although at different levels of detail) of real activities, in context, conducted by individuals working at a task, and revealing the functional and enabling skills required for the successful performance of these activities. Each scenario has the five components identified in Exhibit 2.

Well-grounded and designed scenarios enable the Commission to realize the opportunities described earlier:

First, scenarios let the Commission discuss skill requirements in ways that put them into context and give them meaning for educators.

Second, if the functional skills selected and displayed in these scenarios reflect high-performance work, these scenarios become a way of communicating what high-performance work looks like to the wider corporate community.

Third, scenarios become a model for thinking about redesigning assessment, and ultimately, as assessment shifts, curriculum. The scenarios carry messages about skills valued in the workplace. They show the importance of testing situations that indicate whether students can select and integrate multiple functional and enabling skills. They indicate the importance of a setting for assessment that reveals effort and the willingness to exert sustained attention.

EXHIBIT 2

Components of a Workplace Scenario

1. A **context**, that is, the "arena" or "setting" for any activity (Lave, 1988). For this Commission, relevant arenas or contexts are industries; the Commission's industry sector task forces will have an important role in developing and verifying accurate and realistic workplace scenarios.

2. **Activities**, such as preparing a proposal or arriving at a group solution to a process change.

3. A **person** or **persons in action** within the context.

4. **Performances** that display a variety of functional and enabling skills, and their integration.

5. A **long enough time period** to reveal persistence and effort.

Fourth, by displaying work in its context, scenarios provide an effective counterpoint to the tendency to instruct out of context. Scenarios display many of the components of learning situations that facilitate the acquisition and appropriate use of knowledge and skill, such as the social interactions, resources, and tools typical of non-school situations. Therefore, scenarios can stimulate the use of functional contexts for learning.

V. FORMULATING THE COMMISSION'S APPROACH

This approach to the Commission's inquiry emerged from Commissioners' commentary and suggestions, visits to corporations that emphasize high-level employee skills, review of contemporary research, and discussions with a wide range of researchers and other experts.

Commissioner Comments

At the initial meeting of this Commission in May 1990, Commissioners Palko and Sticht described some of their activities related to the subject of this investigation. Commissioner Palko discussed Project C^3 (corporations, classrooms, and community) in Fort Worth, Texas, which is an attempt to better link educational activities and business needs through a careful analysis of 1,000 local jobs. Commissioner Palko and his colleagues are identifying the job tasks and basic skills associated with these occupations. Commissioner Sticht discussed the findings of his research for the U.S. Army which demonstrates the value and importance of learning in context.

Since this meeting Dr. Packer and other Commission staff have discussed the implications of this functional context approach to instruction with Senator Brock and several other Commissioners. In each case the Commissioners encouraged the staff to identify and describe skills in functional terms. This direction was confirmed during the first meeting of the Commission's Steering Committee, when the group accepted the initial Operational Plan that distinguished functional and enabling skills.

Visits to Corporate Training Centers

Commissioners and staff also visited the training centers of two major manufacturing and sales organizations whose executives serve as Commissioners. On July 9 and 10, staff of the Motorola

Corporation's Training and Education Center in Schaumburg, Illinois, hosted a group of Commission staff and briefed them on Motorola's training operation and strategic plan for education and training. On July 16, the IBM Corporation provided a day-long briefing for Commissioners and staff at its Armonk, New York, management development facility.

In both organizations, training and education programs were built on real job requirements, and the curriculum reflected actual workplace needs. Training took place close to the work situation and was reinforced immediately by actual work performance. Both organizations are implementing new job structures that call for levels of skills much higher than those previously demanded of workers.

Review of Research

The Commission staff held discussions with key researchers in a variety of fields. The Commission's research team consisted of researchers on education policy and labor force training from Pelavin Associates; researchers on job analysis and assessment from the American Institutes for Research (AIR); and researchers on work and cognition from the Institute on Education and the Economy (IEE) of Teachers College, Columbia University.

