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ABSTRACT

Given the importance of technology in our society today, it would seem that the hope for a future in which people are in control of their environment lies in universal technological literacy or, in other words, in the ability to do and use technology instead of just being aware of it. The earliest form of collective arguments for technological literacy stemmed from the industrial arts profession. Educational legislation and the recent series of reports focusing on the improvement of education, however, fail to include any systematic effort to incorporate technological literacy into the mainstream of educational programming. Few models exist that clearly define technological literacy. A comprehensive thrust toward technological literacy will involve the schools, other educational institutions, and the cooperation of radio and television networks, museums, libraries, and other public resources as well as collaborative efforts with the private sector. Educators at all grade levels must alter their curricula to include technological literacy in the curricula for English, mathematics, science, social studies, and the practical arts. It is also necessary to properly address the needs for technological literacy in such support services as personnel development, teacher education, curriculum development, public information, and information networking. (MN)

Information Series No. 266

LITERACY FOR A TECHNOLOGICAL WORLD

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FOREWORD

Literacy for a Technological World defines, explores, and reviews technology and technological literacy. It seeks approaches to the challenges of technology—where humankind is in control.

This paper is one of nine papers produced by the National Center Clearinghouse's Information Analysis Program in 1984. It is hoped that the analysis of information on topics of interest to the field of vocational education will contribute to improved programming. Papers in the series should be of interest to all vocational and adult educators, including federal and state agency personnel, teacher educators, researchers, administrators, teachers, and support staff.

The profession is indebted to Dr. Michael J. Dyrenfurth for the scholarship demonstrated in the preparation of this paper. Dr. Dyrenfurth is Professor of Industrial Education at the University of Missouri-Columbia.

Dr. Warren Groff, Vice President for Academic Affairs, North Central Technical College (Mansfield, Ohio); Dr. Donald L. Joyal, Professor of Managerial and Organizational Behavior, Worcester (Maine) State College; and Dr. Steve Franchak and Dr. Frank Pratzner of the National Center for Research in Vocational Education contributed to the development of the paper through their reviews of the manuscript. Staff on the project included Judy Balogh, Garnet Topper, Dr. Wesley Budke, and Dr. Judith Samuelson. Ruth Nunley typed the manuscript and Janet Ray served as word processor operator. Editorial assistance was provided by Ray Stewart of the Field Services staff.

Robert E. Taylor
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PREFACE

This work is the result of the direct and indirect contributions of a large number of insightful people. Chronologically, I must thank my first mentor Dr. Henry Ziel for sharing his enthusiasm for and insight into technology with me. This began a voyage that I hope will never cease. Important in sustaining this voyage in a myriad of ways, and often unappreciated at the time, are the steady supportive influences exerted by my mother, Inge Dyrenfurth, and my wife Mary. Later Dr. Jerry Streichler taught me to believe in the worth of my ideas, to commit myself to them, and then to test them by deeds. Finally, I could not say enough about the positive influence of the collegial atmosphere so carefully nurtured by my professional colleagues at the University of Missouri-Columbia: Dr. W. R. Miller, Associate Dean of the College of Education; Dr. R. C. Erickson, Chairman of the Department of Practical Arts and Vocational-Technical Education; and Dr. F. M. Miller, Coordinator of Industrial Education. Without their ongoing support, this work and others would simply not be possible.

Important contributions to this project were made by the many professional colleagues I consulted regarding the working outline for this paper.

Dr. Kendall Starkweather
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Dr. Donald Lauda
Dr. Jerry Streichler
Dr. Ronald Todd
Mr. James E. Good
Dr. Keith Blankenbaker
Dr. Lee Smalley
Dr. M. James Ben[illegible]n

These scholars shared numerous useful insights that have allowed me to enlarge and sharpen my vision. Similarly, I owe a large debt to Ibraphim Khaleel whose outstanding research and constructive perspectives contributed significantly to this paper. His work was a labor of love and he deserves the profession's gratitude for it. Because of the provocative nature of this piece, I have tried to be particularly careful to interpret appropriately the thoughts and inputs of all who have been cited, and also of the many whom I could not cite directly. However, the responsibility for the final work is mine and cannot be delegated.

Without the dedicated efforts of my team of work processor editors et al.—Cheryl Perne, Cheryl Fletcher and Denise Gaddis—this document would not have been finished. They all contributed immeasurably with their cheerful diligence and their willingness to question and double-check time and time again. Denise Gaddis especially, as my assistant and right hand, and with her journalistic talents, was particularly instrumental in ensuring the fruition of this challenge.

Finally, my thanks go to the staff of the National Center for Research in Vocational Education for their initiative in commissioning a paper on the topic of technological literacy and for their willingness to publish what I hope will prove to be a provocative work.

EXECUTIVE SUMMARY

The concept of technology has been with us ever since we began to manipulate and seek control over the environment. Today, technology is the very essence of U.S. industry and economic activity.

But, what is being done to help the nation's people adapt to and cope with the changes and demands being imposed by technology? It would seem that the hope for a future in which people are in control of their environment lies in universal technological literacy, or the ability *to do* and *to use* technology—not just to be aware of it.

Given the importance of technology in our society today, the study of understanding technology and its advancement in materials and processing, communication, biomedicine, energy conversion, and power transmission should be incorporated into all students' education. Technological literacy should not be restricted, however, to one subject area or discipline. Instead, each school subject must contribute to the coherent development of a comprehensive technological literacy, according to its content and/or methodological potential.

Finally, in addition to educational programming, aimed at general or vocational needs, support services, personnel development, teacher education, curriculum development, public information, and information networking are needed.

Technological literacy will contribute a vital dimension to the nation. It will give humankind the chance to use this powerful force, rather than to be used by it. Ultimately, it will strengthen the country's economic system and lend to the improvement of the quality of life for all.

This interpretative paper, dedicated to helping technological literacy come about, will—

- probe the context of technological literacy for interactions that have relevence to its understanding;
- present models of technology and technological literacy as envisioned by a variety of practitioners and theoreticians;
- discuss the significance of technological literacy, particularly in light of the central purposes of education and the recent findings of various educational study commissions; and
- present ideas and suggestions to help the educational establishment address the challenges of technology more systematically.

Further, the information provided here would be useful to state and local vocational administrators, policymakers, and interested lay persons, and could possibly influence policy-making and enhance administrative decision making.

INTRODUCTION: THE CHALLENGE

The concept of technology has been with us ever since we began to manipulate and seek control over the environment. The use of technology quickened, however, after the discovery of fire. Fire was used for cooking, comfort, and protection. It served well as an early multipurpose technological tool.

As we extended our knowledge and capacity to manipulate stone, bone, leather, and metal, we developed technology and identified a range of possible applications. The concepts of processes and materials and possibilities and reality were blended to become a powerful force in shaping the futures of humankind.

Technology feeds on science itself, imagination, and audacity! Great thinkers, inventors, and innovators—such as Leonardo da Vinci, Isaac Newton, Albert Einstein, Thomas Edison, and Henry Ford—triggered the cooperative effort that led to exponential growth of technology, knowledge, and capability that people know today and dream for tomorrow.

Today, technology is the essence of U.S. industrial and economic activity. It is the determinant of U.S. military capacity, a significant focus for the recreational activities of millions, the cornerstone of a healthy and desirable future, and the hope for resolving almost all pressing material problems. Technology may even serve as a surrogate religion for some. However, even with the omnipresence of technology, little is being done to help people cope with its demands.

Human resources in the realm of technology have been called "our most neglected asset" (Schaum 1981, p. 39). Norris (1982), the chief executive officer of Control Data Corporation (CDC) projects a job growth of 147 percent for computer maintenance technicians and 107 percent growth for computer systems analysts during the eighties in his industry alone (pp. 2-3).

Given the present and future impact of technology on the nation's standard of living—indeed, on the quality of life—what is being done to help American citizens adapt technology and themselves to the demands of technology?

