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Technology Education

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Technology and Humanity

By Don Shepherd

Some years ago the writer became interested in the interrelationships between technology and people. One cannot be a student of technical things for long without recognizing that these things are in many instances examples of the finest creative genius of mankind. One cannot study technology without eventually coming face to face with the designers, inventors, managers, engineers and scientists who create it. And yes, these people work, love, laugh, play, cry, and raise families

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in ways strikingly similar to the rest of humanity. A separation between technology and humanity is in many ways an artificial one--technology is in fact people in action.

The singleminded notion that technology consists almost wholly of some massive body of "things" has got to go. This approach to technology is what this author calls a noun, or technology as objects, sense of the term. This perspective is useful if one is interested in envisioning a world inventory of technology--a series of stockpiles if one will--with computers, televisions, stereos, autos and medical equipment here, farm implements there, refineries and chemical plants over there, and waste dumps and all that nuclear "stuff" somewhere way out of town. Technology as a noun is an all too useful notion as humankind absolves itself of past failures and shirks its responsibilities to future generations by simply blaming some big old/new "thing" called technology. The human powers of rationalization seem to have a field day with technology as a noun.

Technology can also be perceived as the actions of people. This writer finds it useful to view technology as a mode of thought and action, a mode by which mankind affects change in not only the physical environment but also in the social and ideational environments. Beyond being a body of things, concepts or organizational techniques, technology is also, and perhaps most significantly, a process. Technology can thus be instructively viewed as a verb. Mankind technologies. In this view, human behavior becomes central to technology (Shepherd, 1978).

In anthropology, and most particularly in the body of theory called cultural materialism, one finds support for the idea that human behavior and technology are inextricably linked. Cultural materialists hold that the way in which people interact with their environment to survive--to provide the functional exigencies of life--is the most important variable factor in cultural evolution. Generally, it is hypothesized that "...social organization and ideology tend to be the dependent variables in any large diachronic sample of sociocultural systems" (Harris, 1968). Anthropologist Marvin Harris describes sociocultural systems as consisting, in very broad terms of three parts which are:

1. Ecological Patterns: This component is seen as consisting of generally all technoenvironmental transactions. The tools, machines, techniques and practices which relate social life to the material exigencies of specific environments are all part of this ecological pattern (Harris, 1971). The procurement, transformation, and distribution of energy are seen as important formative factor in these ecological patterns (Harris, 1968).

2. Social Structure: The maintenance of an orderly social life is described as a universal necessity which arises from the practical requirements of production and reproduction. A distinction is made between social structure and social grouping. In the latter not every grouping is organized around a directly economic or demographic role, but the social structure, as an aggregate of groups, has the support of technoenvironmental processes as its major function (Harris, 1971).

3. Ideology: Ideology is an uniquely human means of adjusting individual patterns of thought and feeling to the structural and ecological conditions of sociocultural life (Harris, 1971). Ideology is seen as being shaped by the interaction of both ecological patterns and social structure.

> ...it is a fundamental principle of anthropological analysis that most if not all of this inner behavior and its overt expression conform to definite socioculturally determined patterns, which originate outside the individual, not within him. Ideology thus embraces the entire realm of socially patterned thought (Harris, 1971).

These three factors are used to arrive at the conclusion that "There is no doubt that the technoenvironmental innovation lies at the basis of the most important culturally evolutionary trends" (Harris, 1971). This should not be mistaken, however, for a form of singular "determinism." Harris stresses that these three universal functions are in complex interaction but that materialist considerations, responses to the functional exigencies of life, are the prime mover in culture change.

The interactive nature of the three parts of this sociocultural model indicates not only the importance of technology as a major factor in cultural evolution, but also that technology should be studied within its social and ideological contexts. Technology does not occur in isolation. It is created by people, people

To ignore the interface between technology and culture is to diminish the ability of humankind to affect future cultural change.

who function within cultural and environmental systems. Views from history such as those of Burke (1978), Burlingame (1977), Harrison (1973) and others also confirm the need for a more broadly systemic perspective on technology.

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This notion of systems, the idea that many things are interrelated, is a large part of the philosophical basis for technology education. The above discussions are offered in support of two separate yet mutually interacting, ideas which can be seen clearly only in a systemic perspective.

First, it is useful to view technology as the thoughts and actions of people as they effect change in their natural and man-made environments. These actions often produce "things," yet an important aspect of technology is missed when one thinks of technology only in its noun sense. Technology is in large part the interaction of people, their ideas and actions, and things. Anthropologists, as evidenced by the theoretical formulations of cultural materialists, are coming to an understanding of the close interrelationship of technology and humanity.

Second, technology holds profound implications for the lives of humans as individuals, as members of society, and for the evolution of culture itself. To isolate technical matters from their larger cultural and environmental contexts is to distort reality. To ignore the interface between technology and culture is to diminish the ability of humankind to affect future cultural change.

In all this, what must be stressed is that although technology is seen as a prime mover of cultural evolution, it must also be seen as a component of an interactive system. The ideas and ideals of individuals can and must impinge upon the technological choices facing society, if a more humane society is to be created.

There are few clear answers in the technology and humanity equation, but many have at least begun to ask the pertinent and difficult questions.

The past immediacy of the delicate balance for survival between mankind and the natural elements has evolved into a new and equally threatening balance between people and the consequences of their own technological innovation. The immediacy is not simply for present survival, it is an immediacy which demand present inquiry aimed toward future survival.

> ...the indisputable fact (is) that new discoveries in the sciences and technology hold cataclysmic implications for our future lives. Decisions confront us, decisions which must be made if we are to not to forfeit the opportunity to affect our future as a human race. From the midst of the mass of accumulated knowledge, these cry out for attention and deliberation and ask that priorities be recognized (Toffler, 1974).

A major goal of technology education is the development of a technologically literate citizenry, a citizenry with the ability and motivation to participate in the management of technology toward more humane ends. There are few clear answers in the technology and humanity equation, but many have at least begun to ask the pertinent and difficult questions.

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Technology, Society and Education

By Paul W. DeVore

Technology and Society

Today in the Western world, and in an increasing number of areas of the non-Western world, the dominant characteristic of the society is its technical and industrial nature. While two centuries ago societies were predominantly focused on some form of food gathering, today this factor occupies fewer and fewer people. The great majority are involved in a vast technical apparatus in their work, private lives, and leisure. Yet, it becomes increasingly obvious that humankind today is only beginning the journey in a world which will become more technological, not less.

Humankind's creative endeavors in the technologies have greatly increased the interdependence of all people. Improved technics in agriculture and health care have altered, in an exponential way, the popula-

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tion of the earth, placing greater demands on available material resources and the natural environment. In a similar manner, improved means of information dissemination through the development of the means of mass-communication such as newspapers, radio, motion pictures and, more recently, television have raised the level of awareness of millions of people throughout the world to the potential of a better life for themselves, their families, and their offspring through the creation of new means of production, communication, and transportation. These new levels of consciousness bring forth not only problems of resource distribution and utilization, but also political questions related to who shall govern and how those who do govern shall function with respect to the larger questions affecting their own people and the global society as well.

Technology has always been a potentially disruptive force within a society. However, the character and potential of the technical means have been altered greatly in the last two centuries, particularly since the invention, innovation, and development of computers and microprocessors, two examples of new technical means that have altered the entire nature of society within a span of decades. These and other changes in the technological nature of society have increased the level of awareness of many and created, in some, a genuine state of anxiety brought about by the pace and rate of change, the fear of becoming useless, the increasing alienation of people from the artifacts which dominate their day-to-day life, and the uncertainty about how best to arrive at ethical judgments related to the human condition. Questions never raised before became critical issues by the middle of the twentieth century. How many people should there be in the world? Who should decide? Of the total resources available, how shall they be distributed among the people of the world?

Those who have studied the evolution of civilization have found that truly significant changes in human potential and the order or things seem to come about with the creation of either: 1) a more stable and abundant <u>food supply</u>; 2) new and better <u>material</u>; 3) alternative forms of <u>energy</u> supply and the means of conversion; 4) a more efficient means to collect, store, transmit and process <u>information</u>; or 5) a better means to <u>control</u> tools, machines and technical systems.

The lateen sail is an example of one of the earliest and more significant technical developments relating to control. It enabled mariners to control their boats and sail against the wind. The lateen sail, the stern post rudder and the magnetic compass, together with information about the stars, provided the technical means and information necessary to circumnavigate the globe and engage in regularly scheduled commerce throughout the year.

Today, new forms of energy and materials, information about the orbits of the planets, and control (in the form of inertial navigation and the computer) have provided the means to reach the moon and the stars beyond and, in the process, have changed our perceptions of who we are and what the future may bring. These and other technological developments have altered the reservoir of technical means from which our future will emerge.

This reservoir contains the means for another technological revolution. We are in the beginning stages. It is a revolution based on information and control and the significant component is the integrated circuit chip which has made possible the microprocessor --a computer on a chip. In 1982, over 2.8 million personal computers were sold for use in businesses, industry, schools and offices. The continued development of microelectronics and their offspring, microprocessors, will bring about changes in every aspect of society throughout the world.

<u>A Continuing Evolution</u>

Beginning in the late 1940s, significant changes took place in the structure of the world economic systems. These changes took place following advances in several technical systems. These included:

1. advances in air and sea transportation which decreased costs and travel time between continents
2. improvements in communication and information systems including radio, telephone, television, the computer, and microelectronics
3. unprecedented innovations in new products and new production procedures which reduced costs.

These developments set the stage for the expansion of new markets and the spread of technical means on a global scale.

Three major consequences accompanied the advances in transportation, communication, and production systems. These included an increased interdependence among national economies, an enhanced role of technological innovation in economic growth, and a rapid expansion of global corporations designed to take advantage of the potential of the new technologies (Gilpin, 1970).

The trend toward global interdependence and increased technological innovation continues. The new technologies have enabled the establishment of transnational corporations by providing improved means of transportation and communication. They have also provided new products for world markets manufactured by cybernated systems of production.

Technological Literacy

The goal of any formal education program should be literate students. What does it mean to be technologically literate?

If the question was, "What does it mean to be literate in French or Russian?", the reply would be that the student should be able to speak, read and write in the French or Russian language, implying a knowledge and understanding of the words, symbols, syntax and structure of the language as well as the ability to perform using the language. It also implies a knowledge and understanding of the history and culture of the countries where the language is primary. A similar situation exists with respect to technological literacy.

Today, we live in a complex, interrelated, computerized technical society. The first requirement of a technological society is that it is an educated society, an enlightened and informed society. The best way to focus on the centrality of this rather obvious point is to remember that each and every person on earth is a member of the spaceship earth. The more sophisticated the spaceship and the more crew members, the greater the task of educating people to manage and control it for the safety and security of all.

It would seem that each crew member must have a level of literacy about the functioning of our complex ship so that they will be able to make informed deci-

The creation and use of technical means is a large complex area of human intellectual activity which has evolved over the centuries and has had great social and psychological impact, but is little understood by society. And as critical as the understanding of technical systems is, as a basis for determining public policy and the management and control of technological systems, little effort has been made by public education to address the issue of technological literacy.

sions and will not become frustrated and alienated by its technical nature. This requires citizens knowledgeable about the characteristics, capabilities and limitations of the technological environment of the spaceship an the impact of their choices about the technical design of the spaceship on their future and the future of unborn generations.

The creation and use of technical means is a large complex area of human intellectual activity which has evolved over the centuries and has had great social and psychological impact, but is little understood by society. And as critical as the understanding of technical systems is, as a basis for determining public policy and the management and control of technological systems, little effort has been made by public education to address the issue of technological literacy.

A large portion of our population live in total ignorance about technical systems. their creation, capabilities, operations and limitations. Most live with perpetuated myths and folk knowledge that detracts from true understanding. However, many people are becoming aware of the significance of the problems. For instance, concern has been increasing about the issue of the form of technological literacy. It has become a critical issue because of the problems of society resulting from what is called an industrialized or corporate technical society.

Institutionalized or public education has always focused on literacy and training for the corporate or industrial need. These training programs are called vocational, occupational and career education. The education system has become linked more closely to the needs of business and industry through these programs. They type of literacy required by this approach to literacy is job specific, less complex and seldom transferable to new and evolving technical systems, a fact that is proven each time jobs are eliminated by technological change or obsolescence as in the steel industry.

