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Linking Science Education to the Workplace

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This article examines the issue of linking education in the sciences with the world of work for all students. Traditionally, science teaching has been limited to preparing student for research career in science at the university level. The reform movement in science education is focused on intellectual skills that serve to fortify the human capital of all students and the economic productivity of the nation. The educational issue arises from evolutionary changes that are taking place in the practice of science, the development of a global economy, the nation's entrance into an Information Age, and the changing nature of the workplace. To identify and integrate these factors in the practice of science teaching is the goal of this article.

KEY WORDS: Curriculum reform; preparation for work; human capital; economic productivity.

INTRODUCTION

For over 200 years a major goal of science education in schools has been to prepare students for a career in science. Beginning the elementary grades, efforts are still being made to teach children to "think like a scientist" and "be like a scientist." In later grades the emphasis becomes scientific inquiry, scientific method, and the development of laboratory skills. Each of these objectives is in the context of a specific discipline, such as biology, chemistry, geology, or physics.

A broader vision of career goals in science education is now being sought, one that enables students to actively participate in the economic affairs of the nation as a more productive person in the workplace. The goal is common for all students, not just limited to those who choose to become a scientist. Currently, there-fourths of the entire workforce in the U.S. have only a high school education or less. Of the students who obtain a bachelor's degree only 1.59% will seek a career in science and the number is decreasing (Chronicle, 1984).

The U.S. House of Representatives in the Workforce Readiness Act (H.R. 4078, 1992) proposed the establishment of "a National Board on Workforce Skills to develop a comprehensive school-to-work transition program for students." The Act recommends "developing or adapting curricula and instructional materials which incorporate generic workplace skills" (p. 8). Also in 1992 the U.S. Department of Labor (SCANS, 1992) released a 425-page report identifying the major competencies, skills, and personal qualities typically required for a productive worker with a high school education. The five core school subjects identified as critical for developing the requirements for today's workplace were science, mathematics, English, history, and geography. For the sciences the work goals, as noted later, are those in harmony with the contemporary practice of science as well as with the workplace.

The U.S. Congress after two years of debate outlined a national framework for the reform of education (H.R. 1084, 1994). The Act stresses the preparation of all students for lifelong learning that is deemed as essential for success in the workplace and for civic participation. The Act also stresses the responsibility of parents, business, teachers, and pro-

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fessional educators in helping schools achieve work standards.

Also in 1994 the U.S. Congress passed the School-to-Work Opportunities Act (H.R. 2884, 1994), which President Clinton signed into law. The Act highlights the need for schools to prepare students for occupational advancement, an attribute to be shared by all academic subjects. Currently "the United States lacks a comprehensive and coherent system to help its youth acquire the knowledge, skills, abilities, and information about and access to the labor market necessary to make an effective transition from school to career-oriented work or to further education and training" (p. 3). It was the opinion of the committee that work competencies are taught best within academic courses rather than in career vocational or job related courses. Congress also recognized that the most common life activity shared by all students will be the 40 years of their lifespan involved with some type of work.

The National Education Goals Panel (1995, p. 11) summarizes the purpose of schooling by the year 2000 to be preparation for responsible citizenship, future learning, and "productive employment in our Nation's modern economy." The National center on Education and the Economy (1990) pointed out that "America's choice is one of high skills or low wages."

THE ISSUE

There has been much discussion since 1970 about the need to reform education in the sciences on the premise that the current model is outdated in terms of its service to students, to the workplace, and to society. In addition, the majority of reform efforts have failed to recognize the shifting practice and culture of science, the information age, and the global economy. These are all conditions to which students must adapt in the new millennium to avoid experiencing a low quality of life and the risk of unemployment.

Since 1890 every curriculum reform movement in the sciences has had as a goal "meeting the needs of students." A close examination of each reform effort shows that the emphasis was discipline bound and had little meaning for life beyond the laboratory door. A vision of science education in terms of its contributions to the advancement of our democracy and its economic productivity, and to the work life of the student, has been omitted. What is now sought are science curricula (K–12) that integrate career and life skills into the science curriculum at all grade levels. Students are expected to develop a career awareness on a continuing basis in all academic subjects and at every grade level. These curricula would enable students to achieve optimal mobility in the workplace and a high quality of life for now and the foreseeable future. Schooling is viewed as a knowledge utilization system fortified by standards that meet the criteria of usable knowledge.

One way to get a glimpse of what career education means today is to examine the slogans used to symbolize the issue. Among those commonly used are: "thinking for a living;" a shift from "doing to thinking;" and from "brawn to knowing;" "learning to earn;" switching from "mechanical skills to intellectual skills;" and "a choice of high intellectual skills or low wages." All the slogans carry the implication that people will need to work smarter from now on than in the past to meet the demands of the new job market.

There are other factors to recognize. The largest consumer of education today is business, replacing agriculture and manufacturing. Forty-one percent of all workers are now classified as office workers. They earn 47% more in income than non-office workers. Being an office worker today requires somewhat more than a high school education (Carnevale and Rose, 1998, p. 4).