The hope for a future in which humankind is in control of their environment is based on universal technological literacy. This paper, dedicated to the challenge of helping this advancement come about, will—

- probe the context of technological literacy for interactions that have relevance to understanding it;
- present models of technology and technological literacy as envisioned by a variety of practitioners and theoreticians;
- discuss the significance of technological literacy, particularly in light of the central purposes of education and the recent findings of various educational study commissions; and

- present ideas and suggestions to help the educational establishment address the challenges of technology more systematically.

Definition of Concept and Context

Defining the concept of technology can proceed along at least two distinct routes. The first. and conventional. route would be to list the specifications and details that establish a definitive and mutually exclusive meaning for the concept of technology. The absolutists value such an approach, but the approach seems to lack feasibility when it comes to larger, more significant concepts.

Since technology is a concept of exponential magnitude, it seems impossible to define in an absolutist manner. It would be more feasible to follow the model scientists established when attempting to plot the locations of electrons in the atom. Werner Heisenberg's uncertainty principle prevented the concurrent establishment of absolute location, velocity, and time of electrons. Instead, scientists evolved a probability model that predicted the likelihood of the presence of electrons in a given space at a given time. Similarly, scholars of technology can address concepts of technology based on a probability model. The definitions that follow are intended to serve as a possible core of what ultimately could be agreed upon.

> Technology, defined as knowledge systematically applied to human problem-solving, means software as well as hardware. For example, the social security system and income tax withholding are as much technologies as any hardware system. (Henderson 1977, p. 46)

> Technology [is] . . . knowing *how* to do something from the rules, sometimes from scientific theories, sometimes from pragmatic experience (technic). (Smalley n.d., p. 20)

> Technology is a social process in which abstract economic, cultural, and social values shape, develop, and implement specific artifacts and techniques that emerge from the distinct technical problem-solving activity called engineering which is embedded in that process. (Cutcliffe 1981, p. 36)

The term *technology* is used in several contexts:

a. As a discipline technology is used to denote a field of study in the same way that biology, psychology, or anthropology is used. Technology: the study of the creation and utilization of adaptive systems including tools, machines, materials, techniques and technical means and the relation of the behavior of these elements and systems to human beings, society, and the civilization process.

b. As a system, technology has a meaning ranging from tools and their use to the social impact and influence of tools, technics and products on the lives of particular individuals and groups.

c. Technology is made up of physical elements invented or created by human beings. (DeVore 1980, p. 3)

In fact, Bjorkquist and Swanson (1981) suggest that "probably the clearest, most definite statement about technology is that there is no widely held universal definition of technology" (p.

15). Then they make the following observations about technology and its definition:

> Each definition . . . must be empirically validated and revalidated over time to substantiate the limits of technology. . . . The investigation methods of avant-garde technology educators are to this point largely superficial introspection. What investigative methods will they propose? What are their sources of invalidity? These and other important methodological questions need to be asked and answered. . . . (Ibid.)

Literacy

What does it mean to be literate? Consider the comments by Luehrman, as cited by Benderson in the Educational Testing Service's journal *Focus*:

> Literacy, in a language, means the ability to read and write, that is, to *do* something with a language, not merely to *recognize* that language is composed of words, to *identify* a letter of the alphabet, or to be *aware* of the pervasive role of language in society. . . . (Benderson 1983, p. 5)

Luehrman then claims that computer literacy requires the ability to do computing. Analogously, technological literacy requires the ability to do technology, that is, to use it and not just to be aware of some relevant facts.

Technological Literacy

Rudisill and others (1976) define technical literacy as understanding the technological and industrial basis of working processes. Watkins (1982), however, does not advance such a narrow view. She cites Nannerl Keohane, president of Wellesley College, who says that to become technologically literate, persons "must. . . learn how to think in quantitative and analytical terms, preferably in liberal-arts courses that integrate practical application of mathematics into their subject matter" (p. 1).

Gerald Stashak (1981) points out that technologically literate people will be able to engage in the "intelligent use of technology" (p. 23). They will be better able to—

- contribute to the advancement of technology,
- assess current and future technology,
- control technology, and
- adapt to their changing world.

The following more descriptive meanings were produced by Blankenbaker (n.d.) for the National Industrial Arts Advisory Council:

> What does it mean to be technologically literate? Generally speaking, technologically literate people are able to function effectively in a highly technological society. More specifically, technologically literate people can be expected to—

- understand the relationships among management practices, production/processing practices, and personnel practices as they apply to all forms of economic activity;

- comprehend the function of standard technological hardware;

- understand the interrelatedness of technology, the environment, material resources, societal needs, and individual desires;

- to select and analyze the information necessary to make technological choices based upon appropriate criteria and with respect to a long range, global perspective, and

- to select and efficiently utilize the tools, materials, and processes required in daily life. (p. 2)

Technological Literacy in the Eyes of Its Beholders

Many persons have raised concerns about technological literacy. Industrial arts professionals are prominent among this group. The concept is so prevalent today that even government officials have spoken out on the topic. The Office of Technology Assessment reports that—

> technological literacy will soon be required of all members of the work force, as broader and more extensive applications of information technology are made in offices and plants. Widespread technological literacy may be hard to achieve, however, since about one-fifth of the U.S. population has yet to master the basic skills of reading, writing, and arithmetic. (Gibbons 1983, p. 36)

One of the industrial arts professionals who has explored the concept of technological literacy is Lee Smalley. In his paper "Technology—A Start" (n.d.), he defines technology by relating it to other concepts as shown in table 1.

TABLE 1

TECHNOLOGY'S CONTEXT

Forms of Work	Aims	Consequences
Science	To know why	Themes or laws
Technology	To know how	Rules
Technic	To do or produce	Product or service

SOURCE: Smalley (n.d., p. 20)

Smalley explains his model as follows:

> The science orientation would seem to be standard knowledge; the term technic may be new, but most people will understand that if you do something, you produce something. That leaves technology in the middle: knowing how to do something from the rules, sometimes from scientific theories, sometimes from pragmatic experience (technic). (Ibid.)

Springing from this context, Smalley then defines technology as being the rules for effective action. After pointing out that the concept is usually modified to accommodate a particular endeavor, Smalley lists Halfin's seventeen processes that characterize the work of a technologist. These processes, which first appeared in Halfin's (1973) dissertation are as follows:

- Defining the problem
- Observing
- Analyzing
- Visualization
- Testing
- Designing
- Computing
- Communicating
- Measuring
- Predicting
- Modeling
- Creating
- Questioning
- Interpreting data
- Constructing models
- Experimenting
- Managing

Then, as if echoing Cutcliffe's (1981) concern about what actually occurs in science and social studies courses, Smalley confirms that although "science and social studies might nibble around the edges [of technology], they already have fairly identifiable content sources which do not include technological processes in a meaningful way" (p. 21).

If our population will be using technology, should not the people be literate in it? That is precisely what the ground swell for technological literacy is seeking to accomplish.

Dimensions of Technological Literacy

Based on the weight of technology in our society, the argument is for a systematic study of industry and technology by all youth from elementary school through college (Miller 1970). Such an education makes persons literate in terms of an awareness and understanding of key technological principles. Furthermore, it differs from more abstract efforts at schooling in that students also develop the ability to do or to apply these principles. Whereas, this practical education requires practical, hands-on experiences, it should be noted that students do not have to approach the highly polished skills of the craftsperson.