The other form of technological literacy focuses on the role of the individual in a free society as a citizen of a community, state, nation and world who functions in many roles and is responsible for the proper functioning of the spaceship today and for the long-term sustainable future. This is a much more complex level of technological literacy than the literacy required to obtain and sustain a job in a corporate enterprise.

There are many ways of structuring a program of technological literacy. An economist would focus on the production function, an engineer on the technical, and anthropologist on the cultural and a sociologist on the social. None of these approaches is sufficient to structure a program of technological literacy today. What is needed is the focus of the technologist who is concerned with the study of the creation and use of technical means--tools, machines, techniques, technical systems--and the behavior of technological systems in relation to people, their societies, the environment and the civilization process. The technological literacy of today and tomorrow must be based on a unifying, integrating study of the behavior of natural, technical and social systems.

What is needed is the focus of the technologist who is concerned with the study of the creation and use of technical means—tools, machines, techniques, technical systems--and the behavior of technological systems in relation to people, their societies, the environment and the civilization process. The technological literacy of today and tomorrow must be based on a unifying, integrating study of the behavior of natural, technical and social systems.

This requires a new knowledge base incorporating the study of humankind; other cultures; social systems and the behavior of systems; decision making processes; change processes; the history and development of technical means; goals and values in human societies; technological assessment; technological forecasting; the interrelation of systems and the behavior and control of systems, both technical and social; the invention and innovation process and new technologies and technological systems including energy systems, transportation systems. communication systems and production systems; alternative and future social and technological systems; and the process for designing new technologies and new social and technical skills, among others.

The new literacy must also incorporate the concepts, relationships, and consequences of technical means, together with knowledge and know-how in the appropriate selection and design of technical means and the process of transfer and adoption of new means into society with the least impact on people, the social system or the environment.

Thus, the focus of the new literacy is on the process of creating, using and assessing technical means at several levels. These levels range from a knowledge of the function and use of tools in the broadest sense of the term, to the design of products produced by people using tools, and the use, relation and impact of the products on people. society and/or the environment.

Most efforts concerned with technological literacy have focused on knowing about and using tools or on assessing the impact or effects of technical means. Both are restricted efforts and fail to attain a true literacy. All too often it has been assumed that a casual encounter with tools or the reading of a book or two on technological and social change will produce a technologically literate person. This surface treatment fails to comprehend the complexity and interrelatedness of the task. True literacy will require a sustained effort over time to develop knowledge and understanding of the abstract concepts upon which the technical world has been created and functions. This level of understanding cannot be gained from hearing or reading about inventions and technical systems. What is required is direct and sustained involvement in the processes of the technologist. The mind must be prepared to be capable of observing and establishing differences, similarities and relationships. Human beings are not only perceptual beings, they are also conceptual. They are capable of learning and using technological modes of thought. Harold Halfin, in his study of the intellectual processes or methods of inquiry used by technologists, identified seventeen distinct processes. The processes are defined as "those functional or intellectual skills which are the random or ordered methods, strategies, or operations used by a technologist to accumulate knowledge about an artifact or to solve a technological problem" (Halfin, 1973).

1. Defining the problem or opportunity operationally
2. Observing
3. Analyzing
4. Visualizing
5. Computing
6. Communicating
7. Measuring
8. Predicting
9. Questioning and hypothesizing
10. Interpreting data
11. Constructing models and prototypes
12. Experimenting
13. Testing

14. Designing
15. Modeling
16. Creating
17. Managing

A significant part of the literacy issue is language. Language is not just a means of communicating thoughts, ideas, concepts or technical information; it also structures the way people perceive themselves and how they act and function. Being technologically literate requires that the individual be conversant in several technical languages including the symbolic languages of the various systems.

Finally, to be technologically literate requires a knowledge and understanding of systems.

Technological Systems

Technological systems are composed of elements that are related and which interact in some way. Everything exists in relation to other elements within an immediate and total environment. This means that there is some context within which an element, particle, person, tool, event, action or some other part of a system acts and is acted upon. Perceiving the dynamics of a system requires the identification of some central theme, function or behavior, whether the concern is with the composition and behavior of a given material or of an electronic communication system.

First steps in comprehending a system often involve classification, either at the micro or macro levels. Classifying is the process of ordering and organizing that which is observed about component elements or parts. By classifying or ordering the elements of an on-going dynamic event, a beginning is made in the understanding of the behavior of the element in relation to other elements.

There are different types of classification systems designed for different purposes. Some merely group like objects or elements, as is done in the Dewey decimal or Library of Congress systems for classifying books, the Department of Commerce system for classifying industries, or the Department of Labor system for classifying occupations. These might be referred to as static systems.

Taxonomic analysis is another way to classify the component elements of a system. A taxonomy orders elements according to a central theme, a hierarchy, and relationships.

Certain universal technological endeavors exist in all societies at some level of sophistication. They include the means of producing artifacts, transporting goods and services, and transmitting information. Each of these systems can be classified and analyzed as subsystems according to function, activity, or problem category. Examples include categories such as manufacturing, constructing and processing; terrestrial, marine, air and space transportation systems; and systems of information, transmission, storage, retrieval and use. To be technologically literate, a knowledge and understanding of the evolution, structure and behavior of these systems is essential.

The Study of Technology

Access to Tools*

The design of an educational system to develop a level of technological literacy in all citizens is a complex task. It is, however, a necessary task in a democratic society.

The belief that human beings achieve their highest level of human attainment in a free society and that participatory democracy is the best form of government presupposes that citizens must participate in decisions concerning the design, development, and use of technical systems. Participatory democracy in a society with more than a primitive order of technical means requires participatory technology. One without the other will not work.

Participation in social or technical decisions requires social and technical knowledge and access to social and technical tools.

These are the preconditions if citizens are to again become part of the process with a sense of intelligent participation and not alienation. The challenge to education brought about by the random development of technical means demands major alterations for one primary reason. The characteristics of a society based on a high order of technical means alter the questions with respect to error and failure. Failure in a complex, modern society is of far greater consequence than in earlier societies.

In earlier times, the technical means was not as powerful, dependency on multiple subsystems not as great. If systems were disturbed, they returned to equilibrium in a relatively short period of time and damage to human beings and the environment was limited. Not so with respect to the technical systems of the twentieth century. Yet, as dependent as the survival of society is on the efficient functioning of highly complex technical systems, we find that today the great masses of people are denied access to the tools. The tools of our technical systems have become the property of experts and are under the control of specialists. Thus, the control of the evolution of technical means and society becomes the province of select specialists, none of whom have the responsibility or mandates to be concerned about social purpose and total systems.

If citizens are to regain their freedom and obtain control of their destinies, then they must become involved in the study of technology and gain access to the tools. Dependency on common sense and the folk knowledge of yesterday will not suffice. The technical means of today, with its sophisticated tools and knowledge, requires discipline and systematic study from both a technical standpoint and a social-cultural perspective.

Most citizens have never had the opportunity for the disciplined and systematic study of these systems. Even the technical experts are limited in their understanding. They generally know about and understand the physical forces and principles which provide steorophonic sound, linear induction motors and color photography. Those who create these devices know about and can control these devices. But the issue is not the control of a single device; the issue is the understanding and control of the behavior of technological systems as a major component of our social system and as a critical factor of cultural change and disruption within society.

But the issue is not the control of a single device; the issue is the understanding and control of the behavior of technological systems as a major component of our social system and as a critical factor of cultural change and disruption within society.

The education of citizens for participation in the management of society for human purposes concerns not only the study and comprehension of the behavior of the various technical elements and the tools associated with these elements, but also the study of the behavior of total systems and the social/cultural effects within the total system. The concern would be with the dynamics of the system. The focus would be on what each element does within the system, not what a thing is. The goal of education would be to provide citizens with a means to gain knowledge, to gain control, and thereby mastery over the tools for human purposes.

Unfortunately, education efforts with respect to the study of technology have been narrowly directed, for the most part, toward the preparation of individuals for jobs and specialized roles in society rather than the preparation of self-governing citizens. Also, it has become evident that the new and expanding

Unfortunately, education efforts with respect to the study of technology have been narrowly directed, for the most part, toward the preparation of individuals for jobs and specialized roles in society rather than the preparation of self-governing citizens.

knowledge base of technology has transcended most educators and the competence of the average citizen. Many educators have treated the study of technology as something apart from the daily affairs of citizens and the responsibility of public education. By doing so they have effectively turned the control of a powerful tool over to a regime of experts and denied the majority of the people access to the very knowledge and tools so vital to the processes of creating, managing, regulating, and directing technical means for human purposes. Educators often view technology as an "object" and not as a "subject." as something "out there" not really important to education for life and living and thus inappropriate for study. The technical means of society seems to be an abstract created by others which exists outside the sphere of awareness of educators.

Because of this the educational system has muted the awareness of citizens of their ignorance of technology and pursued the policy of machine tooling citizens into marketable commodities in narrow specialities.

The educational system creates what Arthur Koestler (1941) calls an 'urban barbarian' by denying students access to knowledge and tools and limiting their interest in and awareness about technology. Citizens are placed in the position of being effectively shaped and controlled by those in command of the tools and knowledge of the new technologies. Also, the comprehension of the behavior of total systems is voided and technology becomes less and less responsive to citizens and human purposes.

The issue seems to be one for which education, as a social institution, has not developed successful alternatives. Most education programs have focused on the past, the here and now, and on meeting rather specific vocational needs. What is required is a new mentality, a different way of perceiving society and

What is required is a new mentality, a different way of perceiving society and technology.

technology. All citizens should be involved in determining the questions and finding the answers, and they should be prepared for participation in the process with adequate knowledge and tools for the task. It means a comprehension of the concept of system and the understanding of the interrelatedness of the elements of a system, i.e., everything affects everything else.

The goal of education should be to provide individuals with the means to find order in a complex global society and to attain the knowledge, skills, tools, attitudes, and values required to participate fully in the management and operation of society.

Without access to tools and knowledge of technological systems, citizens have effectively lost control of their technology. They have become totally dependent on technical means but ignorant of them. To alter this course will require that the study of technology by all citizens become as important as the sciences and the humanities. Citizens must become conversant in the language of technological systems and the basic concepts related to the behavior and dynamics of interrelated systems for all levels of society.

Because of the essential nature of this aspect of

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citizen education, the study of technology must become a component of formal education. The study of technology fulfills the criteria of the 'Rule of Irretrievable Loss' formulated by Dick Netzer. The rule is stated simply.

> Students should be taught on a compulsory or universal basis, <u>only</u> those things that large proportions of them will never learn unless exposed to the material at the stage in the education process in question, and which it is important that most people passing through that stage do learn (Netzer, 1981).

Technological literacy is a category of education that meets this test and will require attention at all levels of education.

A Curriculum Structure**

There are numerous ways to approach the design of an education system which incorporates the study of technology as one of the central themes. All approaches require some form of conceptual structure that organizes the components into a meaningful system showing relationships. An analysis of Figure 1 will indicate that, as a minimum, any curriculum design proposing to teach about technology should include the study of the four systems shown--ideological, sociological, technological and ecological--and the interrelating of these systems.

In addition to a structure which organizes components into a meaningful system showing relationships, there is need for a structure which illustrates the dynamics of the processes of the system. The participatory processes in which people are involved as they pursue the design, creation and use of technological systems to serve social purposes are shown in Figure 2. The diagram in Figure 1 answers the question of what to study while the diagram in Figure 2 illustrates the dynamics of the content by showing the relationships among the systems--ideological. sociological and technological--and the processes involved in the evolution of the systems and society. Three critical processes are involved--valuing, enabling, and assessing.

Finally, the study of technology requires a structure which identifies the primary elements of technological systems and their relationships as a means for deriving programs of study designed to understand the content of the many elements and relationships of technological systems. The matrix of Figures 3 and 4 illustrates an approach for the identification of <u>structure</u> and <u>content</u> for the study of technology.

There are three dimensions to the matrix. These consist of 1) components, which operate in certain 2) contexts, at various levels of 3) complexity. There are both technical components and social components.