AIR helps organizations develop tests to screen for a variety of competencies, including those required in the workplace. AIR is currently a contractor to the U.S. Army for its revision of the Armed Services Vocational Aptitude Battery (ASVAB) and the Department of Labor (DOL) for the refinement of the General Aptitude Test Battery (GATB). AIR was asked to develop a paper reviewing past attempts to determine workplace skill requirements.

AIR's paper, "Identifying Necessary Job Skills: A Review of Previous Approaches," which is available to Commissioners, showed that most attempts to characterize the skills used at work have emerged either from the research of industrial psychologists or from other groups such as this Commission. The research of industrial psychologists has focused primarily on general characteristics of individuals (e.g., intelligence, reasoning ability, reaction time) or on the characteristics of jobs (e.g., assemble items, load ammunition, route packages). The level of specificity captured by past efforts has varied from the very general (e.g., problem-solving ability) to the very discrete (e.g., perform a tack weld in aluminum sheet metal).

The research of groups like this Commission has frequently resulted in lists of skills that integrate these dimensions (i.e., of individuals and of jobs), but such lists, as well as those generated by the industrial psychologists, tend to be neither specific nor rooted in a context. Therefore, they do not provide direct links to schools or a sense of the work enabled by the skills identified.

IEE at Teachers College, Columbia University, serves the Education Department as the National Center on Education and Employment. IEE staff have conducted pioneering research on changes in work requirements and learning on the job. Key findings of their recent work were included in the earlier section on implications from workplace studies and cognitive science.

Comments from Experts

This Commission's mission has been reviewed with a wide range of experts on workplace skill requirements, who offered a variety of useful comments. Staff of the three contractor organizations, experts in schooling and learning, emphasized that simply communicating a list of workplace skill requirements to schools was unlikely to result in change. Other researchers and some Commissioners agreed. Put simply, lists <u>alone</u> have not changed education in the past, and they are unlikely to do so in the future. To change education at the level necessary to improve workplace preparation, appropriate outcome measures (i.e., assessments) must be available and used, and instruction must build on an understanding of real-world work situations. Both these requirements imply that the Commission must communicate its findings in a rich, highly illustrative, and actionable manner (i.e., as in the scenarios described earlier).

Criteria for Functional Skills and an Initial List

Building on this background work, Dr. John Wirt, the deputy director of this Commission, prepared a brief concept paper for wider review. This paper was used as the basis for the deliberations of a panel of national experts on workplace issues (described in the next subsection). The paper defined functional and enabling skills and discussed communicating the Commission's findings through scenarios.

The paper concluded with a set of criteria for functional skills (presented in Section IV of this report). The paper

proposed an initial list of functional skills to illustrate the ideas.

The Meeting of Experts

On August 9 approximately 30 experts in analyzing workplace skill requirements convened to discuss the concept paper just described (the participants are listed in Appendix B). The group included 18 researchers and human development specialists from throughout the nation as well as Commissioner Tom Sticht, the Commission staff, and contractor staff. These experts were asked to test the approach: Could the draft set of skills be revised and extended to describe adequately and understandably many or most of the most important aspects of what people do to work effectively?

Dr. Larry Leher of the Defense Systems Management College helped the Commission staff plan the meeting and facilitate the initial discussion. The whole group held a discussion prior to meeting in two sub-groups for two separate three-hour sessions. For part of those sessions each subgroup was divided further into three small working teams. Drs. Kane and Goslin of the contractor team facilitated the sub-group sessions.

Participants generally agreed that a set of generic "functional" skills or performances that were needed across multiple work settings could be identified. They also agreed that refining the list and presenting the skills within a scenario format could overcome limitations they perceived with the draft list of skills.

On August 10 the subgroup meetings continued. One group focused on refining the skills list, while the other group focused on refining the concept of scenarios as a presentation device.

Exhibit 1 displayed the outcome of the work on the skills list, and Exhibit 2 identified the components of a workplace scenario. In response to a suggestion that scenarios with a common theme could be developed across multiple industry sectors, four generic situations were identified: (1) making a proposal, (2) managing a project, (3) developing a group solution for a process change, and (4) providing customer service.