From an economic point of view it must be recognized that 75% of all goods produced in the United States are in competition with products from foreign countries. An awareness of work in a global economy has led nearly 150 foreign countries to begin reframing their science curricula. The seriousness of the work problem is evident from the Congressional debates cited earlier. The current practice of downsizing in businesses—the loss of jobs by experienced workers—results from the failure of a worker to keep up-to-date. This is the factor that has made *learning to learn* a goal of all precollege education. When one speaks of a dead-end job today the reference is to a nonproductive person.

WORK AND LIFE SKILLS

The revolutionary changes taking place in our culture and society influence the realities of living, learning, and working. These changing forces are also establishing a new framework for research in the sciences. Beginning in October 1997 a National Science Foundation (NSF) science research proposal must indicate how the findings are likely to benefit the economy, social progress, and science education (Durson, 1997; Mervis, 1997). It has been estimated that more than 50% of all employed people in the U.S. today are in jobs related to knowledge and information generation, transmission, storage, retrieval, and use. The number includes all of us who teach, do research, practice science, medicine, or engineering, and seek to improve the natural environment.

Computers and robots have led to a new field of intellectual technology. Robots differ from computers in that they can completely take over routine jobs or serve as working partners, such as the Rover on Mars, assembling of watches, assisting in eye operations, translating documents, and serving as laboratory assistants.

A large factor in the productivity of any worker is one's state of health. The concept of health includes physical, social, mental, and emotional well-being. The new focus in health education is lifelong wellness.

Most of the competencies significant in the workplace cannot be taught directly. Nor can they be acquired in the context of the traditional single-discipline based science curricula. The issue is what kind of science education is required for living and working in both today's and tomorrow's information age. First, the curriculum sought needs to be consistent with the practice and culture of today's science. Second, a cross-disciplinary curriculum is essential. Human, social, and work problems are not discipline bound; they typically have dimensions in both the natural and social sciences. Third, the criteria used to select the science standards are those that have meaning in the contexts of life and the workplace, in other words, a science curriculum that bridges the gaps between the natural and social sciences and the humanities.

To deal with all these dimensions of a problem requires a science curriculum that is focused on the development of intellectual skills. These skills go beyond simply the acquisition of knowledge, they emphasize the utilization of knowledge in productive ways. This approach requires a science curriculum organized in terms of issues, problems, experiments and projects, thus placing the center of critical reasoning in the hands of the student.

Science curricula of this nature are identified as unified, integrated, correlative, core, or general education. These cross or trans-disciplinary approaches are seen as being more productive of human capital than the current discipline-bound science courses. They are also more representative of contemporary science where most research is cross-disciplinary as in neurobiology, biophysics, biochemistry, biogeochemistry and hundreds of other combinations of fields. Human capital is measured by one's ability to access information related to a personal, social, or work problem, synthesizing the information and taking appropriate action for resolving the problem.

A school's responsibility for connecting education with work is focused on the adaptive behavior of the student, not on specific job skills or vocational training. It is recognized that traditional science courses representing discrete disciplines are too fragmented in knowledge and inquiry processes to deal with problems of human welfare, quality of life, careers, and economic and social changes. Here the requirement is higher-order thinking skills, such as the ability to analyze and resolve problems, making decisions, and the forming of rational judgments. These are skills that enable students to adapt to a changing workplace. To accomplish these results requires a multidisciplinary problem-centered science curriculum. An overture to each problem or project is the development of an awareness that these learning skills are also required of a productive worker.

COMPETENCIES FOR LIVING AND WORKING

There is no particular order in listing work and living competencies; all are important in one way or another for a productive life. The desired work competencies listed below are those described by business, and recorded in the Department of Labor SCANS (1992) report, and in a study by Hurd (1989). The competencies are grouped into the following categories as a convenience for working with them:

- Basic Competencies;
- Intellectual Skills in Science Education;
- Management of Information;
- Interpersonal relationships;
- Personal Qualities.

Basic Competencies

- Writing—knows and uses reference works, especially computers; can summarize basic ideas.

- Listening—can accurately reproduce what has been said.
- Speaking—can communicate science concepts and principles verbally in language others will understand.
- English—has fluency skills critical for an information age.
- Math—understands statistics and probability; can calculate weight, volume, area, time.
- Reads and comprehends work manuals and laboratory instructions.
- Finds, analyzes, and interprets diverse sources of information, including one's own experience.
- Has a capacity for reasoning, logically and operationally.
- Is able to learn independently.
- Seeks to identify and formulate problems from complex situations on the job and from life in the real world.
- Recognizes and is prepared to adapt to the continuing evolution of job function and life skills.
- Recognizes the place of computers and robots as components on a job.
- Recognizes that basic intellectual skills are not only important for work but also for the quality of a full life, and essential in preparing for college.
- Is able to maintain a cognitive alertness; a focus on new knowledge.
- Recognizes long- and short-term risks and benefits when making a decision.
- Can work collaboratively in making team or group decisions; works well with others.
- Recognizes ethical considerations in resolving problems.