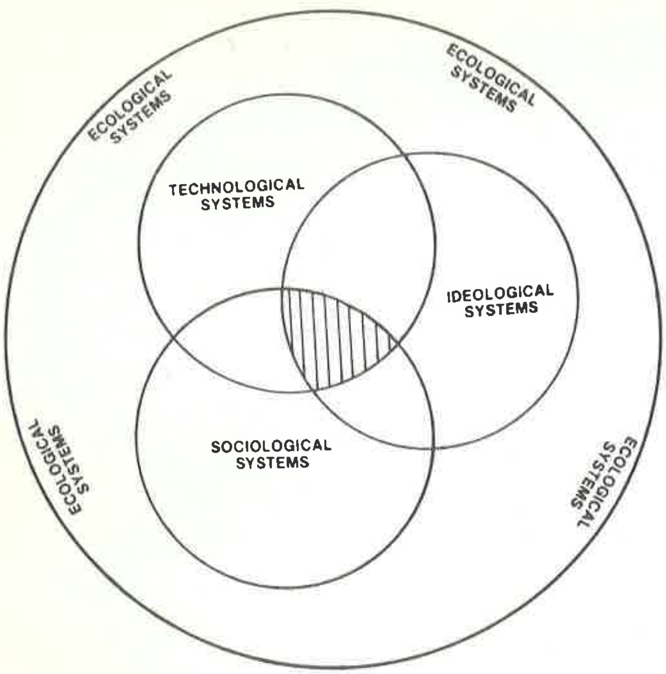

Figure 1: The interrelationship of systems—technological, sociological, ideological and ecological.

Technical components consist of resources, materials, tools, machines, energy, power and information. Social components consist of human elements including work skills, intellectual processes, occupations, environmental relationships, and the organization and management of technical systems, among others. These vary depending on people and the structure of the sociological and ideological systems to which a given technical system relates and the ecological system in which it exists.

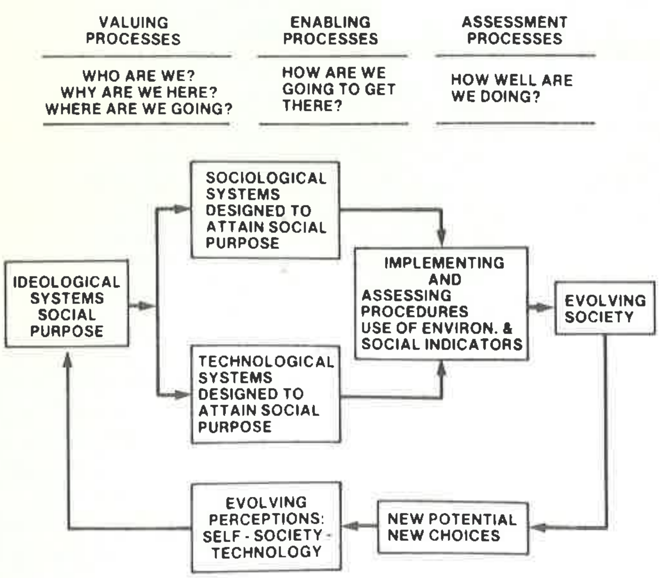

Figure 2: The evolution and relationship of technological systems and social purpose.

The various components are structured and used by people in different ways in three interrelated dynamic contexts, namely, communication, production, and transportation systems. These systems exist in all cultures regardless of the level of sophistication of the culture. The relationship of components and contexts is illustrated in Figure 4.

The evolution of technological systems is illustrated by the third axis of the matrix labeled complexity. The design of the matrix provides a means to illustrate that technological systems have evolved from early tool making, through the craft era, to the power and machine period of industrialization, to the atomic and cybernectic stage of the last half of the twentieth century. Continual evolution is indicated by the word future and the extension of the axis.

The structures illustrated provide a means to organize a program for the study of technology which recognizes the necessity of learning not only about systems and their relationships, but the facts, concepts and intellectual processes of the subsystems and numerous components from a historical, contemporary and future perspective as well. The matrix implies very clearly that it is not possible to study technology without becoming involved with technical knowledge and technical systems and their elements and operation. The same is true for those who would propose to study technology without becoming involved with human beings, social knowledge and social systems. Such approaches will be abortive and interfere with the development of the kind of education programs required to return the control of technology to people for human purposes.

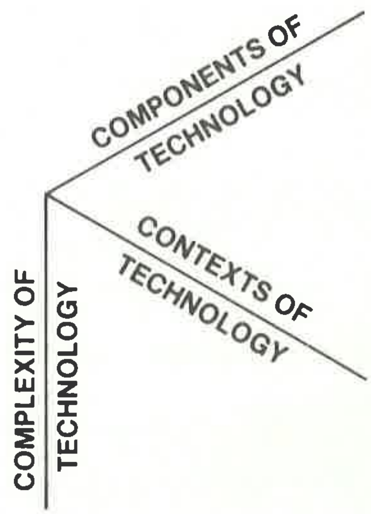

Figure 3: The study of technology--elements of an infrastructure.

*Tools in the sense used in this section refer to all devices from the most simple to the highly complex which are used by society to produce goods and services; transmit, store or retrieve information; and transport goods and services; together with the know-how of their use.

**Portions of this section are from Technology: An introduction (DeVore, 1980).

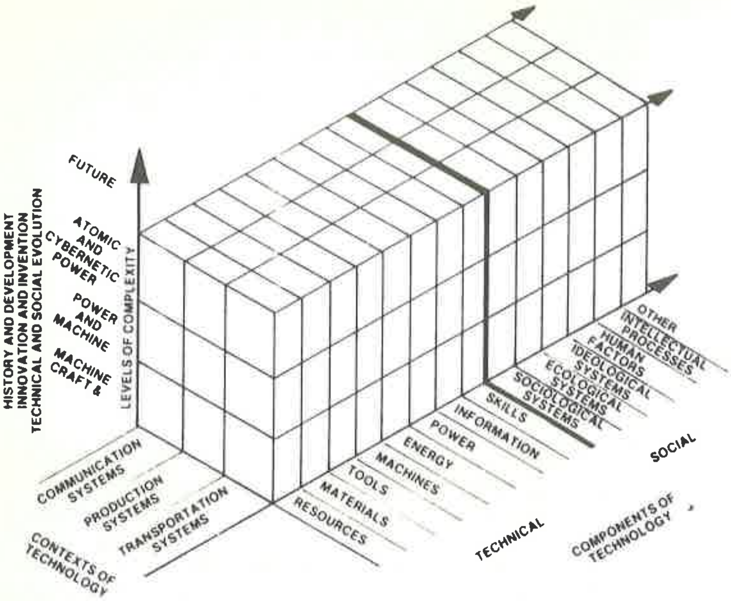

Figure 4: The study of technology--infrastructure.

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The Philosophical Aspects of Production Technology

By Edward C. Pytlik

The production of goods and services is at the core of the economic system of virtually every country in the world. This is true whether the economic system is capitalistic or socialistic, macro- or microeconomic, capital- or labor-intensive, international or national. It holds true whether the economic system occurs in a kingdom, republic, democracy or totalitarian state. The only exceptions to this general rule are the few surviving egalitarian communal societies in the world who have yet to develop an economic system. Production may be formally defined as humankind's efforts to create goods and services of economic value through the use of natural and human resources.

Technology is also a world-wide phenomenon. All societies are at some level of technological development. Even the Tasaday's, probably the least sophisticated of the world's known societies, have developed a recognizable technology, regardless of one's definition of the term.

Definitions of technology range from the rather simplistic 'applied science' to explanations that might run half a page. A definition that lies somewhere between these two extremes is the following:

> A process undertaken in all cultures (a universal), which involves the systematic application of organized knowledge (synthesis) and tangibles (tools and material) for the extension of human faculties that are restricted as a result of the evolutionary process (Pytlik, Lauda, & Johnson, 1978).

By combining the definitions of these two words--production and technology--a terminological foundation is formulated upon which the philosophical aspects of production technology can now be developed. Production technology, then can be defined as the process undertaken in all cultures, which involves the systematic application of accumulated knowledge and artifacts to utilize natural and human resources for the creation of goods and services of economic value.

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The acceptance of such a definition of production technology mandates that the study of production systems have a holistic perspective rather than the myopic view often associated with industrial education. The standard divisions of manufacturing and construction must become more interdisciplinary in nature, restructured and supplemented with areas of major importance that have been previously ignored. Further, production systems must be studied from an historical as well as a contemporary perspective and an international rather than a national perspective. Intellectual, as well as actual. isolationism is an impossibility in today's complex technological world.

The Structure

A revised structure of production, based on the above definition must be expanded beyond the traditional manufacturing and construction divisions to include three new divisions: harvesting, processing and service. The harvest division should focus on those production technologies related to the harvesting of natural or raw materials. Mining coal and metal ores, crude oil and natural gas extraction, timbering, fishing and agriculture are examples of activities included in this division.

Included within the parameters of these activities, and therefore included in their study, are all the infrastructure, operations, technology and personnel necessary to carry out the activity. Occasionally some of the resulting products are passed on directly to the consumer. Food in the Third World, for example. is often available to the consumer without an intervening process. However, the majority of the products resulting from the activities contained in the harvest division pass through a processing stage before being consumed by society.

The processing division of the structure should contain those production technologies especially devoted to the post-harvest operations of natural and raw materials. Ores are refined into ingots of metal; coal, oil and natural gas are refined into a myriad of products; timber is converted into lumber and paper; fish and agricultural products are processed into food for human and animal consumption, fertilizer and cloth; chemicals are processed into a variety of fibers and plastics; energy is converted from one form to another. Many of the products resulting from these various processes are passed on to the manufacturing division, but not all. Again. some of the products are consumed directly by the society.

The manufacturing division should be restricted to those infrastructures, operations, technology and personnel that convert processes and unprocessed natural materials into individual items consumed by society. Steel ingots are converted into shops and automobiles, bulk rubber into tires and boots, lumber into cabinets and tables. paper into bags and books, and so on. These products are manufactured in a variety of ways, ranging from using simple tools and a maximum of labor to using very complex tools and a minimum of labor. Because of this, the manufacturing division can be further subdivided into five general classifications. They are:

Household. In this classification, products are produced or manufactured in the home, primarily for home use or family consumption.

Handicraft. Handicrafts are products that are often, but not always, produced in the home using simple hand tools. Usually the items manufactured are sold for income rather than consumed by the family.

Intermittent. This classification includes those manufacturing operations that are small in nature. Their production of a particular item is not constant; emphasis is on producing small volumes of a number of different items. Worker controlled machines are almost always used in this production process. A production line, where operations are placed immediately adjacent to each other and the item passed from one to the other until completion, may be used. But these production lines are not permanent. Each time a new product is made the sequence of operations usually must also change.

Continuous. A continuous manufacturing operation is concerned with making large volumes of one or just a few items. Emphasis is placed on making large numbers of items in the shortest period of time. The production lines in this manufacturing method are often permanent, with minor changes made as the design of the product is modified. The machinery used is very sophisticated. Often a worker controls a machine that performs a series of complicated operations by manipulating a few levers or pushing a few buttons.

Automated. The automated method for manufacturing products is a complex system in which the materials move through the required operations with little or no human assistance. Human perception, muscle and senses have been almost entirely replaced by electrical and mechanical energy. The control of the production line is often a cybernetic system, i.e., automated and/or robotic systems controlled through a feedback or closed-loop system connected to a computer.

The construction division of the structure for the study of production systems should be concerned with the largest of the products developed by humans. It should include the infrastructures, operations, technology and personnel necessary for the successful construction of edifices such as buildings, bridges, tunnels, canals, dams, roads and railways. The goods produced by the construction division are used by society to fulfill their living, working and transportation needs. The worker-machine relationship in construction is unique in that, although much of the machinery is very sophisticated and complex, it is almost always directly controlled by the worker. At the same time, there are many construction operations that still require individual hand labor, using tools and techniques that have remained unchanged for thousands of years.

The service division is the fastest growing area of production. No actual goods are produced in this division. Instead the focus is on the creation of services of economic value through the use of human resources. All levels of education, all aspects of health (hospitals, doctors, nurses, nutritionists, etc.), protection (legal. police. fire, military), recreation, and maintenance and repair (plumbing, electrical, automobile, etc.) operations are all examples of services performed within this division.

The structure outlined above expands the number and types of production systems included in the study of production and places an emphasis on the production technologies. But of equal importance is to study the impact that these various production systems and their technologies have had on society. This can be done by studying production technology from a variety of perspectives, historical as well as contemporary, international as well as national.