In the final session the group of experts agreed on the following recommendations:

- This Commission should define "skills that high school graduates need to ensure a productive career." The Commission should not focus solely on entry-level skills but should also include those skills required for movement up a career ladder. Individual progress and corporate success imply that the ability to learn effectively and to take on new roles is a required entry-level skill, regardless of the nature of the initial job assignment.

- The Commission should emphasize the importance of the affective dimension in workplace performance.

- The Commission should emphasize that students leaving school must be able to do more than read, write, and compute as measured by standard assessment instruments. They must be able to apply those skills in real-life, authentic performance situations.

- The Commission should state that textbook-based training alone is insufficient for effective workplace performance. Skills developed through liberal studies must be exercised in reality-based applications in order to transfer effectively to workplace settings.

- The Commission should recognize that scenarios can cover a variety of situations, from those that are work-based to those that are more personal (e.g., the planning and budgeting to afford a car). For purposes of the Commission's report, the scenarios should be based on work situations. In this way students will also learn about the world of work.

VI. DEFINING WORKPLACE SKILLS: NEXT STEPS

The set of functional skills required by high school graduates to achieve work readiness depicted in Exhibit 1 provides a starting point for this Commission. The working inventory of skills and the scenarios to communicate them require refinement and further definition, a process in which key industry leaders and organizations must be involved. It is also important that both the functional skills and the scenarios be assessed by people actually in the workplace, including workers, first line supervisors, and senior executives. The Commission's next steps are as follows:

1. Task force investigation and testimony by industry experts;

2. Development and verification of workplace scenarios; and

3. Review of the literature, industry studies, and other data sets on skills requirements.

Each of these steps must be taken before the Commission reviews its main report and the reports of each sector task force. Elaborating and defining workplace skills completely will entail determining the enabling skills necessary to support the performance of functional skills.

Task Force Investigation and Testimony by Industry Experts

The meeting of the expert group in August began this process. On January 18, the full Commission will meet at the Motorola facility, so that all Commissioners will have the same briefing that the Commission staff received.

Most investigation will occur at the sector task force level, where staff will help task force members identify key industry associations and leading businesses and business leaders in the sector. These people and organizations will be invited to suggest refinements and expansions of the initial skills inventory consistent with the needs of their sector.

Development and Verification of Workplace Scenarios

The five sector task forces will identify a total of 50 jobs that represent the range of opportunity for recent high school graduates. The working set of functional skills must be verified by establishing the need for their application within these jobs. The enabling skills required for effective performance in each of the jobs to which they apply also must be determined.

The last three scenarios contained in Appendix A are examples of the results of workplace studies that have been conducted over the past decade. As this report has indicated, anthropologists, economists, and cognitive scientists are providing some important new insights into the actual cognitive skills involved in conducting work. The Commission's effort will draw on the expertise of these researchers in several ways. The researchers will be asked to share previously collected data and

insights, to develop scenarios from their data, and to confirm the contents of the scenarios with people at work.

Once the 50 jobs are identified, researchers who have observed the industries in which these jobs occur will be asked to use their extant data (supplemented perhaps by some telephone interviewing) to construct scenarios such as the last three in Appendix A. In this process the researchers will provide feedback on the initial skills list and its relationship to the skills required by the job being described. The researchers will also provide any data they have on the enabling skills required in their sectors.

The first scenario in Appendix A, describing the medical transcriber, was developed by interviewing persons involved in that work. It provides a model for the development of additional scenarios when existing research is not available to capture the particular requirements of a specified job. Working with experienced researchers, staff of key industry associations (e.g., the National Association of Manufacturers (NAM) and the National Restaurant Association (NRA)) will be asked to develop scenarios in this manner based on their experience in the sector. Commission staff working with sector task forces will provide a similar scenario writing resource when necessary.