Attaining technological literacy involves each of the domains of human behavior traditionally used to encompass the goals of schooling. Cognitive, affective, and sensorimotor goals are all well represented in the literature addressing technological literacy. However, proponents for technological literacy from the liberal arts community give cause for concern by sometimes forgetting or minimizing the need for practical applications

Reasons why educators need to attend to technological literacy in our formal and informal education systems have been recognized. As listed by Gibbons (1983) and Blankenbaker (n.d.), these reasons are—

- to develop an adaptable labor force.
- to facilitate adjustments to technological change.
- to increase productivity.
- to increase our entrepreneurial capacity and opportunity to capitalize on technological development.
- to contribute to career awareness and decision making in technological areas.
- to improve decision making as involved in one's responsibilities as a citizen.
- to enhance personnel effectiveness and consumer efficiency.
- to increase occupational effectiveness and range of opportunities, and
- to strengthen our usefulness to the defense establishment.

Given the wide scope of technology, the varied purposes of education, and individual perspectives, not all persons need to be technologically literate at the same levels. Because of this proponents of specific programs for developing technological literacy must consider the content, focus, and scope of technology being addressed, the age and experience of the person, and the level of that person's need.

ANALYSIS OF TECHNOLOGICAL LITERACY

At the 1933 Chicago World's Fair, John Norton's mural depicting the tree of knowledge had basic sciences as its roots and the industrial application of science as its fruits. The World's Fair's motto—"science finds, industry applies, man conforms"—implied that technology is applied science (Kranzberg 1983). Although Kranzberg acknowledges cases for which this relationship exists, he disputes the necessity of having the application of science be the sole criterion for deciding whether something is technology. Consider his remarks at the recent conference to commemorate the fiftieth anniversary of the Chicago Museum of Science and Industry:

> For much of history, science and technology were two separate activities, carried out by different communities who rarely came into contact with one another; they used different methods and sought different goals. (p. 8)

Kranzberg points out that such technological determinism, in which "technology is the prime factor in shaping our values, our institutions and other elements of our society" (ibid.) is not accepted by all scholars. One opposing view that he cites is Lynn White's—"Technology opens doors; it does not compel one to enter." White sees technology as an enabling mechanism, a means by which man is free to employ as he sees fit.

Concepts of Technology, Literacy, and Science

Can technology be defined? Bjorquist and Swanson (1981) claim that "there is no widely held universal definition of technology" (p. 15). However, scholars of technology have identified essential elements that are the nucleus for a universal definition. For example, the ideas of Lux and Norris seem widely shared.

> Technology *practicas* in order to test or refine theories of efficient action, which can only be derived from practice. *Knowledge* (ology) of *practice* (techn) is technology. (Lux 1983, p. 1)

> I use the words "technology" and "know how" interchangeably. I use the broad definition in order to relate technology to the everyday experience of people and help them gain broader understanding. (Norris 1980, p. 2)

A more detailed look at the definition of technology is provided by Mary L. Good (1983) in her remarks at the Critical Issues in Science and Technology Conference, sponsored during the occasion of the Chicago Museum of Science and Industry's fiftieth anniversary celebration.

> The best definitions I have seen . . . were put forward by Stephen White in a paper entitled "The New Liberal Arts". . . . These definitions clearly indicate the role of science in providing a base for technology and it hints at the most important aspect of technol-

ogy development, the process of innovation or the process by which technology becomes a part of our life style. (p. 1)

Writing about the concept of technology, Harvey Brooks (1980) and Hannay and McGinn (1980) assign these characteristics to technology:

- Centralization/decentralization tension
- Complexity
- Consumer sovereignty vs. complexity struggles
- Environmental solutions and externalities
- Procedural systems
- Relations between modern technics and users
- Scale
- Significant impact on western society
- Standardization
- System's context
- Ubiquity

In marked contrast to others who have dealt exclusively with technology's impact on society, these writers brought attention to the reverse impact of society on technology. They portrayed the following control mechanisms:

- Technology assessment
- Judicial resolution
- Environmental context
- Political context
- Market context
- Financial context
- Social context

Literacy

Background information on literacy is found in *A Bibliographic Guide to Functional Literacy* (Reder, Walton, and Green 1979). This set of annotations includes a reference to Goody and Watt's "Consequences of Literacy." The Goody and Watt annotation, like others in the *Guide*, established an overview of the premises central to the literacy and also provided a means to ascertain the theories set forth by thinkers in that field.

The Goody and Watt annotation in the *Guide*, for example, describes consequences of literacy as follows:

> Goody and Watt . . . argue that the relatively widespread adoption of literacy had pervasive effects on Greek culture (and, by implication, on numerous other Western societies which later adopted the Greek model of literacy) . . . they stress its impact on the development of logic and history as new modes of inquiry and analysis. (pp. 50-51)

Carrying the consequences of literacy further, the assemblers of the *Guide* also present a summary of Havelock's "Origins of Western Literacy" in another annotation:

> In tracing the impact of literacy on . . . Western culture, Havelock speculates . . . as literacy spread, it progressively "freed" the human mind from the burden of memorizing all

> important information. The "mental energies" were then available for new modes of inquiry and analysis. The production of novel or unexpected statements . . . encouraged the development of novel ideas, upon which the advance of all human and scientific knowledge depends. (p. 50)

Beginning with the conventional concept of literacy, Hunter and Harman (1979) in *Adult Literacy in the United States*, differentiate between it and functional literacy.

> Conventional literacy is . . . the "ability to read, write and comprehend . . . familiar subjects and to understand whatever signs, labels, instructions and directions are necessary to get along in one's environment." Functional literacy is "the possession of skills . . . to fulfill self-determined objectives as family and community members, citizens, job-holders. . . ." (p. 16)

Just how far the concept of literacy has shifted from merely reading and writing is shown in a Harris (1970) poll that defined literacy as "the ability to respond to practical tasks of daily life" (p. 10).

A common thrust in all literacy efforts points to the learner as the chief beneficiary of the experience. Along this vein, Paulo Freire developed a concept that he called "conscientization." Accordingly, he suggested that learners become conscious of their environment and change it to meet their needs (Reder, Walton, and Green 1979).

Extending this concept further, the Adult Performance Level Project (APL)—as annotated in the *Guide*—was designed to "'specify the competencies which are functional to economic and educational success in today's society and to develop devices for assessing those competencies in the adult population of the U.S.' The APL Project defined functional competency as a broader construct than a functional literacy" (p. 11).

M. James Bensen, Dean of the School of Industry and Technology at the University of Wisconsin-Stout, has observed the shift in meaning from the traditional definition of reading and writing. In personal correspondence with the author dated June 20, 1983, Bensen noted that because of a recognition of what is needed to function in our society, some persons have shifted from use of the term *literacy* to *operacy*. In addition to the general knowledge that everyone should possess, the concept of operacy encompasses a set of capacities that everyone should have in order to be able to *do*. In short one should—

- know enough not to be intimidated,
- know critical factors about acquiring equipment for home or work,
- know how to evaluate applications to identify helpful and harmful ones, and
- be able to apply these knowledges to basic technological tasks commensurate with one's needs.

Science Distinguished from Technology

Lux (1983) created an industrial arts program that encompassed an entire curriculum development sequence. Beginning with the establishment of a philosophical base, he observed that technology and science are clearly distinguishable. Citing Kranzberg, Lux points out that "scientists concern themselves chiefly with the problem posed by sciance, not by technology" (p. 4), and that technology similarly springs from old technology and not from science. Further, "with the practice must go the theory of that practice" (p. 11).

In his analysis of science, technology and society (STS) programs, Cutcliffe (1981) spoke to an interesting finding at the Technology Education Symposium II. He stated that "very few STS courses directly address the issue of technological 'literacy.' That is, few STS courses seek to preserve the central elements of engineering, seek to explore in detail the distinction between technology and engineering" (p. 36).

Lux (1983) also recognized that "technology is seldom an organized part of the science curriculum and seldom do the science laboratories provide the tools, equipment, and materials to support adequate or even minimal instruction in technology. Further, few science teachers have had even the remotest contact with engineers or technologists, just as industrial arts teachers typically have weak backgrounds in science" (p. 5).