The Perspective

The study of the historical genesis of production technology is much more than an academic exercise. By tracing the evolution of production technologies one can develop an excellent understanding of why specific contemporary structures function as they do. Foundational technical developments may be studied to establish what blend of innovation, invention, ingenuity, entrepreneurship and leadership were necessary for the creation of various developments. Contemporary research may then be analyzed to determine if perhaps a key variable is missing from current research on critical technical developments.

Historical perspectives also allow for the establishment of trend analyzes, which aid in predicting the future directions of production technologies. Knowledge of the who, where, when, why and how of the development of production technology may appear to have just academic value, but analysis of this information provides excellent insight into contemporary occurrences and aid in predicting what will come in the future.

The contemporary perspective of the study of production technologies should have as its central theme the controversy of centralization vs. decentralization. Multinational corporations using capital-intensive technologies such as computers, robots, cybernetics and automation have transformed the western world and are threatening to do the same to the remainder. But at what cost to those cultures? At what cost to the environment? Are the predicted benefits worth the increased unemployment, pollution and cost?

An alternative proposed by some, and almost universally ignored by the high technology advocates, is to decentralize the production activities. Technologies that are labor-intensive rather than capital-intensive are advocated, as are the use of local materials and local control. The emphasis is to become more self-reliant and less dependent upon the large corporations.

This centralization vs. decentralization concept is international in perspective. Having unsuccessfully tried to duplicate western world technological development, many Third World nations are beginning to seek alternative, intermediate or appropriate technologies. Of course, attempting to duplicate 200 years of technological development in 20 years could have been a much more significant reason for the Third World development failures than the type of technology advocated.

Another controversial issue related to the international perspective of production technologies is the whole area of international trade, tariffs and protectionism. The massive US unemployment crisis of 1982 was all too quickly and simplistically blamed on the increase of imported Japanese automobiles and steel. Many other related causes remain virtually unnoticed and still unresolved. The high cost of labor, the decreasing rate of productivity, the lack of a quality product, products not designed to meet consumer demands, excessive profit taking, and the rate at which human labor is being replaced by machines are all issues related and relevant to the unemployment crisis.

<u>Summary</u>

The proposed philosophical concept of production technology was designed to complement the basic underlying philosophy of technology education. It was based on the combined definition of production and technology which necessitated the restructuring and expansion of the traditional structure into five divisions: harvesting, processing, manufacturing, construction and service. Finally it was advocated that the perspective for viewing production technology be historical as well as contemporary, international as well as national. The examples presented are meant to be just that. No attempt has been made to provide an all-inclusive method for the study of production technology.

Transportion Technology: A Philosophical Perspective

By Mark R. Skinner

Technology education is a subject area of growing interest today, for economic and social as well as purely pedagogical reasons. If one looks for its roots, one soon discovers that technology education is similar to many areas in education. It is rooted in a discipline, technology, in the same manner that mathematics education is rooted in the discipline of mathematics or that science education is rooted in the disciplines of astronomy, biology, chemistry, geology, physics, et cetera. In order to develop a philosophical perspective on one sub-discipline of technology, namely transportation technology, it would seem that a possible approach would be to examine this area from the viewpoint of several schools of philosophy, to see if this may bring any central themes or concepts into focus. These themes or concepts might then form the basis for scholarly inquiry in the subdiscipline.

Overall, the discipline of technology is concerned with the structure and behavior of systems of technical means, as for example, chemistry is concerned with the structure and behavior of systems of molecules. Additionally, technology is concerned with the mutual interactions among humans, the environment, and systems to technical means. Thus, as we pose the central questions suggested by the selected schools of philosophy, we will seek to be alert for the implications transportation technology has in the areas of behavior, structure and interactions.

Transportation technology has been described in several ways. Some people look at it as being ways of increasing our mobility, while others talk of the displacement of animate and inanimate objects. It can also be thought of as the creation of 'place utility.' The value or usefulness ('utility' to the economists) of something may be thought of as a function of the location of that something. For example, the can of frozen orange juice that you forgot to buy at the store last night isn't of much value to you when you've run out at breakfast. Had you brought it home from the store, it would be a great deal more useful to you, for you would have increased its 'place utility' by changing its location to your kitchen, that is, by 'transporting' it. Transportation technology then, is the study of the ways in which place utility is created or increased.

While it is probably inappropriate to speak of a philosophy of transportation technology, one can view transportation from a philosophical perspective. That is, one can ask the central question posed by various schools of philosophy in order to determine the role transportation plays in our lives. One might, for instance, ask how transportation technology has

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affected our being-in-the-world, how it has affected our perception of the world, and how it has affected our existence in the world, particularly in regard to our freedom of will.

Perhaps the most interesting and most powerful characteristic of all technology, which includes transportation technology, communication technology, production technology, appropriate technology, or any other subset of the discipline, is the ability of that technology to create new realities, or new sets of possible behaviors.

From a perceptual, or phenomenological. viewpoint, reality is simply the sum of the things we are able to perceive. Technology alters this set over time through, at the most basic level, the creation of new artifacts. These artifacts, in turn, help us to change our perceptions of ourselves. For example, the fact that we perceive objects (or 'phenomena') such as automobiles, aircraft, ships, submarines and earth satellites. all of which are transportation technology artifacts, causes those of us who live in the industrialized 'developed nations' of the northern hemisphere to perceive our lives differently from the way in which the Maroons of Surinam, who are the descendants of African natives imported to work as slaves on South American sugar-cane plantations who escaped into the bush and re-established African tribal society, perceive their lives.

At the next level, it is not just artifacts which affect our perception, but support systems as well. The automobile as we know it is inextricably linked to roads and highways (over 3 million miles of them in the USA alone), to gasoline stations, and to many manufacturing centers.

At a third level. the auto is the cause for much regulatory activity, from traffic signals to courts; much of the activity associated with the petroleum industry, from exploration to refineries and refining; and much of the clustering of our population around the manufacturing centers where autos, auto parts, and auto support systems and/or support system parts are manufactured. It is perhaps at this level that a subtle yet crucial transformation begins to take place. It is here that we see that a 'transportation artifact,' such as an automobile. has its true phenomenological importance to us not in terms of its existence as an artifact <u>per se</u> and not even so much due to the support systems (roads, fuel, etc.) with which it is linked, but that its great importance to us lies in terms of the structures in society we have created to support it, and which it, in turn. supports. Much of our life is concerned with the ways we organize ourselves industrially to produce goods and services. It is this rationalized system of production, which itself is linked to the auto in several ways, which is so important. Elements of rationalized production, including standardized, interchangeable parts and the division of labor, are necessary for the mass production of automobiles, but the automobile is likewise necessary for mass production, for it allows laborers (and managers) to get from home to the plant where the products are manufactured. Furthermore, the necessity of commuting to work constrains the location of workers' homes and influences the shapes of the communities comprised of those homes and their associated support systems. for example, shopping, medical care, and recreation facilities. Thus while the automobile has not <u>caused</u> our society to develop as it has, it has enabled or facilitated that development.

In terms of logical condition one might say that the automobile and its support systems form necessary, but not sufficient conditions for the phenomena which we collectively call 'western society' to obtain. To illustrate this point, consider the following example (Note 1). In order to ensure that the event or phenomenon known as 'fire' will obtain (i.e., occur, exist, etc.), that is, in order to ensure sufficiency, four conditions must obtain simultaneously. Oxygen must be present, a fuel capable of combining exothermically with the oxygen must be present, a temperature high enough to initiate the reaction must be reached, and there must not be substances in the immediate vicinity, such as fire-retardant chemicals or water, to prevent the oxygen and fuel from uniting exothermically. These four are the necessary conditions for the event we call 'fire' to obtain. If any of them is lacking, there will not be a fire. Given the simultaneous presence of all of them, though, we know that fire will occur, and thus taken together, the four necessary conditions constitute the sufficient conditions for the event 'fire' to obtain. That is, they guarantee that there will be a fire.

Similarly, while the automobile is not the 'cause' of our society's being structured as it is today, the societal structure would be unlikely to exist as we know it without the automobile, aircraft, ships, and other artifacts of transportation and their related support systems. Therefore, from a phenomenological perspective, it may be argued that transportation technology has played a major role in structuring the society we live in.

Perhaps the most interesting question we can ask, then, if we accept the preceding assertions, is, "In what ways will the phenomena of transportation technology shape the world of the future, the world in which we will live the rest of our lives?"

Another perspective on transportation might approach the issue by asking in what way the technology has changed our being-in-the-world. As noted previously, all technology exhibits the characteristic of changing the set of possible behaviors open to us. Reality, or our being-in-the-world, may be equated with the set of possible behaviors open to us. Has transportation technology altered that set, or more specifically, has it enlarged the set? Historically, it seems that it is indeed the case that transportation technology has enlarged our set of possible behaviors as it has developed.

Early on, our increasing abilities to transport goods and ourselves led to dramatic increases in trade, which made it possible. at least for the wealthy, to enjoy items not produced locally. Some form of transportation technology, and to this day scholars are not in total agreement as to the exact form that was used, enabled the ancient Egyptians to construct the Great Pyramids. Perhaps more important than the increased availability of goods and changes in the local scenery were the increases in human mobility that improved transportation systems offered.

Over the course of several centuries, from the fourteenth to the mid-twentieth, all-weather transportation systems developed. Several specific technical developments can be cited as having been crucial to this process. Among them are the lock, which greatly expanded river navigation and made the inland transport of heavy or bulk cargo and passengers much easier; the magnetic compass, which allowed ships to operate out of the sight of land; the stern post rudder, which allowed ships to become large enough to operate safely on the high seas; and the sextant and chronometer, which allowed sea captains to determine the position of their vessels anywhere in the world. On land, the developments in bridge building and road building, and then the coming of railroads, began to get Europe, Britain, and later, the USA, out of the mud. Later on, the development of aviation, of electronic aids to navigation such as radio. radar, sonar, and of systems such as Loran and Navstar have greatly increased the speed, safety and reliability of all-weather transportation systems.

While these specific technical developments, many others, and the systems they have spawned, have certainly altered the set of possibilities open to members of societies wealthy enough to employ them, their direct impacts may not be the most important. Their widespread diffusion and adoption has led us to drastic changes in an aspect of our being-in-the-world which Martin Heidegger calls 'autochthony,' or 'rootedness.' In Discourse on thinking, Heidegger (1959-1966) asserts that a most important characteristic of humankind throughout history has been the relationship of people to the land: that people in unsophisticated cultures have 'grown roots' as it were, in that they have a very close relationship with the land they live on, derive their sustenance from, and pass on to succeeding generations.

Our transportation systems have, however, made it increasingly possible, beginning in the middle ages but especially in the last century, for us to move about within our own countries or to emigrate to distant places. This vastly increased mobility has in truth broken our bonds with the land and has, if Heidegger is correct, led to many of the problems which afflict contemporary societies.

Concurrently, the number of choices open to citizens of the developed nations has expanded greatly. We are able to access many activities due to the transportation network that has evolved. We have opportunities as varied as jobs in large industrial organizations, high technology medical care, fresh produce in winter, and ballet and football, all of which would not exist or which would be radically different if we were unable to move large numbers of people and large quantities of goods between multiple origins and destinations with relative ease and with relatively little expense. Since many activities require large numbers of producers or consumers, whose travel must occur in a coordinated fashion, many of the things we take for granted in our daily lives would not exist without transportation. Thus transportation may be seen as a necessary condition for much of our daily being-in-the-world.

A third philosophical perspective from which one might choose to view transportation technology and its impact on our lives is that of existentialism. In this case, one might ask th question, "How has transportation technology affected humanity's free will, or freedom of choice?" As indicated earlier, transportation has contributed to the enlargement of the set of possibilities each of us confronts as a member of a sophisticated society. Thus one might argue that due to the increase in the number of choices, freedom of choice has been increased.

It is possible at least in some instances, to find cases where freedom has been diminished. If one is on foot, on a bicycle or on a horse, one is prohibited from using the Interstate Highway systems. Access to and egress from that system is permitted only at officially approved locations. We in the USA are currently constrained to operate our automobiles at 55 mph or less. As a further example, the airspace over certain cities is restricted to aircraft that carry special equipment. Overall, then, it appears that while we have created many more possibilities, which have given us a measure of additional freedom, we have had to adopt social or operational constraints which restrict the absolute freedom of individuals to use those systems in order to make them safe and functional for all of us.