The developers of each scenario will be required to subject the proposed scenario to review by people working in the settings described. Workers and supervisors will be asked questions such as these:

- Does this description accurately reflect what you do or supervise?
- What functional skills are displayed by each scenario?
- What critical behaviors are not represented among the skills identified and the scenario communicating them?

The responses of these people will be used to verify the completeness of the functional skills inventory and to refine the scenarios.

Review of the Literature, Industry Studies, and Other Data Sets on Skills Requirements

The paper prepared by AIR provides a starting point for the review of existing studies and data bases. The sector task

forces will supplement the studies reviewed in this paper by identifying and reviewing studies of skill requirements and related data bases. Government-sponsored research, such as a recent series of studies sponsored by the Department of Labor on literacy requirements of maintenance, dietary, laboratory, and manufacturing workers, provides one source of such data.

Other research and data are available through the industry and occupational associations. The American Banking Association and the National Restaurant Association have each performed considerable analysis of the skill requirements for workers in their respective industries. Studies and data bases such as these will be used by sector task forces to refine the working set of skills.

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APPENDIX A

WORKPLACE SCENARIOS

Adaptability in the Medical Transcription Office

Job: Medical Transcriber

Background: Sweetwater General Hospital is a 350-400 bed hospital with an 85 percent occupancy rate. It has an in-house medical transcription department which normally has six medical transcribers, but currently is short-handed with only four available. The job of the medical transcriber is to receive tapes from physicians and transcribe them. The tapes contain narrative summaries of patients' course of hospitalization and treatment. In this hospital the narrative has to be transcribed and in the patient's folder before patient check-out.

Action: Sylvia Slater is a top-notch medical transcriber at Sweetwater General. This has been a particularly busy week and today she has six tapes in various stages of being transcribed. Three doctors have patient check-outs by 11:00 A.M. tomorrow; Dr. Moon who is foreign born with a heavy accent that makes his tapes difficult to understand; Dr. Allegro who likes to take his written transcripts, edit them heavily and return them to the transcriber for revision; and Dr. King who wants immediate service on his tapes no matter how many other doctors are ahead of him.

Sylvia doesn't think she can finish the tapes in time for all the patient check-outs so she goes to Nan Leukmeyer, her supervisor, to discuss the problem and possible solutions. She and Nan make the decision to call in a contract transcriber company that the hospital uses as a back-up. Nan special requests a particular transcriber who is from the same country as Dr. Moon and seems to have less difficulty understanding his accent. Sylvia then calls and leaves a message on Dr. King's service. He is in surgery, probably for six hours. She tells him his narrative has been transcribed and will be delivered to his office. She explains that if he wants the transcript completed in time for his patient check-out he will need to return it for revision by 9:00 A.M. the next day. She is able to reach Dr. Allegro with whom she discusses her time constraints. Sylvia works out a schedule whereby she will have his transcript ready by 4:00 P.M. and he will read it before he leaves for the day; he agrees to hold his changes to a minimum so she can finish transcript in time for his patient check-out.

After finishing her scheduled daily work, at Nan's request Sylvia looks over the first draft of a new transcriber to determine if her knowledge of anatomy and physiology is adequate for the job or she should be sent to a medical terminology brush-up training course offered by the hospital. Sylvia states that, in her opinion, the course would greatly help the new transcriber.

Skills Demonstrated:

Resource Management:

Time: understands constraints on producing a usable end product

Human resources: makes good use of colleagues and supervisor to achieve objectives

Information Management:

Identifies, finds, and selects necessary information to convey sense of urgency to supervisor and to doctors

Represents, conveys, and communicates information to others effectively particularly the doctors who are the clients

Converts information from one form to another by transforming oral information into a written report

Social Interaction:

Serves clients the doctors and ultimately the patients who pay for the services

Influences an individual by using persuasion and charm to convince doctors to compromise on usual procedures in order to accommodate everyone to the extent possible

Negotiates to arrive at a decision with doctors over what is acceptable

Works with human diversity through demonstrating her ability to handle communication with different cultures and with different educational classes

Systems Behavior and Performance:

Understands how system components interact to achieve goals in a complex hospital setting with conflicting objectives

Identifies, anticipates and manages consequences by realizing in time that the end product (medical histories) will not come out on time without some adjustment of process

Links symbolic representation to real world phenomena, i.e. by transforming doctors oral transcriptions into actual written reports

Monitors and corrects performance by looking over reports and making any corrections necessary

Human and Technology Interaction:

Uses technology appropriate to tasks, a transcribing machine

Problem-Solving in the Stockroom

Job: Material Handler

Background: Mickey is a material handler in the stockroom of an electronics factory. He is working on a job that is part of the routine for material handlers, known as "pulling" orders. This job entails locating, counting, and moving bins of component parts which eventually become assembled into a final product.

Action: Mickey needs 150 pieces of a certain part but discovers that the bin in which the parts are stored has only 100 pieces in it. He seems to be 50 pieces short. However, when he consults the "bin card" -- a form lying inside the bin which is a handwritten record of parts added or taken out -- it shows that 4,000 pieces should be in stock. Where are the other 3,900 pieces? Mickey searches the stockroom, looking for bins at other locations that might contain the same part. He finds two full bins, which together contain 5,000 pieces. Mickey can now complete his order and get on with his routine work. But a problem remains: there is a discrepancy between the number of parts physically in the bins (5,100) and the number recorded on the bin card (4,000) and Mickey knows that if this discrepancy is not straightened out now, there will be continuing problems with this part.

Mickey consults his supervisor, Bert, to discuss reasons for this mismatch. Bert is unsure of the reason, but encourages Mickey to pursue the problem. Mickey decides he can get to the bottom of it by consulting another inventory record located in the computer. According to the computer inventory file, 21,000 pieces are on hand. If the computer is accurate, then nearly 16,000 pieces are physically missing! Mickey has either a surplus of 1,100, if he believes the bin card, or a massive shortage of 15,900, if he believes the computer.

While he investigates the records, Mickey banters with co-workers in the stockroom, learning who had worked on this part and collecting information to help solve the problem. He deduces the computer record is wrong since it is so far off the physical count. In order to correct what he presumes is a computer error, Mickey needs access to a screen that displays the history of all transactions for that particular part. He asks Bert to enter his code into the computer (as a material handler, Mickey is not authorized to see all the screens). By comparing the transaction history on the computer screen with the handwritten bin card history, he discovers that the supervisor had neglected to enter into the computer the fact that 15,900 pieces were pulled out of stock two weeks ago.

This error is adjusted, so that the computer record matches the physical count. However, the physical count still does not match the bin card, so Mickey makes that correction as well. When these corrections are made and when the three sources of information about the number of parts in inventory -- physical, computer, bin card -- finally conform, Mickey at last pulls his order.

In a high performance workplace Mickey and the supervisor would work together to develop a process so that in the future such errors would no longer happen.

Commentary: The situation Mickey encountered occurs quite frequently in the stockroom and although it is "nonroutine" it may be considered part of the normal day's work for material handlers.

Skills Demonstrated

Information Management:

Mickey needed to understand that information about parts is of several kinds: quantity, location, receipts, and withdrawals; and that records for such information are stored simultaneously in several places (identify, find, and select necessary information). He had to assimilate and integrate information from multiple sources (physical bins, bin cards, computer screens, and humans) and, to act upon it he had to represent, convey, and communicate information to others (supervisor, co-workers) effectively.

Social Interactions:

Mickey operated in an existing relationship with co-workers, with established routines for communication. He knew his supervisor and fellow material handlers well enough to communicate the problem and seek advice and information (understands how the social/organization system works; participates as an effective member of a team).