However, Lux's observation is mild compared to Snow's in his earlier work "The Cultures and the Scientific Revolution." Here Snow says, "Pure scientists have . . . been dim-witted about engineers applied science. . . . Their instinct . . . was to take it for granted that applied science was an occupation for second-rate minds" . . . (ibid., p. 1). Reflecting upon Snow's statements, Lux comments, "Clearly, 'science and technology' are the buzz words of the moment, and maybe the time is ripe to realize the aspirations which Snow sought a quarter of a century age" (p. 2).

Computer Literacy Versus Technological Literacy

What is computer literacy? As with technology education, the definition is considerably different than practice. It is significant that even the computer establishment is beginning to raise questions about what is being done in the name of computer literacy.

Marc Tucker, director of the Project on Information, Technology and Education, is cited in a *Wall Street Journal* article asserting that "what's going on in the majority of schools in the name of computer literacy is misguided" (Shaffer 1983, p. 27). Writing in the American School Board Journal, Tucker (1983) elaborated on his concern:

> People probably will tell you that the way to make students technologically competent is to buy microcomputers. . . . Computers ultimately might be an important part of the solution to the problem of productivity and technical competence, but not too soon . . . they never will be a silver bullet that makes the agonizing choices unnecessary. (p. 32)

Whereas most computer literacy programs concentrate on teaching programming skills, a more enlightened view of computer literacy is to teach applications, for example, how to use computers. In general courses, this application focus means being able to use computers for word processing, graphics, spreadsheet preparation, database searches, and communications. Because computers are even more powerful when interfaced with other technological hardware, computer literacy must also involve the use of computers to control equipment at work and in the home.

Computer literacy is important today and will be important tomorrow. However, even with the ubiquity of microprocessors, the advocates of computer literacy must learn their place in the rightful order of things. Computers are but one part of the technological species. Technology is not a part of computing, rather computing is an aspect of technology. Given this relationship, the concept of technological literacy subsumes computer literacy.

The History of Technological Literacy

As stated before, a variety of scholars have addressed the topic of technological literacy. The earliest were philosophers and utopians who argued that people needed a broad understanding of the world and its primary forces in order to live intelligently. However, these authors did not use the term *technological literacy*. Nor did they focus on the critical dimension of this concept, namely the ability to do. The ability to do is the distinguishing feature of technological literacy. Anyone who is technically literate not only knows why, but is also able to apply that knowledge.

The earliest form of collective argument for technological literacy known to this author stemmed from the industrial arts profession. Beginning with the publishing of Warner's early work: *A Curriculum To Reflect Technology* (1965), the field's references to the topic increased rapidly in the seventies. Most of these began with a nationally funded forum entitled "Man/Society/Technology Forum." Shortly thereafter, the American Industrial Arts Association changed the name of its journal to *M/S/T* to reflect this same theme.

In some of the Sputnik-triggered National Defense Education Association science institutes, this concept must also have been raised. The history of educational programming in science and philosophy is filled with efforts to teach the interaction of science, society, and human values. Did such programs teach about technology—or did they teach the practice of technology?

Legislative Traces

In recent years, many bills have been introduced that deal with the topic of science and technology. However, legislation has resulted in little systematic effort towards a nationwide educational thrust to incorporate technological literacy into the mainstream of our educational programming at elementary, secondary, and postsecondary levels.

With the many titles under the old Elementary and Secondary Education Act, would not that have been the ideal means for fostering an education program which reinforced the very aspect that built our nation's economic system? What about the National Science Foundation bills? Could scientists have demonstrated their conviction at that time? Quite simply, scientists did not deem the study of technology important until the weight of public opinion and the force from two generations of neglect were so great that they could no longer ignore it.

Emergence in National Reports on Education

Our educational crises have also triggered a series of national reports that all focus on the improvement of education, mainly at the secondary level. In general, all of these call for increased educational rigor, respect, and remuneration for teachers, and higher expectations for student achievement.

Also clearly called for is a core of studies that might be termed the "new basics." But not all the reports agree upon this point. Goodlad's (1983) perceptive study and Boyer's (1983) report to the Carnegie Commission for the Advancement of Teaching both call for technological literacy by name. The National Research Council's *Educa'on for Tomorrow's Jobs* (1983) strongly implies a need for technological literacy. However, the National Commission for Excellence on Education in its report. *A Nation at Risk* (1983), conspicuously avoids any mention of technological literacy, as does the Education Commission of the States' published report, *Action for Excellence* (1983), prepared by the Task Force on Education for Economic Growth. Comments about technology's presence, challenges, and demands are dramatically infused throughout the Task Force's report, but it does not present the obvious links between its findings, conclusions, and recommendations.

Models of Technological Literacy

Few models exist that clearly define technological literacy. Much more prevalent is the outline of some prominent features of technology and the subsequent inference that "people need to know about it"—it being the content referred to in the models. For example, a survey of prominent writers conducted by the author resulted in the following suggestions for the components of technology:

- Alternatives
- Computer literacy
- Control of technology
- Creations
- Decision making
- Feedback
- Improvement
- Information
- Innovations
- Modeling
- Optimizing
- Potential impact (assessment)
- Stability
- Systems
- Technological futuring

Ongoing discussions in the Technology Symposiums, conducted by leading technology proponents from the industrial arts profession, presented similar singular views. A retrospective and cross-sectional analysis of all the symposia would have generated a much more coherent, but unfortunately inaccessible, view of technology and technological literacy.

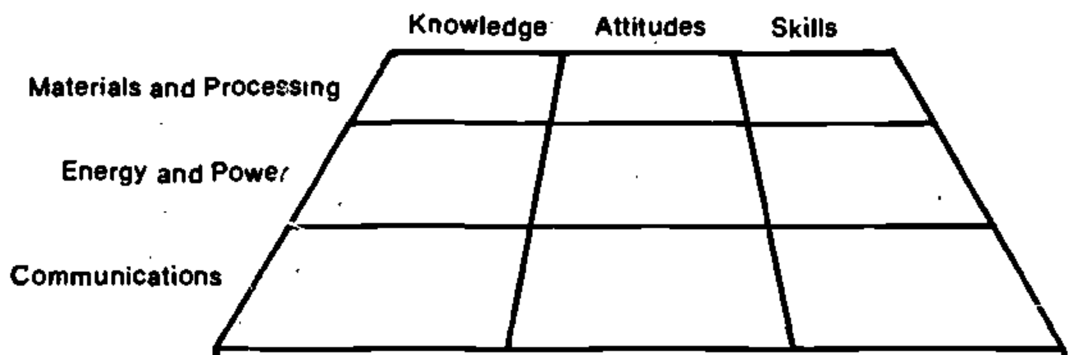
An Initial Approach

Despite extensive work in technology, very little has been done to address the challenge of designing educational programs that will instill technological literacy in our nation's youths and adults. A model (see figure 1) originally published in *VocEd* (Dyrenfurth 1983) acts as a stimulant for discussion and as a reference to approach that problem. Furthermore, it attempts to delineate the industrial technology subset of technology.

It is clear that there are numerous application arenas for technology, such as medical, military, commercial, agricultural, and industry. If a comprehensive model for technological literacy were to be developed, the technology components would have to be identified and arranged.

This would be a formidable task, and one not to be undertaken by those with limited life expectancies or funding. Typically, to reduce their task to a manageable size, careful curriculum developers define some of the possibilities as being "outside their scope." For example, developers of industrial arts curricula, despite protests from a vocal faction of technology educators, have often stated that because of their mission, their focus would be on *industrial* technology, that is, the means by which industry produces and disposes of its goods and services.