Perhaps the area where freedom has most noticeably been increased, though, is for people living in areas which have traditionally had poor transport facilities that have subsequently been upgraded. Some of these areas have seen large-scale cultural change occur as the flow of people, goods, services, and especially of ideas, has increased.

Having briefly examined transportation technology from the perspective of only three schools of philosophy, it is evident that many important questions regarding the structure of the systems of technical means which comprise transportation technology, the behavior of those systems, and the interactions of those systems with humans and the environment have been raised. Whether viewed from a phenomenological, ontological or existential frame of reference, it appears that developments in transportation technology have been inextricably linked with many of the changes that have occurred in our world. It remains for us, as scholars in the discipline of technology, to explore those questions and changes, and then, as technology educators, to share the results of our inquiries with our students at levels appropriate to their needs, as we attempt to assist them in becoming technologically literate citizens who are able to understand and cope with the world in which they will spend the rest of their lives.

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1. The author is indebted to Professor Theodore Drange, of the West Virginia University Philosophy Department, for his suggestion of this example in a 1976 discussion of necessary and sufficient conditions.

Communication Technology - - Euphoric Bliss or the Prophet of Doom?

By J. Barry DuVall

I shall never forget our visit to the nuclear plant at Three Mile Island. First of all, you have to picture a wall filled with hundreds of panels that light up and provide warnings.

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There was a canned lecture being given to our Commission about the control room which I was not interested in, so I watched what was going on.

After about five minutes, I heard a bell sound and saw an operator flip some switches. The lecturer didn't stop, so I asked him if he would mind telling us what happened. He said that an alarm went off--and that we would learn later that an alarm does not necessarily mean that there is something that you should be alarmed about. It just means that the operator should check something--and he pointed out that behind each panel was a blinking light that told the operator what the problem was, so that they could push the right button and shut off the alarm.

Ten minutes later another alarm went off. I spotted the blinking light. The operator looked at it, turned some dials, and it went off.

Fifteen minutes later I heard the alarm again and saw the operator scurrying all over the place. and then he called one of his assistants over who started removing those little plastic panels one by one.

I raised my hand again and said, 'Sir, would you mind asking the operator what is going on now?' They had a whispered conversation and he said, 'Oh, it's nothing important. It's just that as you may have heard an alarm went off--but no light is blinking--which means that the appropriate light bulb is burned out.'

John Kemeny, Chairman of the President's Commission on Three Mile Island, in Christian Science Monitor, May 8, 1980.

What is important to know is that a 'meltdown' of the reactor core, resulting in an explosion and high levels of exposure to nuclear radiation, would occur within 30 seconds if a failure (such as a break in the water supply to the cooling tower) were to occur.

It is apparent that the technician in the above scenario would not have been able to remove all the hundreds of panels and find the faulty bulb in time. If there had been a failure when the bulb burned out, the area would have been devastated.

This is only one example of what could occur right now, somewhere in our world; it is presented here because it is indicative of the extent to which we rely on communication technology--the tools, techniques, and technical systems for managing information. As in the case of the Three Mile Island example, we often have become confident and apathetic, hoping with naive optimism that nothing will go wrong.

The elaborate instrumentation, switching, and control consols which can be found in all nuclear facilities contain thousands of devices and systems for managing information. Many of the systems have redundant capabilities which provide a 'fail safe' in case the primary system doesn't work. Some don't.

Communication and Communication Technology

The major purpose of any type of communication is to manage information. Given the amount of data generated each day, this places a heavy burden on the technology of communication to help us extend our communicative capacity beyond the limitations of our senses.

When we communicate, we manage information by conveying some meaning to a receiver. Sometimes the receiver is another person; sometimes it is a device or machine. Without our technology--tools, techniques, and technical systems--we would be limited to acts of communication between people. Other exchanges of information (person to machine, machine to person, or machine to machine), would not be possible. Figures 1 through 5 show how communication occurs between people and machines.

Today we use communication technology to protect ourselves from dangerous materials in our environment, to transmit and receive information from space, and to monitor sophisticated inputs from sensors planted beneath the sea floor. But communication technology is also involved in collecting information for our evening paper, in paying for our groceries, or in 'fine tuning' the color on our TV set. In fact, it is difficult to think of life without some form of technology to help us communicate.

Communication also occurs between many other life forms on our planet. In most instances the basic process is much the same as it is in human communication. Information is transmitted from a sender to a receiver. What is different is the method of transmission--the senses or methods that are used to convey information.

In all exchanges of information, no matter whether information is transmitted between animals, humans, or machines, there is always the possibility that the same information that is transmitted is not received. This is what is known as message efficiency. There are many reasons why the same information that is transmitted may not have been received. However, the major reason for loss of efficiency in the transfer of information is noise. Noise is simply interference, something that blocks the transfer of the message content. In machines noise occurs as radio wave interference, through the loss of electronic impulses in a circuit or even through faulty performance of some component in a complex system. In humans, noise might take the form of the receiver not listening to the information being transmitted, or not understanding what the receiver is trying to communicate. It might also occur as a confusing signal in the background, something that interferes with the process of receiving the message.

The Technology of Communications

Communication technology relates to our tools, techniques, and technical systems for managing information and places a major emphasis on 'man-made hardware.' It is this hardware that enables new possibilities well beyond the limit of the human senses. In this way technology provides an extension to our limited sensory capacities. Without technology it would not be possible for machines to transmit information to human receivers, and it would not be possible for humans to communicate with machines. A content model for communication technology is shown in Figure 6.

There are many ways to organize the body of knowledge in communication technology. One of the simplist ways is to identify major systems, general content organizers which group similar types of communication into clusters or families. This can be done by considering the ways information is transmitted or received using technology. Three major systems which are frequently referenced in the literature are visual, acoustical and electronic. Most acts of machine communication occur in one or more of these categories. Figure 7 shows how the transfer of information between machines in these major systems occurs.

A device in one of these systems groupings transmits information in the form of energy to a receiver.

If communication is to occur the information that is transferred must be accepted by the receiver. Information is accepted either as impulses utilizing same form of energy that was transmitted or as information that is changed into another form (transduced).

Communication Technology--Profiles of the Future

Major changes are taking place today in industry and society which are a direct result of 'runaway growth' in the field of communication technology. High technology activity in New York's "Tech Island," (Long

Island), Chattanooga's "Energy Valley," or Maryland's "SciCom" belt is commonplace, with every state and region now trying to create its own unique rendition.

There seem to be commonalities in all of these efforts. Most of the new high technology industries that are being created emphasize soft technology, plants without great capital outlays for equipment and inventory. Most high tech industries focus on some aspect of communication technology in terms of their principle product or service. A review of America's fastest growing private companies in 1982 (INC, December, 1982) reveals that 37% of the top one hundred high growth firms are engaged in communication-oriented products or services.

These products take many forms: remote sensing systems, robotics, data communication, super chips, semiconductors, microcommunication, fiber optics, videotext, electronic mail, conductive polymers, superconductors, computer assisted design, computer integrated manufacturing, and others.

Many of the new systems now being created interface with other systems. In the new digital electron beam microfiche disc storage system now manufactured by Mnemos in Lawrenceville, NJ, 6000 documents can be stored on one twelve dollar disc the size of an LP record. The system interfaces several systems: electron beam, lithography, fiber optics, laser technology, and computer storage, and retrieval. As we progress into the future, the combinations will become even more unpredictable. What should be apparent for all of us is that there is no turning back. Society will not halt its information flow.

The challenge and responsibility facing the schools has never before been more clear. The survival of generations to come, on this and other planets, depends on our ability to selectively manage increasing amounts of information. What we do today in our classrooms and laboratories may help to make the difference.

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The Ultimate Interface: Technology Education and Future Studies

By Lee Smalley

Introduction

Technology education is defined, described and analyzed adequately elsewhere in this and other publications, so there is no need to repeat that information here. What will be developed here is the relationship between the purposes and concepts of technology education and future studies. It is assumed that technological literacy is the central theme of technology education and can be used as a representative symbol. Just as the family represents the main thrust of home economics, and physical activity the core of physical education, so does technology literacy serve as the rallying cry, the 'bang board' against which ideas can be tossed as a gross indicator of how they will serve the purposes of technology education.

Technological Literacy

Literacy is not generally related to an elite group, but to the masses, for literacy information is useful for some sort of citizenship activity, not for an occupational or leisure pursuit. Literacy also suggests a level of competence, below which you will somehow fail to discharge duties adequate to maintain yourself in the community or society in which you live.

There are many different kinds of literacy. Being able to read and write are fundamental to making a contribution in our advanced technological society. What about being economically, historically, scientifically, or chemically literate? Each of these are more or less important, depending upon one's values and the importance of the knowledge, skills and attitudes in these particular areas. Literacies may range from an individual interest to a necessary function based upon societal expectations and requirements to function even on a minimal level.

So where does technology fit in this scheme? What is its position relative to science, history, art, math, economics, child rearing, etc.? The importance of technology seems to be moving to one of the top positions as the changes brought about by technology influence individuals, institutions and societies in most areas of a person's life: health, education, transportation, jobs, leisure, etc.

Assuming there is such a thing as technological literacy, how would one know the extent of one's literacy or illiteracy? Some areas seem to have a narrower range of scope than the field of technology, so in these areas it would be easier to test for a level of competence. A few questions may provide some indication of the knowledge, attitude and skills in the area of music, for example. The texts could be standardized so that a number could indicate the level of

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music literacy a person had relative to other people in their age group.

What guidelines would have to be developed before a test for technological literacy could be standardized? There seem to be at least four questions that would have to be addressed before any kind of assessment could take place.

1. Should the social implications as well as the technical aspects of a technology be included?
2. Should a sampling of exclusively industrial technology (communication, manufacturing, construction, transportation) be included?
3. Should soft (without hardware) technology as well as hard (with hardware) technology be a part of technological literacy?
4. Should all three time frames (past, present, future) be included?

The way you answer each of these questions would narrow or broaden the concept of technological literacy and of technology education. A liberal interpretation of these questions would yield different content and organization from the usual industrial arts that has been taught for the last 80 years, but that would be expected in any curricular change.

Reasons for Teaching Future Studies

For the purpose of this paper, only the last question concerning the time frames will be considered. A careful look at the implications would lead to only one answer, "Yes, all three time frames need to be included if a person is to be considered technologically literate." If the theme of technology education is technological literacy, then why should future activities be included in technology education courses?

It is difficult to define only the present. This is such an elusive term that unless it is carefully delineated ahead of time, one moves quickly into either the past or future tense. What is the present for a geologist is not the same time span for an electronic engineer, so to involve only the present would cause severe problems.

To leave history out would seriously disturb the futuring process, for the past is necessary to get a perspective on the present. All data is historical and may provide clues as to how we arrived at where we are now.

The present is necessary to know where one is at, to establish a sense of reality, for unless there can be some agreement on present characteristics, it would be unlikely any consensus could be reached.

The future is where the action is. All decisions are future oriented. This is the one area where changes can be made, where the results are not in yet. People need to relate the present to alternative futures.

This rationale should establish that a person who is technologically literate would have to have some level of competence in all three time frames. This should prove that in any area of education, one should engage in the past, the present and the future. This is especially important in technology education because technology, in the broad sense, is the process of realizing our future.

The Interface

Following are some concepts that illustrate the interface between future studies and technology education.

Too much time and effort is spent on isolated activities in schools.

1. People need to make connections. Too much time and effort is spent on isolated activities in schools. Certainly as young people enter into a new organization or community, they need to see some cause and effect, some relationships and connections between events, people, offices, etc. This connection, in technology, can come between the past and present, or the present and future. A simple example would have a student group identify characteristics of present day transportation, and then go into history to see how this came to be. They may build models, or develop drawings showing the evolution of the steam ship or the automobile. Graphs may be developed on a computer graphics tablet showing million miles traveled on various means of transportation over time. In connecting the present with the future, a scenario may be developed that a group or individual may be interested in. If a group wanted to explore the increased use of a personal pager, they could describe possible events and changes in 1993, then working forward to the present, identify what would have to happen in the next ten years for this to become operational.

By involving the future in the curriculum, you automatically include all three time frames, and thus assure some connections between them.