Understanding Systems Behavior:

In the workplace, problems do not always announce themselves. Mickey might have simply pulled his order once he found the extra bins and never made the effort to resolve the discrepancy at the level of record keeping. To recognize that a serious problem existed (identifies anomalies), he needed to know a great deal about the relationship of the stockroom to the rest of the plant (understand how system components interact to achieve goals). For example, he needed to know that the company had a computerized system for keeping track of inventory; he needed to know how information was entered and processed in that system as well as in the stockroom itself. To recognize the significance of discrepancies in the records and to resolve them, he needed to link symbolic representations (on bin card and computer) to real world phenomena (parts in bins and past actions of co-workers) and he had to integrate information from multiple displays.

Human and Technology Integration:

Mickey used the computer system as a device for analyzing the nature of the problem and predicting sources of error (employing computers for input presentation and analysis).

Adapted from Scribner, S. and Sachs, P. (1990). A Study of On-the-Job Training. Technical Report #13. New York: National Center on Education and Employment, Columbia University.

Teamwork in an Airlines Operations Room

Job: Baggage Service Planner

Background: Chris works in "ops", the operations room of Atlantic Airlines in a busy metropolitan airport in the Western United States. "Ops" is a communications and control center which is in charge of coordinating all activities having to do with the arrival and departure of Atlantic planes. This airport is a hub for Atlantic Airlines, and most passengers who arrive here have to make connections. Several times during the day, a flock of AA planes from all corners of the country descend from the air, roll into the eight gates, exchange passengers, baggage, and crews, are serviced with fuel and food, and go out again to different destinations. Chris sometimes thinks of the ops room and the areas associated with it (the ramp, the gate, the baggage area etc.) as a pulsing organism which periodically sucks in planes, people and objects, takes a deep breath, and then expels them again - hopefully on schedule. These periods of heightened activity, each lasting about an hour, are called "complexes."

Tonight, Chris is working with four other people in the ops room: Victor, the supervisor; Dave, the Passenger Service Planner, who is in charge of communication with gate agents; Kendon, OPS-A, who talks to jet pilots, either by voice or through an onboard computer; and Rob, OPS-B, whose duties involve communication with the pilots of Atlantic Hawks, the airlines's small commuter planes.

Chris is the Baggage Planner in the ops room. Her duties center around maintaining the vital link between the ops room and "the ramp", where the ground crew stands ready to service the airplane and take care of the all-important baggage transfers. Before she bid into the ops room (this is a union job and seniority counts), Chris herself worked on the ramp. She had started there several years ago as a baggage handler, had become a baggage transfer driver, then a crew chief on the ramp. This experience is invaluable to her in her present position.

In the ops room, Chris and her colleagues are seated back-to-back, facing the various communication technologies arranged along the walls: computer terminals, radios, phones, flight information displays (FIDs), and the like. Information about the next batch of planes comes in over radios, phones, computer screens, printers, and video monitors. It is taken in, processed, and hen sent out again in the form of directives to other parts of the system (i.e., pilots, fuelers, baggage loaders, maintenance people, etc.). The place is noisy, with phones ringing, printers starting up, and radios squawking; the radio channel for Tower and Ground Control are on much of the time, which exposes ops workers to a constant barrage of directives to planes approaching, landing, on the ground, etc. Of great help to Chris and her colleagues is the fact that they can "look at" the gates where planes arrive. A video camera is mounted at each gate facing the incoming plane. This camera can be controlled from the ops room, so that operators can zoom in on a particular plane to check how far along it is in the boarding process. A bank of eight video monitors, corresponding to the eight gates, is mounted high up on the back wall of the ops room.

Action: So far, the second shift has been pretty ordinary but they have all been briefed by the supervisor that a plane switch has to be made during the next complex. Aircraft #677 coming in from Seattle and scheduled to go on to Santa Ana has developed a problem with one of its fuel tanks. The repair shop that specializes in this type of repair happens to be in Los Angeles. So, during complex 8, aircraft 677 will switch destinations with aircraft 676, which comes in from Reno at roughly the same time with destination Los Angeles. As complex seven wraps up, Chris and her colleagues begin to focus on the upcoming swap.