Intellectual Skills in Science Education

- Works out ways of dealing with problems that result from an integration of science, society, technology, and self.
- Uses procedures or methods characteristic of the contemporary practice of science, such as team work.
- Knows and can use appropriately science concepts that ramify most widely in everyday life including personal, social, and economic affairs.
- Recognizes that there is no one method that represents the practice of science or that or the workplace.
- Recognizes continuous changes in the framework of the sciences that make some fields obsolete while creating new ones.

Management of Information

- Is able to learn both independently and as a team member.
- Knows how knowledge is acquired, synthesized, interpreted, and made productive.
- Can separate fact from opinion, fiction, and superstition.
- Relates new knowledge to existing knowledge in appropriate contexts.
- Interprets data inferentially as well as literally.
- Can express data in various forms, written, tabular, and graphic.
- Can interpret tables, charts, graphs.
- Recognizes most problems in science and life are cross-disciplinary.
- Recognizes that more and more jobs are being taken over by "intelligent" robots.
- Is capable of transforming ideas into productive goals or services.
- Recognizes that human problems are situations for which there are likely to be different courses of actions depending upon perceived values or risks.
- Recognizes that higher order thinking skills and knowledge are the raw materials of commerce.
- Has skills for coping with ambiguity that arises from too much or too little information.

Interperson Relationships

- Is effective as a team member in sharing information, and making group decisions or collaborative judgments.
- Works cooperatively with others, including both sexes and those of diverse backgrounds.
- Can handle conflicting situations and recognizes differences of opinion involved.
- Can explain or summarize ideas in understandable ways to other persons.

- Can put ideas and directions into action on problems.
- Is conscious of differences among people.
- Assumes responsibility in a system-wide search for ways to improve, adjust, and upgrade work tasks.
- Has a sense of self and personal development.
- Is sociable.
- Recognizes changing demands in the workplace and seeks to adjust quickly.

Personal Qualities

- Is work oriented, develops a work ethic.
- Is self-confident, has a positive attitude toward self.
- Is scientifically literate in a civic context.
- Recognizes specific job education as a function of business.
- Has a capacity to assume responsibility.
- Recognizes lifelong learning as human capital.
- Is aware of the financial and social costs of ignorance.
- Is capable and willing to learn new skills.
- Assumes civic responsibilities.
- Respects the rights of others; shows tact and consideration.
- Seeks to maintain a high level of wellness, physical and mental, and is free from substance abuse.
- Recognizes education as a 40-year investment in job security.
- Is able to set life and work goals.
- Recognizes there are many ways to learn.
- Follows instructions, written and oral.
- Is reliable—is on time.
- Demonstrates self-control and works without continuous supervision.
- Speaks the language of one's business career.
- Has honesty and integrity.
- Recognizes the value of knowledge in career demands.
- Is able to use the tools of cyberworld, such as computers and related technologies.
- Works well with people of differing backgrounds.
- Has a sense of inventiveness.
- Is capable of and is willing to change.
- Seeks to resolve problems, pays attention to details.
- Recognizes that most jobs today are more than routine tasks.
- Is sensitive to the ideas of other members of a group or team.
- Offers constructive dissent without hindering team work.
- Recognizes that single task skills do not meet the demands of today's workplace.

The attainment of these competencies requires the cooperative endeavors of parents, business representatives, teachers, and the U.S. government. There is no one best model for this cooperative endeavor. However, there is agreement that the revolutionary changes taking place in all aspects of our society, science, and the workplace call for equally great changes in the education of current and future generations of young people.

SUMMARY

The whole question of work preparation is seen as a purpose of every academic subject from elementary through high school. The largest number of new careers are in business. As one examines the future of the job market, the most certain factor is that it will not be like that of today. It is evident that the vast majority of jobs in the future will depend upon knowledge rather than brawn and mechanical skills. But by itself knowledge is of limited value unless one has the intellectual skills to bring it into action.

Many of these skills are best learned through a science curriculum that involves students in projects, investigations, and problem situation—a lived curriculum. These are activities which in turn call for decision making, forming judgments, or taking action. Opportunities for middle and high school students to have some work experience in local job markets is highly desirable.

As far as people's lives are concerned it is advancements in information technology that are having the greatest influence. Computers, electronic communication systems, office automative, and technological progress are having an increasing impact on the modes of work as well as on people's lives in general. Science curricula developers will need to modify continually the framework of science education to accommodate these changes in the way people learn, work, and live and to which people must learn to adapt.

To sum up, the national demand for a reform of education as a whole is to recognize changes in the ethos and practice of contemporary science, in the nature of our society and culture, and the impact of knowledge and technology on the workplace and the future of our economy. The need to link education and work is essential for the welfare of people and the quality of life. For professional educators these alternations mean the development of a new form of integrated research reflecting the scientific, social, technological, and economic shifts in how we live and work. Plans for these changes are now being widely studied by such organizations as the Center for Occupational Research and Development, 1996; National Center on Education and the Economy, 1995; Satellite Town Meeting, 1995; National Governors' Association, 1992; The William T. Grant Foundation Commission Work, 1988; U.S. Department of Labor, 1988; National Governors' Association, 1987; Committee for Economic Development, 1985; and the National Institute of Education, 1977.

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