Table 2 shows how selection of a "specialization," such as industrial arts, seriously restricts



Components of Literacy

- Awareness of key processes and their governing principles. (What is it and how does it work?)
- Understanding of essential relationships among key principles and areas of technology.
- Comfort with basic technological hardware. (Willingness to use and capability of using tools, machines, and materials.)
- Ability to conceptualize how an unfamiliar technological process or machine operates.
- Imagination to apply existing technology to new problems or situations.
- Sense of personal limits. (When to call in an expert.)
- Familiarity with technology's effects on individuals and society.
- Ability to evaluate a technological process or product in terms of personal benefit as a consumer.
- Ability to choose among technological alternatives in daily life.
- Insight as to the relationship between careers and the technological future.
- Ability to project alternative futures based on technological capacities and applications.
- Knowledge of technological information accessing methods and sources.

SOURCE: Adapted from Dyrenfurth (1983, p. 43).

Figure 1. An initial model for technological literacy

TABLE 2

THE CONTEXT OF TECHNOLOGY

Categories of Knowledge	Characteristics or Foci	Application Arenas
Religion	Divine wisdom	Theology • • •
Science	Nature and its explanation	Chemistry Physics • • •
Technology	Doing, applying principles in solving practical problems	Annihilation Healing Industry Agronomy • • •
Philosophy	Systematic thought	Metaphysics Epistemology Logic Ethics • • •
Social Science	Behavior	Sociology Psychology Pedagogy Andragogy Anthropology • • •

NOTE: A preliminary and tentative view of the context of technology is shared in the illustration. It presents a series of major categories of knowledge. (Human endeavor is in the left column.) The key characteristic or focus of this endeavor is listed in the middle column. Finally, the application arenas are listed in the right column. In each column, the items listed are intended to be illustrative rather than exhaustive. This model provides the background that could be used when restricting the scope of development work to one of the arenas of technology.

the scope of the ensuing literacy. But selecting a single area, as those in column one of table 2. does make development of a program much more feasible, although it still is a large and challenging task.

The model's third component, headed by "Application Arenas," presents a slate of outcomes that should occur if a person chooses to become technologically literate in a particular field. The model presents the interaction of—

- the range of possible types of educational outcomes,
- a view of technology, and
- the concept of technological literacy.

The following steps illustrate the use of this model:

1. Begin by asking—with respect to the first statement on the vertical plane and the first component of technology—the following questions:
   - What cognitive outcomes do I expect from students?
   - What affective outcomes do I expect from students?
   - What sensorimotor outcomes do I expect from students?
2. Then, still focusing on the first statement, repeat the process for the second (energy and power), and each successive component of technology.
3. After completing steps one and two, continue these interactions with each successive statement defining literacy.
4. When finished, you will have delineated a comprehensive and complete set of goals that determine exactly what technological literacy means in your context.

IMPLEMENTATION AND DELIVERY

After attempting to ignore technology education for generations, scientists—particularly science educators—are clamoring for a role in developing scientific and technological literacy. Despite the general absence of any significant study of technology, conventional wisdom has policymakers and local, state, and national bureaucrats pushing the concepts upon the science educators.

Lost in the frenzy of the action is the distinction between science and technology—a distinction that should ensure collaboration and a significant role for vocational, technical, and practical arts education programs. The capabilities of these fields in terms of actually developing technologically relevant capacities (as contrasted to mere awarenesses or knowledge) seems to be overlooked. Also overlooked is the industrial arts profession's engagement of forty-plus years with the concept of technological literacy.

However, despite that early start by industrial arts, no profession owns exclusive "rights" to technology education. Technology's impacts are not restricted to one subject area or discipline. Each school subject must contribute to the coherent development of a comprehensive technological literacy, according to its content and/or methodological potential.

Despite these facts, the mathematics and science contingent wants the technology education thrust more than other disciplines, and it seems that the decision makers will give the thrust to them. Whether or not this development transpires, the process of incorporating technological literacy into the formal and informal educational systems must be approached methodically to ensure that a comprehensive system is developed. Learning activities and experiences will need to be deliberately designed and carefully installed into the daily experiences of students. The program activities (depicted in figure 2) will need to include carefully planned experiences that present a comprehensive overview of technology. This aspect will undoubtedly be the most challenging in terms of both design and delivery.

Only after students have absorbed the comprehensive overview of technological literacy should they experience the more narrowly focused programs. Programs that focus on a subset of technology can make valuable, second order contributions to technological literacy. The traditional, nonoccupationally specific school subjects of science, social studies, industrial arts, home economics, and the practical arts components of business and agricultural education, for example, can make useful contributions to technological literacy within their scope. They will continue to be important.

A comprehensive thrust toward technological literacy will involve the schools, other educational institutions, and the cooperation of radio and television networks, interactive video and cable networks, museums, libraries, and other public resources. In addition, collaborative efforts with the private sector must be considered.

To date, coordination and continuation among various delivers are not common attributes in our efforts to attain technological literacy. Programs to develop technological literacy will also

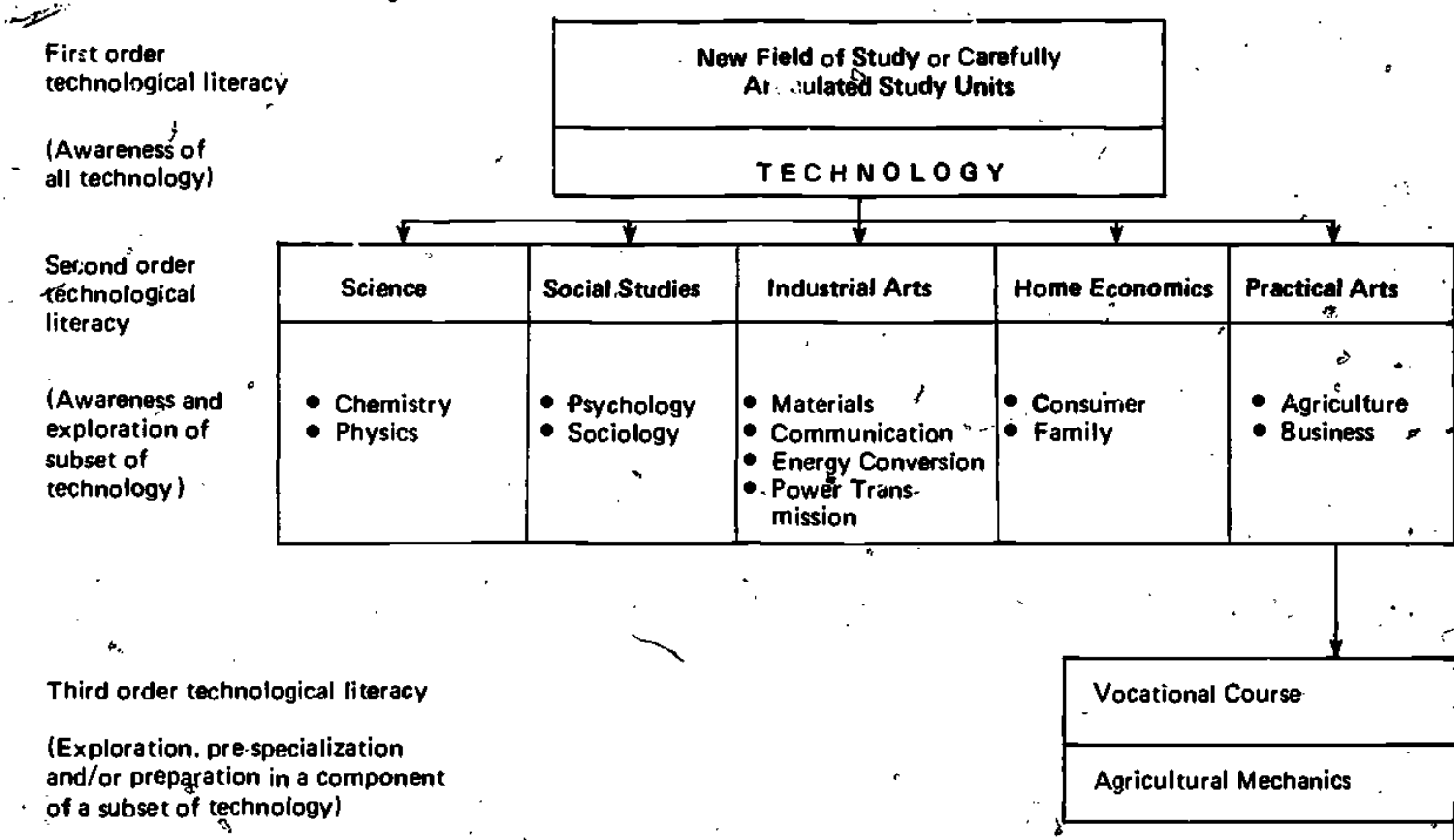


Figure 2. Orders of technological literacy goals

need to be carefully coordinated and articulated in order to achieve the desired first, second, and third order goals. Additionally, because significant educational achievements cannot be attained by means of a "quick fix," the thrust toward technological literacy must be ongoing.