To get the situation clear in her mind and to help her decide what she needs to do, Chris makes the following note for herself:

Gate 14: aircraft #676

SKED:	1091 from RNO to LAX
TODAY:	1091 from RNO -> 1018 to SNA

Gate 15: aircraft #677

SKED: 1018 from SEA to SNA
TODAY: 1018 from SEA -> 1091 to LAX

She circles gate 14 and gate 15. Obviously, she has to communicate with the crew chiefs at these gates to make sure that they are aware of the planned changes. In an ideal world, they would have consulted their computers but she knows from experience that things often get hectic on the ramp. She figures she'd better make sure nothing will fall between the cracks. If you "ramp rats" weren't ready, there might be a delay in getting these planes out and that would be a delay counted against them in their performance rating. This would be reflected in their bonuses but maybe more importantly, it would be a black mark on their excellent record.

Chris picks up the radio: "Ops to gate 15"; "ops to gate 15, come in please." A voice comes over the radio. It is Redge, the crew chief at gate 15. "Go ahead, ops." Chris explains that the aircraft for 1018 today will "take out" 1091 to Los Angeles because of a problem in the fuel tanks. "So, please, let your transfer drivers know." Obviously, it wouldn't do to have the Santa Ana baggage show up in Los Angeles.

While she makes sure that the ramp personnel at both gates are properly informed and prepared, she also, almost unconsciously, listens for other relevant information in the babble of noises that fills the room. Dave is updating the "leads" at both gates about the impending swap. Rob is placing a food order for one of tomorrow's flights, and Kendon is talking on the radio. Her phone rings. She hears the beginning of a Tower communication about flight 1018 but picks up the phone. It's Grosso, one of the transfer drivers for tomorrow morning shift who wants to switch places with a friend on the afternoon shift. Chris says: "that's fine" and makes the requested changes on her record sheet. Keeping the ramp crew records is one of the duties that comes with the job.

Meanwhile, Kendon, raising his voice slightly, and half turning his head into the room announces: "108 is on the ground." She knows this is information he picked up from listening to the Tower and Ground Control. She picks up her radio and, with an intonation that sets this communication off from others, announces to the ramp: "1018 is on the ground for gate fifteen." She knows that the ramp crew at gate 15 are getting ready to roll out the stairs, that the baggage driver is ready to collect the bags coming off the plane, distribute them to the appropriate gates for their connections and load on the baggage going to LAX. She enters the plane's touch-down time on her complex sheet, a matrix listing incoming against outgoing flights that shows how many bags from each incoming flight have to be transferred to the various outgoing flights.

Dave, who has put on a headset to cut down on some of the noise in the room, has been talking on the radio. Now he turns to face the room and says: "1091 was 16 minutes late out of Reno; he's trying to catch up some but it'll be tight." Chris knows that to switch passengers, crews and baggage between the two planes and have them both leave on schedule will require good planning and quick work by everybody. She turns to the supervisor: "Victor, do you think we could give 1091 an extra set of stairs?" Victor thinks that's a good idea. So Chris calls the crew chief at gate 14 and asks him to have rear stairs ready for 1091. Dave, who had been listening, picks up his phone at the same time to call the lead gate agent at gate 14. They will use the rear stairs to board outgoing passengers while the arriving passengers disembark via the front stairs, a procedure that substantially speeds up the turnaround time for the plane.

Chris gets up from her workstation and walks over to the camera controls at the opposite wall. Looking at the monitors for gate 14 and 15, she manipulates the camera controls. Gate 14 is empty. At gate 15, she sees the Marriott truck in place but the fuel truck has already pulled away. So they are making good progress.

While she's standing there, Rob asks her: "Hey, Chris, can you see how many Hawks are out there?" The Hawks, the airlines small commuter planes, are parked at the most distant gate and are often hard to see. Chris focuses the camera and tells Rob that the gate is still empty but it looks like one is taxiing in.