2. People need to practice imagineering. Getting people to wander around in the future provides an exceptional opportunity for young people to stretch their ideas and imagination. They need to try out some of their ideas, to visualize them, and get the reaction and analysis of others. A model automated factory may be designed and built so that students can visualize the differences between that factory and present day operation. Social as well as technological consequences can thus be explored. An inner-city personal people mover could be developed, as well as a closed system pipeline to carry coal slurry from Montana to

Imagineering is an American tradition and one that should be developed in our school system. Tying the future to technology education is an ideal vehicle for achieve this important aspect of technological literacy.

Minnesota that would actually 'work,' thus allowing people to visualize this bit of a possible future. Imagineering is an American tradition and one that should be developed in our school system. Tying the future to technology education is an ideal vehicle for achieve this important aspect of technological literacy.

3. People need to work on problems where there are no 'right' answers. One of the differences between American schooling and that in other countries is the added incentive and practice for the process of problem solving in American schools. Real problem solving comes about when neither the student nor the teacher have the preconceived notion as to what the correct answer really is. Since the future is not written yet, it offers the optimum time frame for young people to practice the process of decision making, and then to explore some of the implications. Since technology is such a driver of social change, any technological

The interaction between future studies and technology education is a natural one for developing true problem solving skills

change will influence other changes. What is the best communication mix? What are the implications of more man-made materials? Where does the electric car fit in? To get a fuller understanding of these problems, and potential solutions, would include hands-on activities in simulation and model building. The interaction between future studies and technology education is a natural one for developing true problem solving skills, as opposed to many of the contrived experiences teachers usually have their students involved in, where an answer is already known and students then try to massage the data to correspond to what the teacher expects.

4. People need to explore alternatives. A mature adult will automatically think of alternatives when a problem or opportunity presents itself, but this is not always the procedure when young people are presented such an occasion. They may decide too quickly, act without adequate information, or apply a previous solution to a different problem. The future has to be thought of as full of alternatives, for it has not yet come about, and various people and groups have different ideas as to what should happen. By assigning similar problems to individuals or small groups and seeing visually the two or three dimensional solutions, young people may grown up surrounded by alternative solutions and thus be more likely to build this into their thinking process. Offering the problem of how to design a toy for a mentally retarded youngster, how to produce it, market it and package it, should spark the spirit of competition in a controlled environment where it can be monitored and discussed. The process of incorporating other ideas into a compromise is the next necessary step and one that would come naturally in a technology education class where students were investigating future alternatives.

5. People need to create their own future. The most powerful concept in future studies is the self-

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fulfilling prophecy. When people ask, "What is the future going to be?", the only reply can be another question, "What are you willing to work for?", for that becomes the most likely future. If a person is always negative or pessimistic, what do they have to work for? If young people do not like some of the proposals for the environment, the rush toward robotics, the atrophy of our railroads, or the shape of our new buildings, then they need to offer an alternative and try to bring that one about. Technology education content should constantly be related to issues and problems that impact upon individual and institutions. By going through some of the previous experiences that have been cited and culminating with this concept of the self-fulfilling prophecy, teachers are preparing enlightened, active citizens who will provide leadership in the years to come. Young people do not have to be the helpless, disenfranchised group they sometimes are, for they, like others, can provide an influence; if they do their homework! The opportunity to work on real technological and social problems in a future time frame, with the prospect of continuing this involvement toward its fulfillment would seem to be good, solid, basic education for an American citizen.

Conclusion

The interface of future studies and technology education is both a necessary and a fruitful one. It would be difficult to conceive of a good educational program that did not get students involved in all three time frames, and especially in the area of technology. Industry and technology have played a crucial role in shaping America, and thus Americans, but what we have seen in the last 200 years may be only a beginning. We have gone through the agricultural and the industrial revolution, and now we are going through the first phase of the technological revolution.

Our most important job, as teachers, is to prepare young people to go into this change with eyes open, hands ready, minds alert, relevant skills, knowledge of available information, an attitude that is positive, and a commitment for a place in the future.

Our most important job, as teachers, is to prepare young people to go into this change with eyes open, hands ready, minds alert, relevant skills, knowledge of available information, an attitude that is positive, and a commitment for a place in the future.

If technology education teachers can do this, then they will have achieved the promise of education. Anything less will be too little and too late.

Simulating High Technology in the High School Industrial Arts Manufacturing Class

By John R. Wright

American industry is rapidly moving into what has been called the High Technology Era. During the past fifteen years, the energy intensive manufacturing industries have had a difficult time trying to keep costs down and productivity up. On the forefront with these problems are the American automobile and steel manufacturers. Outdated technology, energy inefficient equipment, and high labor costs have all contributed to their low productivity and high retail cost problem.

Several trends can be identified as American manufacturers re-group and begin to solve their high cost/low productivity problems. Some companies have moved their plants to the sun belt states in an effort to cut energy, labor, and tax costs. Others have

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lobbied for delayed environmental regulations and tax incentives for Research/Development and capital investment. But the most significant trend has been the development of computerized manufacturing technology. Industrial robots, computer aided design and computer aided manufacturing techniques represent a shift from electrical/mechanical to electronic/mechanical technology. This shift is generally referred to as the High Technology approach. It is symbolized by closed circuit cybernetic systems which are controlled by computers and feature self-correcting feedback capabilities.

Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) are revolutionizing manufacturing. CAD speeds up the drafting and design process and allows engineers to make use of space never before explored in design. Its sister CAM provides automatic control and accuracy in machine tools and is advancing automation at a rapid pace in the manufacturing and aerospace industries.

> The introduction of robot welders in automobile assembly has resulted in a boost of 20% in productivity, at a reduction of 10% in the labor force at the General Motors Plant in Fordstown, Ohio (Norman, 1981).

In addition to robots which weld machine parts or load and unload materials, new mobile transport robots are being used in a West Germany Opel plant. They look like simple pallet trucks but can move about the plant unaided by human beings (Quinlan, 1983). This transport development has the ability to tie the CAM manufacturing centers together and advance manufacturing processes toward the totally automated plant.

<u>Education</u>

The implications for education in a high technology society are of course obvious. We will need to provide the type of experiences in our public schools that will help our students understand modern technology and introduce them to the new occupational opportunities that they may have in the future. In addition to a strong background in science and math, our students will need to try out some of the high technology systems. According to Bottoms

> We have to look at some kind of super tech curriculum for high technology. It will be systems oriented, developing a combination of skills in such areas as electrical, mechanical, fluids, thermal, optical and microcomputers. It will have a strong technical base, and allow people the capability to continue to learn as the technology changes (1982).

The systems approach that Bottoms has alluded to is right on target with the recommendations of the National Standards for Industrial Arts Study and the position of the American Industrial Arts Association. The systems of communication, manufacturing, construction and transportation should replace the traditional areas of woods, metals, power, drawing and graphic arts if we truly intend to prepare our youth for the High Technology Era.

The systems approach that Bottoms has alluded to is right on target with the recommendations of the National Standards for Industrial Arts Study and the position of the American Industrial Arts Association. The systems of communication, manufacturing, construction and transportation should replace the traditional areas of woods, metals, power, drawing and graphic arts if we truly intend to prepare our youth for the High Technology Era.

<u>Manufacturing Simulations</u>

The high school manufacturing class in industrial arts has several distinct advantages over the junior high school manufacturing class. Because the students are older and have a better technical background, they can design more complex manufacturing systems (Wright, 1981). A simulation part of the class includes role playing management and labor positions as well as setting up some type of materials processing system. It is this latter area that we need to update and develop if we want to prepare our students for the High Technology Era. The hand processed simple line production simulation that we have used in the past must give way to the use of automatic processing and transportation systems controlled by microswitches, cams, memory drums and of course, microprocessors.

The standard laboratory equipment in the industrial arts program is ideal for simulating automatic equipment. The table top drill press is easily converted to pneumatic power and micro-switch control. Single axis equipment such as the drill press, radial arm saw, powered mitre box saw and a number of sanding machines adapt very well to up/down or on/off control devices. Ideally, the class should start with simple controls such as micro-switches or cam devices. The next step is to try to process the complete operation without human intervention. Figure 1 shows how a powered mitre box saw has been set up to clamp the stock in place and automatically cut the 45 degree mitre of a clock door.

The basic circuitry is designed to control air flow with mechanical flow valves, operated by 12 volt micro on/off switches. The limitation of this type of automatic simulation is based on the fact that the action is either full on or full off. Pneumatic cylinders are used for the simulation because they are clean and within the price range of the average school shop budget.

The next level of sophistication is to replace the on/off human control with a programmed microprocessor. The microprocessor has the ability to provide on, off and duration commands which are delivered in the form of 5 volt electrical pulses. Because 5 volts is too low to activate a microswitch, an amplifier/driver circuit is used with the auxiliary power supply. The latch circuit is used to control the on/off drive. A pulse will turn it on and another pulse will turn it off. The time between the pulses is programmed into the microprocessor. Most all microprocessors have this capability to deliver a 5 volt control pulse, and just about every school has several microprocessors available. Figure 2 shows a simple block diagram of microprocessor control theory.

In Figure 3, and IMSAI 8080 mircroprocessor provides control to two pneumatic cylinders which make up a load/unload industrial robot simulation. This robot can be used to teach students how to program in BASIC and can also be used with another machine (or group of machines) to load and unload materials.

In practice, the Research and Development team is expanded in the high tech student enterprise to include this type of specialized automatic tooling along with the regular task of designing jigs and fixtures. The outcome of this simulated processing approach is exciting and technically appropriate for today's industrial needs.

<u>Transportation Simulations</u>

The simulation of modern processing technology is based on manufacturing centers which are set up by processes. Robots are used to load and unload machines and either stack parts or pallets or drop them on to a conveyor belt. Both types of transportation systems can be simulated in the industrial arts laboratory.

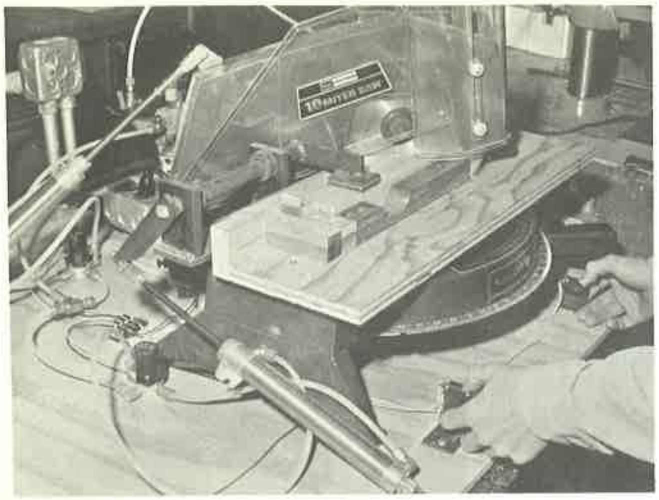


FIGURE 1:

This picture shows a power mitre box saw that has been converted into a pneumatic powered and micro switch controlled machine. By pressing both micro switches, the material is automatically clamped and cut at the same time. It is safe because both hands are required to operate the dual micro switches.

Microprocesser Control Theory

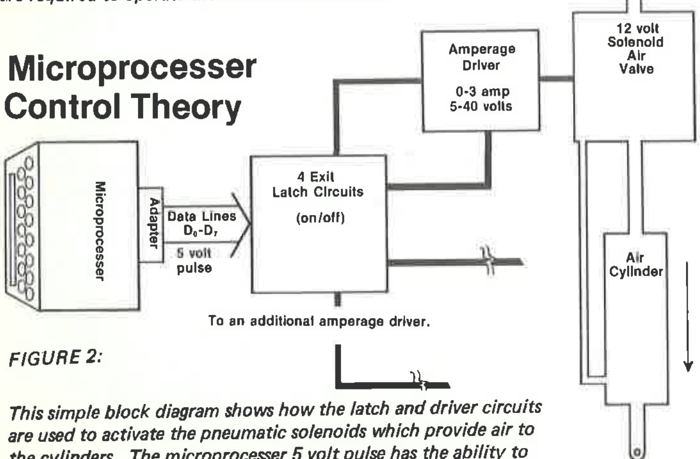


FIGURE 2:

This simple block diagram shows how the latch and driver circuits are used to activate the pneumatic solenoids which provide air to the cylinders. The microprocesser 5 volt pulse has the ability to turn on and off the latch curcuit based on simple programming.