First and Second Order Contributions to Technological Literacy within General Education

The following examples represent a few of the many programs that could be mounted in the quest for technological literacy. Note, for example, the broad mandate presented by first and second order goals of technological literacy as shown in figure 2.

In correspondence with the author dated September 16, 1983, Robert Haavind, editor in chief of *High Technology* magazine, identified his broad concern for addressing what he termed "rampant technical illiteracy in our society." In his correspondence, Haavind also cited a discussion he had with Simon Ramo, a prominent industrialist.

> The general public does not understand the process of identifying a problem, gathering data, developing alternate solutions. . . . It is not the technical details that are so critical; it is the willingness to accept baseless substitutes for this approach. . . . The public needs a sense of where technologists fit into this process, their methods, and their limitations.

A mandate so broad requires educators to incorporate technology education into the common core of learning experienced by all students. This requirement amounts to the bulk of the elementary, junior high, and middle schools altering their curriculum to include technological literacy in the curricula for English, mathematics, science, social studies, and the practical arts.

Science

Science instructors will need to infuse and highlight the technological capabilities relevant to the theoretical concepts for their discipline. They will need to integrate experiments that will have students working with real objects in which technological applications can be observed. For example, inserting pins of different metals into a lemon may demonstrate the principles of corrosion. A road salt solution into which different bridge and/or car body metals are immersed would demonstrate the same principle but with a critical difference—the latter approach represents a practical application of the principle that specific elements affect certain items (in this case, metals) in separate ways.

Industrial Arts

Industrial arts can also make significant contributions to the first and second order goals of technological literacy. To address first order goals, industrial arts must join with other subjects to develop its part of a comprehensive overview of technology. Industrial arts can address second order goals on its own. In both cases the contribution of industrial arts will focus on the subset of technology known as industrial technology. Because of the unique industrial arts laboratories available, instructors can easily make students aware of and allow them to explore the technologies involved in materials processing, energy conversion, power transmission, and communications. In doing so, students will invariably engage in the activities of problem solving, designing, producing, constructing, experimenting, and observing—all with a extensive hands-on experience. These activities reinforce the basic skills learned in industrial arts and other subjects.

Postsecondary Programs

Postsecondary education also has much to contribute to our nation's quest for technological literacy. For example, science, technology, and society (STS) courses—the majority of which are offered by liberal arts colleges and by humanities and social science departments of engineering institutions (Cutcliffe 1981, p. 36)—have the potential for infusing technological literacy intc the mainstream of postsecondary education. However, two prerequisite actions are needed: (1) to modify the STS courses to include a set of practical, hands-on experiences that directly focus on the first and second order goals of technological literacy and (2) to replicate the successful courses in all institutions of higher education: community, junior, and technical colleges, four-year colleges and universities, and advanced graduate institutions. One or more of these modified courses should become a required part of the general education core that most institutions have established.

Creative possibilities for teaching technological literacy at the postsecondary level already exists. For example, the New Jersey Institute of Technology's (1980) Man & Technology Bachelor of Science Degree Program represents one new alternative. A recent announcement proclaimed:

> Designed to bring together studies in technology and science with the humanities and social sciences, the program provides its students with a broad liberal arts training and a basic familiarity with the technology that is found everywhere in our modern society. . . . (p. 1)

Second and Third Order Contributions to Technological Literacy within Specialized Education

The editor in chief of the *T.H.E. Journal* (Technological Horizons in Education), Sylvia Charp (1982), stated:

> The United State's lead in technology is threatened by the significant investment that other nations are making in research, development, and education. It is to the educator the task falls to insure that . . . qualified people are available. . . . Employers are . . . providing their own . . . training due to the lack, inadequacy, or unavailability of current training. (p. 8)

Michael Usdan (1983), with the Institute of Educational Leadership, George Washington University, Washington, D.C., in testimony to the Senate Subcommittee on Education, Arts and Humanities, pointed out the shifts in labor needs and the implications they have for vocational education. He commented:

> Vocational education is too significant and all-encompassing not to be embedded in the mainstream of our educational system. Academic skills are as essential as technical or specific job related skills if an individual is to receive an adequate vocational education. (pp. 3-4)

Vocational Education

Recent vocational education responses to society's demands for technologically literate and technologically skilled people have concentrated on the high technology area. Typically, the new high-tech vocational education courses in robotics, electronics, and cable television teach only specific skills. Omitted is an understanding of where specific learned technological capabilities, such as the ones mentioned, fit into the overall system of technology. Eliminating those omissions will enable students to gain a complete understanding of technological literacy and, upon entering the work force allow them to be more flexible when dealing with adjacent or new technologies. While extra effort and time are required, the results are rewarding.

Recognizing the difficulty in using specific traditional occupational programs to address current challenges, the Center for Occupational Research and Development (CORD) proposed a model for secondary school vocational education. Shown in figure 3, the model seeks to remove some traditional skills from the vocational curriculum and to substitute a broad base of technological concepts and principles. Students gain a fundamental understanding of the concepts, principles, and systems they are studying through hands-on experience (p. 7).

The pedagogical strength of this approach—the way it would put into practice the fruit of the research on learning, namely that students *learn what they do* in school—is evident in the one four-week strategy as shown in figure 4. Each week would be spent studying one system—mechanical, fluidal, electrical, or thermal. Discussions, lab demonstrations, and video tapes would be provided on the first two days of each week. The third day, students would practice the analytical applications of the technical concepts and principles. The last two days would be spent in the laboratory where the student would build, observe, operate, test, and measure the physical phenomena under study. (p. 6)

Labor Education

Specialized education within the school is not the only area that needs to give attention to technological literacy. Both private sector and government initiatives toward technological literacy are likely to yield positive results. For example, Chamot (1981) in "Technology: How Europeans Cope," an article in the *AFL-CIO Federalist*, notes that "another problem widely shared by unions . . . is the need for improving the technological knowledge of our members and staff (p. 14).

Necessary Correlates

Educational programming directly aimed at general and vocational education clients is not all that is needed to address properly the needs for technological literacy. Support services, including personnel development, teacher education, curriculum development, public information, and information networking are also necessary. In addition, technological equipment in all our educational facilities is necessary. Norris (1982), has noted that "skills of today become obsolete tomorrow, and investment in retraining is required" (p. 13).