Commentary: Chris likes to think of the whole ops room crew as constantly working on updating their collective take on the current state of the world. Everyone is working on what "the picture" is, i.e. engaged in absorbing and in turn making available to co-workers information about the current situation. That is why people in the ops room are constantly engaged in monitoring each other's information needs. They ask each other for help, they offer assistance, and they provide others with whatever pieces of information they pick up. Much of the information the ops room works with is relevant to different operators for different reasons. For example, the delay of one plane may pull in its wake disturbances in the departure of others and it is extremely important that information about changes be available to everybody who is involved in shaping the directives that go out of the room.

Skills Demonstrated

Resource Management:

Time: is alert to time-sensitivity of required actions;

Material: schedules appropriate technology;

Human: involves people in and outside her immediate work environment to get job done

Information Management:

Identifies salient information as it comes in through voice (phone and radio) or computer against a noisy background;

Appropriately "packages" information for co-workers in ops and on the ramp; is able to project herself into their position sufficiently to do so;

Translates video, auditory and electronic information into other modalities;

Understands and fills out complex paper forms.

Social Interaction:

Participates and identifies as team member;

Orients to an is responsive to others' information needs;

Is able to take initiative and make suggestions to co-workers, including supervisor.

Understanding Systems Behavior and Performance and Interaction with Technology:

Understands the ways in which the ops room is tied to its associated locales, i.e. the ramp area, the gate area, ticket counters, pilots, maintenance, etc.;

Understands information needs of different parts of the system; pilots, ramp, gate agents;

Is able to communicate through appropriate technologies with remote parts of the system: video, radio, phone, paper documents, computer;

Monitors consequences of directive sequences as they propagate out of ops room into other parts of the system;

Takes action to increase efficiency of the entire system.

Prepared by Jordan, B. Institute for Research on Learning. Palo Alto, CA. 1990 from the Workplace Project funded by Steelcase Corporation and Xerox.

Working with Machines in a Shop

Job: Machinist

Background: Tony and Jose are sitting in the machine shop office with a blueprint in front of them. They are experienced machinists who recently learned to work with new computer-controlled (CNC) machines. Each CNC machine has the capacity for performing a wide variety of operations on a single part. Tony and Jose have to plan the sequence of operations and write a computer program in alphanumeric code that instructs the machine on how to carry them out. The particular part they are working on now requires nine different machine tools and ten operations (drilling, milling, threading, etc.) which have to be coordinated in a machining plan before they even approach the machine.

Action: Tony and Jose discuss how they will sequence the turning and milling operations. Tony suggests the possibility of alternating them. Jose points out that it would save machine time if all the milling operations could be done together; they wouldn't have to keep stopping and starting rotation of the part. Tony sees the point but reminds Jose that if they do this, they will have to make sure that the threading is done before any milling takes place: milling thins the part and makes it more subject to bending and this will affect the accuracy of the threading operation. Jose agrees. After they have laid out the full sequence of operations and chosen the appropriate tools, Tony pulls a sheet of line paper from the desk drawer and starts to write the computer program. He specifies the paths the tools have to take to execute the machining plan in terms of points in Cartesian space. As Tony works on the program, Jose uses a hand calculator to figure out one of the part dimensions that was left off the blueprint but has to be specified in the program. When the program is completed they will enter it in the terminal mounted on the machine and test run it without any material. If it works, they will feed in the material and step through the program one operation at a time, correcting as they go, until they are sure they are ready to start up production.

Skills Demonstrated

Resource Management:

Time -- understands the need to plan ahead before beginning job.

Social Interaction:

Works well collaboratively in a team by contributing specific consideration to the final plan.

System Behavior and Performance:

Understands the special capabilities of the new machine and how to sequence operations efficiently. Has expert knowledge of how operation affects various metals. Can link symbolic representation to real world phenomenon through understanding programs which involve new forms of special representation, and has a knowledge of formal mathematics.

Human and Technology Interaction:

Has the ability to select and use appropriate technology to see various ways of sequencing operation to produce the same parts.

Prepared by S. Scribner, L. Martin and K. Beach, Laboratory for Cognitive Studies of Work, Graduate School and University Center, City University of New York.

APPENDIX B

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