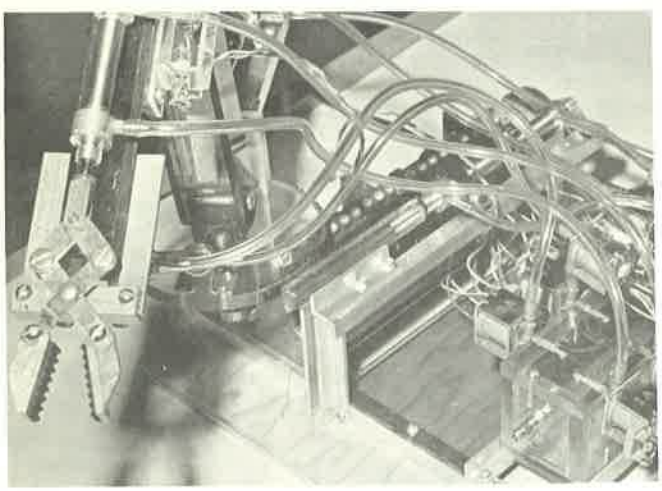


FIGURE 4:

Controls for robots can be simple mechanical devices or the programable microprocesser type. Low cost Bimba pneumatic cylinders come in a variety of sizes and types. In this picture a small Bimba cylinder controls the grippers for a pick and place task.

FIGURE 3:

A simple robot can be constructed using pneumatic cylinders and solenoids, air flow valves, latch and driver curcuits, a 12 volt power supply and a microprocesser. The basic parts of this load and unload robot are less that $200.00 (excluding the micro-processer). Most schools have several microprocessers and can afford afford the cost of the robot parts. Students really enjoy the challenge of building pick and place robots.

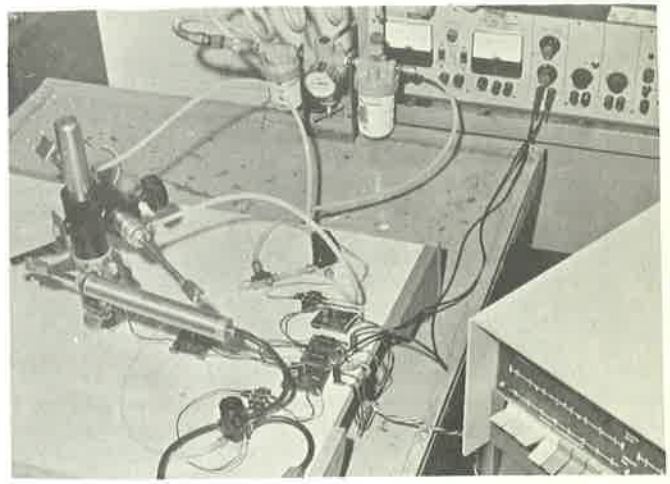
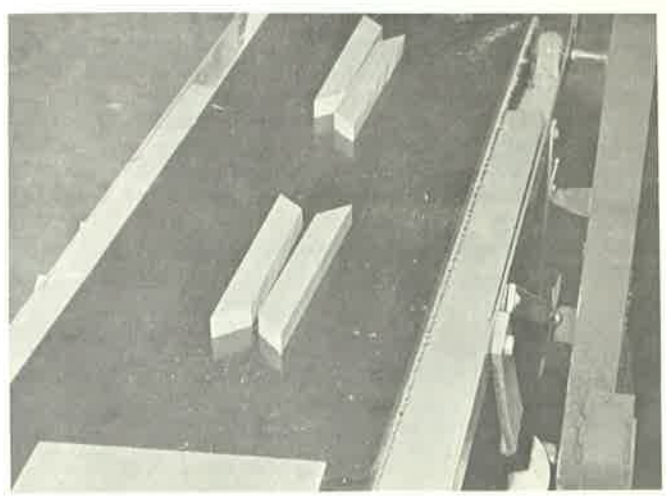


FIGURE 5:

Conveyer belts can be used to transport parts from one manufacturing center to another. A microprocesser can be used to time both the manufacturing and transportation processes for future decision making. Belts can be made from old wringer washer machines and a used farm pvc belt.



Low cost conveyor belts can be fabricated using the parts of a wringer-type washing machine (Wright, 1978). Two angle iron rails with pillow block bearings hold the rollers which are powered by the washing machine motor and transmission. In Figure 5, parts are shown traveling down the conveyor belt on their way to the next manufacturing center. For continuous manufacturing simulations, the entire sequence (manufacturing and transportation) can be timed and analyzed using the microprocessor. For batch manufacturing simulations, tote buckets or hand trucks are usually used. These can be replaced with moving transportation robots which are powered by step motors, automobile starters (with 12 volt battery), or electromagnetic monorail vehicles. Guidance and control can be simulated by mechanical rails, pick-up magnetic strips, or bumper paths installed on the laboratory floor.

Timing the Line with a Microprocessor

Every microprocessor can also handle a program called the Critical Path Method (CPM). In simple terms, each process on the line is timed with a stopwatch and recorded for minimum and maximum times in seconds. This data is fed into the microprocessor station by station until all stations are recorded. The computer will determine the critical path (longest distance of time) of the line production. Tooling may be added or processes consolidated until the most efficient line is developed. On the day of the manufacturing run, you'll find less 'bottlenecks' and problems as a result of this effort.

In addition, the inventory of supplies for the enterprise can be kept on a disc and a simple cost analysis would be available on demand. Hook it up to a printer and get weekly account reports, item analysis, and CPM printouts for the R&D group. All this can be done in the simulated high tech manufacturing class just like it is done in industry.

Conclusion

The literature is replete with the implications of the high technology industrial systems of the future. The need for public school programs to focus on the math, science, computer, and technological literacy aspects of basic education is real. We must respond in industrial arts with classes which make use of the new technology (including the microprocessor) and simulate the industrial system and technology of the future. We can do that in each of our technological systems. Manufacturing, as one of the systems, can make its contribution to the total effort if we update our processing techniques. We may not be able to afford the expensive industrial equipment in this new era, but our ability to simulate that technology is only limited by our imagination.

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Communication Technology: Unlimited Possibilities for the High Tech Society

By Frank R. Trocki

Approximately fifteen years ago futurists such as Bell, Kahn, and McHale wrote that our society had entered a new industrial state. The term 'post-industrial society' was coined to identify the new composition of our industrial and business institutions. From this point in time, as technological progress skyrocketed, other writers created other cliches to help define the numerous technical, social, and cultural developments, changes, and problems transcending all of our basic institutions. Some of these included: 'The second industrial revolution,' 'The nuclear family,' 'God is dead,' 'Participatory democracy,' and 'Technological literacy.' As the eighties began, a new buzz word, 'high tech,' started to capture the hearts of educators, salespeople, industrialists, politicians at all levels, as well as the under/unemployed.

The reason for the creation of this new term, which has been used to describe an industry, a national priority, a society, is the direct result of a technological development, the computer. Its evolution has enabled industries to interface it with other machines: to increase productivity; to accomplish tasks that are considered hazardous; or to allow for the operation of the third shift without humans on the premises. Its continued development has allowed us to use this tool in our homes, at a relatively low cost, to create budgets, shop, bank, and play games.

Using systems such as "The Source" or "CompuServe" in the home, school, or office gives us the power to communicate instantly with an individual, with several, or with special interest groups (SIG's) in North and South America. Each allows us to obtain the latest news, weather, or sports from either UPI, AP, or regional newspapers. It may be used to tutor our children/students in preparing for college entrance exams or to aid us in selling, exchanging, or bartering for goods and services. Most importantly, these systems give us the power to store and retrieve the information at a later date, immediately obtain a printed, and if desired, edited, version of the information, and finally, if one wants, strike the images

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from the CRT with the speed of light.

These are impressive applications of a technology that has evolved over the past thirty years and, based on its projected potential, is still considered to be in its infancy. However, accompanying any technological development comes social, political, economic, and educational consequences and commitments. Depending upon the type of decision or direction taken, the computer may create conflict, confusion, anxiety, despair, or as Alvin Toffler wrote, future shock. Therefore, all our institutions must determine: 1) appropriate uses for this phenomenal tool; 2) include an identification of its positive and negative effects; 3) determine a method for the allocation of monies for purchasing and for further research.

More specifically, in higher education, teacher educators must not only determine how, but immediately begin to infuse information and activities on computer-aided management and instruction for education (CAMIE) in their pre-service and inservice courses and workshops. To accomplish this objective, ready-made or individually developed software may be used. Either direction is appropriate because the most important consideration to remember is the commitment to implement. However, doing this may invoke or cause the following changes:

- Retraining teacher educators
- Realizing the fact that we have entered an information age with knowledge accumulating at an exponential rate
- Determining what is necessary to know for teaching in a high-tech society and exclude what is not necessary
- Challenging myths
- Revising courses with possible course development
- Restructuring program scope and sequence
- Deleting programs
- Changing teacher certification requirements
- Increasing funding for hardware and software

The communication technology core curriculum in the School of Technology at Eastern Illinois University has undergone many of these changes to meet the challenge of preparing communication teachers to teach in a high-tech society. The program's basic philosophy advocates the study of communication technology through the presentation of universal concepts identified in the literature, by industrial experts, and through advisory board and faculty consultation. Through an identified core of six courses (19 hours) an individual will gain knowledge and develop competencies in two major divisions of communication technology, visual and electronic. The application and effects of the computer are infused into each of these divisions.

Visuals

The technical content of this division is derived from the areas of graphics and graphic arts. All students are exposed to concepts in technical, production, and architectural drafting and design. Approximately eighty percent of laboratory time is devoted to traditional board work. However, students spend approximately ten percent of their laboratory time developing basic computer-aided design and drafting (CADD) skills using inexpensive color computer systems with tablet digitizers. This approach was adopted due to the prohibitive cost of 'industrial' type computer graphic systems which many universities and public school could not afford, and keeping in mind the level of sophistication necessary for exploratory courses and programs at the public school level. It must be remembered that it is not the cost of equipment but whether the appropriate concepts can be taught through simulation, with the nature of the future learner taken into account, that is important. An inexpensive color computer accomplishes these objectives and provides computer literacy.

Graphic arts content primarily deals with the generation of images to be reproduced using both the photo-offset lithographic and screen printing processes. Concepts of image preparation (layout, design, typography, typesetting, pasteup), image development (continuous tone and line photography, stripping, platemaking), as well as the actual reproduction are stressed. Much of the information in this area appears to be traditional. However, innovative concepts and activities are introduced.

For example, each student must become proficient in the use of the microcomputer as a wordprocessor. This skill enables the students to prepare their manuscripts for a journal that is produced at Eastern. The magazine, Communication Forum, is entirely created (using many student generated articles), printed, and distributed by the students. The students also learn to use the micro as an information source. Articles are accepted via the telephone, research is conducted using "CompuServe", and ideas are exchanged through the CB simulator and selected SIG's. Four major goals are accomplished through this activity. The lifecycle of a magazine is illustrated; the importance of planning, consistency, layout and pasteup work, are better understood and appreciated; it serves as a prelude to the senior level Production Systems course which utilizes a similar but more intense organizational approach; and most importantly, the significance of the computer as an information data-based and communication device is rationalized and mastered.

Electronic

Eastern's Television and Radio Center serves as the classroom and primary laboratory for this area. The program is under the auspices of the Vice-President's office rather than a particular school or department. This allows all interested persons to schedule and use the facility on an equal basis. Instruction in the use of the television studio, control and editing rooms, camera and ancillary equipment, is handled by the assigned instructor with the assistance of the center's technicians.

Students, who work in teams of four to five, are responsible for designing, developing, and producing a ten minute minimum television program concerning a social/cultural effect of communication technology. If the final product(s) meets the standards of the center's director, the segment is aired on the university's cable station as part of a half-hour magazine format type show. If not, each student has gained valuable experience in a medium that seems, at times, to dominate not only our lives, but those of our students.

Very little time is actually devoted to this area of study and development. This is unfortunate considering the importance and effect of this technology now and in the future. An interactive television system, coupled with the computer, fiber optics, and satellite transmission capabilities, offers unlimited potential for a wired and truly global society.