Personnal Development

Personnel development will become a pivotal factor in determining whether we will be successful in our quest for technological literacy. "Rapid technological change has placed great strain on educators as they attempt to adapt instruction to the requirements of new technology, while at

ELEVENTH GRADE VOCATIONAL UNITS	TWELFTH GRADE VOCATIONAL UNITS
CURRENT EMPLOYABILITY SKILLS	**CURRENT EMPLOYABILITY SKILLS**
•COMPETENCY-BASED INSTRUCTION IN SPECIALIZEO SKILLS FOR: OPERATION MAINTENANCE REPAIR FABRICATION TESTING •KEYBOAROING •SHOP SKILLS	•COMPETENCY-BASED INSTRUCTION IN SPECIALIZED SKILLS FOR: OPERATION MAINTENANCE REPAIR FABRICATION TESTING •COMPUTER LITERACY
PRINCIPLES OF TECHNOLOGY	**PRINCIPLES OF TECHNOLOGY**
•UNIFIED TECHNICAL CONCEPTS •MECHANICAL, THERMAL, ELECTRICAL, AND FLUIOAL LABS •PROBLEM-SOLVING (MATH) LABS •HI-TECH CAREER FAMILIARITY	•UNIFIED TECHNICAL CONCEPTS •MECHANICAL, THERMAL, ELECTRICAL, ANO FLUIDAL LABS •PROBLEM-SOLVING (MATH) LABS

SOURCE: Adapted from Center for Occupational Research and Development (1983, p. 4)

Figure 3. Secondary-level high-technology programs curriculum outline

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
WEEK 1	5-MINUTE VIDEO-CONCEPT INTRO 7-MINUTE VIDEO—MECHANICAL APPLICATION OF CONCEPT DISCUSSION	HARDWARE DEMONSTRATION ON MECHANICAL APPLICATION OF CONCEPT DISCUSSION	PROBLEM SOLVING (MATH) LAB	HANDS-ON LAB—MECHANICAL APPLICATION OF CONCEPT	HANDS-ON LAB—MECHANICAL APPLICATION OF CONCEPT
WEEK 2	7-MINUTE VIDEO—FLUIDAL APPLICATION OF CONCEPT DISCUSSION	HARDWARE DEMONSTRATION ON FLUIDAL APPLICATION OF CONCEPT DISCUSSION	PROBLEM SOLVING (MATH) LAB	HANDS-ON LAB—FLUIDAL APPLICATION OF CONCEPT	HANDS-ON LAB—FLUIDAL APPLICATION OF CONCEPT
WEEK 3	7-MINUTE VIDEO—ELECTRICAL APPLICATION OF CONCEPT DISCUSSION	HARDWARE DEMONSTRATION ON ELECTRICAL APPLICATION OF CONCEPT DISCUSSION	PROBLEM SOLVING (MATH) LAB	HANDS-ON LAB—ELECTRICAL APPLICATION OF CONCEPT	HANDS-ON LAB—ELECTRICAL APPLICATION OF CONCEPT
WEEK 4	7-MINUTE VIDEO—THERMAL APPLICATION OF CONCEPT DISCUSSION	HARDWARE DEMONSTRATION ON THERMAL APPLICATION OF CONCEPT DISCUSSION	PROBLEM SOLVING (MATH) LAB	HANDS-ON LAB—THERMAL APPLICATION OF CONCEPT	HANDS-ON LAB—THERMAL APPLICATION OF CONCEPT VIDEO REVIEW OF CONCEPT

SOURCE: Adapted from Center for Occupational Research and Development (1983, p. 7).

Figure 4. Four-week presentation strategy for one technical concept

the same time they address other changes in instructional needs" (Gibbons 1983, p. 32). Systematic inservice efforts will be needed to bring instructors at all levels, including teacher educators, to a point where they will be more comfortable with technology.

Understanding technology and its components should be the first goal of personnel development efforts. The second will involve the development of a repertoire of practical, technology-based learning experiences and activities relevant to the instructor's field. Finally, and perhaps the most necessary component is to install mechanisms that will permit the updating of each instructor's technological knowledge on an ongoing basis.

Norris (1979) also pointed out that CDC has developed a worldwide, computer-based technology exchange service that permits buyers and sellers to match their needs. Could this not serve as a base that might be adapted to the continuing education needs of America's instructors?

Teacher Education

Teacher education is not exempt from the aforementioned need for personnel development. Faculty must participate in an equal manner. Additionally, there will be a need for structural changes in the composition of teacher education programs and a need to increase significantly the level of expectation within all teacher education courses.

In light of technology's demands, as well as the findings of the recent national educational study commissions, it seems appropriate to increase the proportion of subject matter course hours and to decrease the number of nonmajor, general educational foundations and methods courses. Similarly, for those educators charged with the responsibility to develop technological literacy, at least one solid fundamentals and applications course in physics, chemistry, and mathematics should be required.

If all of this cannot be accommodated within the traditional four-year program, educators will need to consider a five-year program. Before doing so, however, the profession might consider the possibilities of raising the quality and quantity of work required in each current teacher education course including the addition of the suggested science and application requirements.

Research and Development

Substantial research and development efforts must be funded to support the programs called for throughout this publication. Initial efforts could be to convene a well-qualified and nationally representative group to develop one or more models of technology, and then to use those models as a base from which to operate. Validation of these products would logically follow.

Once this intellectual base is established and widely disseminated, a far-reaching curriculum development effort will be needed. This effort will need to incorporate many of the sound practices that the previously described Principles of Technology model implemented. To prevent a loss of time—a critical factor when dealing with fast-paced technology, and also a factor that can drain dollar and talent resources—this curriculum development effort will require a significant amount of national coordination. In order to secure this level of coordination, elementary, secondary, vocational, and higher education state departments will need to defer some of their autonomy in the interest of efficient and effective progress toward the goal.

The new curriculum effort might well begin with the aim of identifying the clusters or subsets that together comprise all of technology—in the same way that the career education movement led to the fifteen United States Office of Education occupational clusters representing a system encompassing all jobs. Each technological cluster would contain a continuum of skills, knowledge, and attitudes that range from the most basic application of its principles to the highest skill level.

Additionally, as efforts are made in developing a comprehensive technology curriculum, the basic tenets outlined in CORD's prospectus "Principles of Technology" (1983, p. 5) should be considered. These have been modified here to make them applicable in all fields:

- Existing teacners must be able to teach the new curriculum with a minimum of additional training.
- The new curriculum must utilize existing classroom laboratory and shop facilities as much as possible to minimize the need for physical plant modifications and specialized lab equipment.
- The sequence of instruction must be composed of relatively independent modules that allow instruction to be scheduled as appropriate for whatever amount of time can be made available.
- The new curriculum materials should provide students with the practical, hands-on learning experiences that are the unique strength of technology education.
- The curriculum must strenthen students' mathematics and problem-solving skills as they relate to technological principles and careers.

More is needed than just curriculum research. To be objective in the task, it will be necessary to develop and validate instruments and procedures for measuring technological literacy and its components. Ultimately these instruments will need to be standardized. It may even be possible to incorporate technological literacy scales in such widely used tests as the SAT, the Iowa Tests of Basic Skills and the Iowa Tests of Educational Development, and others of the same genre.

Consciousness Raising

The last point necessary to address in order to properly implement and support programs that develop technological literacy is the general consciousness level of the American populace. Efforts to achieve technological literacy will fail without public support. Along with public service advertisements, an ongoing television series, presented from several different perspectives [similar to Burke's (1978) *Connections*], will be needed. Satellite distribution and cable will increase their accessibility even further.

Programs should also be designed to address the special needs of students and other learners in a variety of settings. Perhaps specially targeted campaigns could be tailored to raise the consciousness of our legislators, business managers, and education administrators—all will be making decisions involving technology education. With existing technology and information networking for these target groups, technological literacy will definitely be feasible.

RECOMMENDATIONS

The rapid changes in technology in this country and our citizens' lack of technological literacy are causes of concern in the areas of education and government. But at the same time there is much cause for hope, particularly when one sees the insightful points raised by private sector and public sector observers. Study commissions are recognizing the need for instituting programs that thrust technology into the educational mainstream. There is a greater awareness of technology on the part of journalists, and legislators are beginning to recognize education's needs.

As Norris (1979) observed, "All technology is in part a product of our education system" (p. 14). By moving in the directions outlined in this paper, education will increase its capacity to contribute a vital technological dimension to the nation's human resources. This contribution will help this country strengthen its economic system, enable its citizens to defend themselves better and more intelligently, and allow them to improve their quality of life. If persons apply themselves diligently to the challenges of developing technological literacy in a myriad of concerted ways, humankind will succeed—they will have a chance to use technology rather than be used by it. Time is of the essence—as Ferry (Lauda and Ryan 1971) points out so dramatically:

> the coming generation will be the last generation to seize control over technology before technology has irreversibly seized control over it. A generation is not much time, but it is some time. . . . (p. 294)

The problem of technological literacy is bigger than any one of the educational disciplines. Empty claims obviously will not "cut it!" Genuine performance and the hard work necessary to develop technology-based curricula will be accepted as evidence of our capability.

- Instructors in mathematics, science, social acience, vocational, technical, or practical arts need to address the challenges of providing technological literacy to all. For each of these disciplines to attempt it alone would invariably doom the effort to failure.

- Traditional paths are not always the answer. One critical point of attention to be considered is the efficiency of our educational system. It will need to improve drastically; not so much in terms of instructional technology, but more so in terms of what we specify the core of "new basics" to be. With high performance from all educators, and outstanding courses and programs, excellence can be achieved.

- The incorporation of technological literacy as a basic skill among those mandated by state minimum competency laws, along with a scale for measuring competency, seems necessary if education is to maintain any semblance of relevance and credibility.

- The establishment and subsequent validation of a comprehensive model(s) of technology and its components are necessary prerequisites for most of what is to come.

- The establishment and subsequent validation of a comprehensive model for technological literacy's various levels of attainment, and a system for measuring this process, will be necessary to install a *performance-based* approach.

- Securing support for a long-term national research agenda in technology education and technological literacy is needed because there are no "quick fixes."

- The implementation of a widespread, ongoing public information campaign that brings the concepts of technology, its developments, and the implications to our populace is needed to overcome the current absence of technological literacy.

- There is a need for a systematic transfer and infusion model that communicates information about new technological developments and their implications for applications to appropriate members of the educational systems. (The agricultural extension concept and NASA's technology utilization system are good examples.)

- In order to ensure delivery capability, a systematic *personnel* development plan that is integrated with the aforementioned technology transfer and infusion system is needed.

- An increase in advocacy efforts by educators is necessary so that they are heard in the ranks of those developing our nation's science and technology policies.

- A yearlong conference of the "best and the brightest" from the ranks of all educational practitioners, including vocational, technical, and practical arts instructors; liberal arts/humanities; technology; science; and social science fields should be convened. This group would be charged with the mission of developing a ten-year program of work for infusing technological literacy into the mainstream of our educational systems.

- The development of a series of proposals will also be necessary to solicit funding for specific aspects of the program of work that the government is not likely to support.

GLOSSARY

GLOSSARY OF TECHNOLOGICAL TERMS

Appropriate Technology. Coates and Hitchcock (1980) cited the House Committee on Science and Technology's working definition of this term as follows:

> Those technologies which are decentralized, which require low capital investment, which are amenable to management by their users, which are in harmony with the environment, and which are conserving of natural resources.

An earlier definition by the National Science Foundation, being more precise, has stronger research implications. Appropriate technology is technology which is best suited to the specific local cultural, economic, social and political conditions at the site of application. The design or adaptation of such technology includes an examination of conditions of the site and consideration of several factors normally not identified through the marketplace. Some the these factors include preferences of users for technology which conserves natural resources, is compatible with local labor skills, and which enhances the social and ecological fabric of the site of application. The markets for appropriate technology are varied and widely diffused, and include the small farmer, the small businessman, and the small manufacturer. (p. 3-4)

High Technology. Typically this refers to the most sophisticated, esoteric, and often the most recently emerged, technological knowledges, skills, and hardware application.

Participatory Technology. Carroll (1971) has defined this term as follows:

> This term refers to the inclusion of people in the social and technical processes of developing, implementing, and regulating a technology, directly and through agents under their control, when the people included assert that their interests will be substantially affected by the technology and when they advance a claim to a legitimate and substantial participatory role in its development or redevelopment and implementation. The basic notion underlying the concept is that participation in the public development, use, and regulation of technology is one way in which individuals and groups can increase their understanding of technological processes and develop opportunities to influence such processes in appropriate cases. (p. 647)

Technical Literacy. For purposes of this discussion, this term is indistinguishable from technological literacy.

Technician. A person who works with moderate to high-level technology in trouble-shooting, control, and operation modes. Usually technicians are the graduates of a one-, two-, or three-year technical education program.

Technicism. This is "a state of mind that rests on an act of conceptual misuse reflected in myriad linguistic ways, of scientific and technological modes of reasoning" (Murchland 1983, p. 301).

Technics. "Specific technical skills associated with a particular technological act or behavior" (DeVore 1980, p. 3).

Technique. "A body of specialized knowledge and procedures used in a given field of technological endeavor" (DeVore 1980, p. 3).

Technocracy. "A plan of social reform based on greater control and utilization of industrial power" (Morehead 1955, p. 480). Usually implies control by a technological elite.

Technocrat. A person who advocates a technocracy and usually also one who is a member of the technological elite.

Technological Anaesthesia. The blind acceptance of technological innovation regardless of what it is or of its consequences.

Technological Barbarism. A term describing a general absence of technological literacy, of ignorance in the uses of technology, and of a closed mind toward it.

Technological Clusters. The subsets that make up technology.

Technological Determinism. A theory that human action is not free but rather determined, that is, brought about by technology and external technological influences acting on our will.

Technological Literacy. The possession of a broad knowledge of technology together with the necessary attitudes and physical abilities to implement the knowledge in a safe, appropriate, efficient, and effective manner. Technological literacy requires that one be able to perform tasks using the tools, machines, materials and processes resulting from technology.

Technological Press. The accumulated forces of technology and their indirect effects on individuals, society, and its institutions.

Technologist. A person who systematically studies and uses technology. Usually one who has graduated from a baccalaureate-granting technology program.

Technology. "The study of the creation and utilization of adaptive means, including tools, machines, materials, techniques, and the technical systems; and the relation of the behavior of these elements and systems to human beings, society, and the civilization process is the field of study known as technology" (DeVore 1980, p. xi).

Technology Assessment. The attempt to judge the merit of technology, or of one of its processes or artifacts, in terms of a set of criteria. Usually the term implies an attempt to ascertain worthiness by weighing advantageous and dysfunctional aspects. "The attempt to comprehend, and to make informed decisions about, the implications of technological development" (Carroll 1971, p. 650).

Technology Education. The entire continuum of educational programs, both formal and informal, that have as their intended purpose the development of increased technological capacity. This scope necessarily encompasses the range from programs that originally introduce a comprehensive overview of technology, through those that develop an awareness of technology's component clusters and that then guide exploration of these, to the prespecialization and preparation programs with more specific technological foci. Also encompassed are technology-centered upgrading, retraining, and adult education courses. The distinguishing features of all are a treatment of technology or subsets of it as the primary content and an appropriate focus on developing an ability to do something with this technological content, i.e., to apply it.

As stated in the American Industrial Arts Association Brochure (1983): Learning experiences in technology education will:

- promote the understanding of technology,
- develop safety habits,
- provide knowledge to make career decisions,
- develop consumer awareness,
- promote personal and social growth,
- develop problem solving ability,
- develop basic skill in the use of tools,
- reinforce learning from other subjects, and
- promote constructive use of leisure time. (pp. 4-7)

Technology Transfer. The engendering of new technological capacity (i.e., the skills and knowledge necessary to perform technological acts) in one person, population, or country by another.

Technophobes. People who have technophobia.

Technophobia. A fear of technology. "Technophobia arises when we regard technology as a malevolent force that manipulates and dominates us like objects" (Murchland 1983, p. 299).

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