However, until present certification laws are changed, graphics and graphic arts concepts will dominate our instruction. This is not to be misconstrued as a negative statement, especially if the computer is infused into the current instructional program. Nevertheless, the importance of this technology must be considered and possibly be given an equal instruction time in the future.

A problem with moving in this direction is that it brings up other questions. What does one include, exclude, or delete from the program considering the ever increasing generation of knowledge? Who does the retraining or, most importantly, must receive the retraining? Many questions remain unanswered for the high-tech society in which we live. There are, however, existing and exciting alternatives and possibilities from which to choose. Considering our ability to exchange, store, and retrieve information and ideas. a multitude of possibilities will be created for the future. All it takes is a commitment.

Production: The Practitioner's Perspective

By John W. Sinn

Production is a significant part of modern life. Defined as providing goods and services, virtually all people are directly affected by production. either in the act of producing, or through consumption of products. As such. all human endeavors are interrelated to production. Examples of production interrelationships could include producing world food supplies through agriculture, constructing bridges and roadways for transportation. manufacturing computers and telephones for communications, and servicing the production systems in each of these same examples. Within this context, however, production requires specific functional components. regardless of culture or type of product. The 'functional components' are viewed not only as necessary for all forms of production. but perhaps equally as significant, the components are universal in nature with all production acts governed to some extent by the components as part of their functioning.

This paper will address the major universal production 'functional components.' These include productivity. quality. research design and development. time and motion, cost analysis, processing, safety, and materials requirements planning. Each component provides key areas needing to be addressed by educators concerned about production. This article includes recommendations for specific courses in university-level industrial education programs. At the secondary level it is assumed that much of what will be discussed could be integrated into existing courses. In all cases, however. the following is viewed as relevant and necessary content for programs concerned with education about production technologies and industries.

One of the first and most important areas to be studied as a key component in production is productivity. Productivity is a basic industrial issue today because many American industrial enterprises simply are not producing as efficiently as enterprises from some other parts of the world. The productivity problem has permeated the American society to such an extent that many industrial workers really do not understand that there are more productive methods available for producing industrial products. American producers must get increased productivity out of the same inputs--competing better using the same workers. materials. finances. machinery and so on. Teachers of production should discuss what productivity is and what it means to individuals and the industries in general. Our students must understand, in economic terms, the implications of productivity. or lack of it. We should teach about what makes a company tick--it's inputs. general activities. problems. production schedules, costs, what the competition is doing, and so on. In this way students may gain a better understanding of why they must be productive.

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Production educators must teach about building quality products in an efficient manner. Quality has long been a trademark of industrial educators. often under the guise of craftsmanship. The task now is to combine a reasonable balance of quality and efficiency. It is not acceptable in modern industry to only make the product quickly. at the expense of quality. or to build the product of high quality at the expense of efficiency. Rather. students must be taught that they need to work efficiently and obtain good quality in the process (Steiger Interview). Moreover. students should be helped to understand that each time a product is rejected in quality assurance. time was lost. either due to scrap or for additional re-work. In either case. the extra man-hours bring down the overall productivity of the industry. The point is. students should. under no circumstances. be given the impression that they can be 'Master Tinkers,' puttering along in a craftsmanlike manner to accomplish their task. Production students must be taught to aggressively, efficiently and competently accomplish their tasks.

Another area which should be studied in production is research. design and development. Research and development has been studied in industrial education in the past under the guise of project building and problem solving. The concept and skill of researching and developing, logically and scientifically. including problem identification, analysis. information gathering. etc.. should be pursued as related to appropriate industrial types of problems and content. The problems pursued through research and development should not be done for activities sake. but like actual industry. they should be done to generate new methods for production, new knowledge, products. and so on. The point is. and this should be stressed with students. research and development brings forth areas for industrial production of the future. Related to research and development. design is a significant industrial activity where basic decisions about materials and processes are made for later production. If sufficient design work is completed prior to the start-up of production, fewer problems will exist during production. The significance of this point can be noted by observing the difficulties in trying to make improvements in workers and systems 'after the fact' rather than in the planning stages (Bolz. 1977). As part of product design for production. experimental models and prototypes should be fabricated. Made from various materials. models should be constructed to give a three-dimensional form to design ideas. This should take place early in the process of designing a product and may be repeated at various stages of development. Following various models, prototypes should be constructed to full/part scale to present an accurate working representation of the proposed product. There may be several prototypes for a single design function. Much useful information can be obtained from these prototypes. each contributing to the final product. when the following functions are addressed:

1. Design the product to be made with existing equipment
2. Determine/prepare specifications to be used in production
3. Test performance of the product to determine whether or not it performs the intended function
4. Follow the product through production and assist with problems that may occur (Continuum Educational Enterprises)

Additional design questions which should be considered by production students in an attempt to study product cost reductions, could include:

1. Can parts/components/materials be eliminated?
2. Can functions of parts in the product by combined/simplified?
3. Can material or processing requirements be substituted to make the design more cost effective?
4. Can the product be redesigned to incorporate upgraded-efficiency processing, assuming a different process can be purchased? (Moski. 1980)

A fourth area for study in production is time and motion. Time and motion study is an attempt to determine and improve time and movement inputs, leading to increased productivity. Time and motion generally provides details such as process symbols and descriptions. time recordings and their averages. cost columns. and foreign elements such as breaks, interruptions. etc. It has long been known that time and motion studies, when properly used. could improve production. Students. as prospective workers. should be taught both the concept and process of time and motion.

Related to time and motion studies. another area which should be studied as part of production is production planning and control. including plant layout and flow charting. Process flow charting uses symbols placed in a condensed production format. connected.and numbers are placed in the symbol to correspond to a chart with all procedures for producing the product listed. The advantages of process flow charting is that the entire production system (or a sub-component) can be analyzed from a graphical schematic (Stallsmith. 1982). Times and costs can be placed alongside each process on the chart, permitting further comparison and analysis. Time and motion as related to planning and control in production should account for the following considerations:

1. Standards should be established for each task/activity in the production setting
2. Costs as related to established times must be controlled or reduced
3. The question. 'is there a better. more efficient method, for accomplishing a task?" should always be paramount
4. Observe performance trends. over time, related to established standards, and be prepared to act to improve trends if it is warranted (McNesby. 1978).

Similarly, by placing the plant layout in schematic diagram form. analysis can readily identify obvious trouble spots. For example, if in studying the layout diagram it is observed that some space is not being fully used, the prudent manager would attempt to better maximize on the space. Production educators should teach about various production layouts as well as the various symbols. general relationships and so on. involved in plant layout and flow diagramming. Students should observe through actual and simulated production problems how the layout and flow diagrams can prove useful in personnel and machinery allocation. both on a day-to-day basis as well as for plant/capital expansion in the future. Relationships of people. machinery, and materials movement should be carefully analyzed to determine lengthy (costly) movements and potential bottlenecks or other costly down-time possibilities (Kemmet. 1980).

Another tool useful in explaining production is cost analysis. Cost analysis is simply a technique of identifying cost inputs for analysis and cost reduction relative to a given product (Chaplin. 1976). One approach which can be used for general cost analysis includes cost categories for information about part name. materials specifications and cost. labor inputs. and labor costs. A simpler approach sometimes used provides an itemized listing of cost inputs for the product. Other cost analysis factors which should be studies as part of production include various break-even analysis methods. The break-even cost analysis can aid in determining production and profit levels as well as which maohine will be most cost effective in the production setting. Another cost analysis tool which should be studied by production students is related to capital investment. This area is becoming increasingly important since monies for investment and expansion must be used very prudently. Typical capital investment approaches used in industry include depreciation. rate of return. return on investment. present value, and others. Assuming adequate capital expansion cost analysis. break-even analysis. and general cost analysis is pursued, it can aid in keeping production at competitive levels.

Students must study production processes as related to the larger issues of production. Most traditional industrial education programs have studied production processes in a limited sense, working with a limited number of machines and how to run them. We must now do more than simply teach how to run the machines. We must now teach what each machine or process is capable of doing, how to most efficiently perform the operations. the process advantages and disadvantages, general economics of choosing one machine/process over another, how to set-up and train for one machine/process over another, how to set-up and train for major processes. and so on. It is important for our graduates to know how to control, select, maintain. train for. and most importantly. obtain optimum efficiency of operation on a given process. If a product or subcomponent is being analyzed for cost reduction, analysts can conduct studies to determine the most cost effective and productive process. Process advantages and disadvantages (capabilities/limitations) can be listed for comparison and ultimately, optimal processing capability. Additional typical production process areas to study for cost reductions and increases in productivity within production classes might include the following questions:

1. Can some operations be eliminated or combined?
2. Can the efficiency of the operation be upgraded?
3. Can some processing components be recycled or reclaimed?

Related to processing. production students should study maintenance. Maintenance is an attempt to keep production equipment operating at an acceptable level. Effective maintenance helps insure production by influencing the useful life of equipment. Product quality and equipment salvage value are also directly contingent on maintenance activities. Production students should study about and become involved with several basic maintenance decisions relating to maintenance management for optimum functioning:

1. Maintenance Organization. Should it be centralized or decentralized? How much should the machine operator do? How is maintenance supervised?
2. Contract versus in-house maintenance. Should all (or any?) maintenance be done by enterprise personnel?
3. Repair versus replacement. When should equipment be replaced rather than simply repaired?

4. Individual versus group replacement. If the enterrpise uses many of the same machines should each be replaced when it breaks down or should all like-machines be replaced simultaneously?

Production students should study computer aided design (CAD) and computer aided manufacturing (CAM) as part of their education. CAD permits a designer to work at the screen of an interactive graphics terminal to develop a geometric model which describes the size and shape of a component to be produced. At a basic level CAD-CAM interfaced provides a sophisticated system for combining design and manufacturing functions to increase efficiency. Essentially CAD-CAM systems use CAD generated functions with a single effort. In fact, many manufacturing operations are increasingly relying on CAD data to be used to program their numerical control tapes used for various shop floor operations (Krouse. 1981). When design. manufacture and control functions are combined it can approach being a computerized factory. Theoretically, an automated factory could be operated by an individual at a graphics terminal. developing a component design, feeding the design into NC equipment and monitoring and controlling with various scheduling, routing, inventory and other programs. If many systems are computerized in the continuous production setting, consistent work speeds, tool wear, materials flow, tool changing time, quality levels, and other factors can result in higher productivity. The computerized factory system has tighter control throughout, providing more predictable production circumstances and results. Another computer application which should be studied by production students is data collection and processing. For example. in an order processing situation, quantity and types of products ordered are entered into the computer when the order is received. The input is matched against the inventory and the inventory record is reduced. The computer prepares a shipping order. invoice record and shipment schedule, based on quantity. Other computer data collection and processing applications in production could include salary and wage payments, income tax withholdings. payroll deductions, among others. Production operations analysis is another computer application area which should be studied. The following decision making areas indicate common production operations analysis concerns for computer applications:

1. If a product can be made at more than one plant location, how much production should occur at each plant?
2. If products can be shipped from more than one plant or warehouse, which plant or warehouse should service which customers?
3. When and how often should materials be ordered from suppliers to keep inventory levels at minimum levels without creating production line shortages of materials?
4. To meet finished goods production requirements, how many machine-hours should be scheduled for next week? How many labor hours? How many shifts? Is overtime necessary (mcNesby, 1978)?

Materials requirement planning is an attempt to determine the most appropriate material, procure the material, place proper amounts of the material in a logical type of inventory system. and schedule the materials for production--all at optimum production levels. Materials and inventory requirements planning is particularly important due to the costs which are involved in materials planning, acquisition. and control, estimated to be among the highest costs in the production setting. Several material considerations must be addressed to determine the most productive material for a given product. These include design of the product, its service requirements, and fabrication or processing requirements. It is suggested that the production curriculum should include material sciences courses where students study major industrial materials, what holds them together, where they come from. how they are refined. properties and characteristics, testing and inspection, major applications, and so on. Due to high interest rates, high storage costs. and other general costs, materials are a major cost factor in production. Materials costs. if reduced, could be used in more productive ways associated with capital investment. product development. and so on. Several materials and inventory management tools are available for study in production. including procurement costs, carrying costs, total incremental costs, economic order quantities and reorder point. all relating to materials requirements planning. Materials requirements planning (MRP) is a system useful for obtaining optimum production which permits industries to accurately plan material needs for upcoming production, thus working to capacity. Although frequently done by computer. particularly in the case of complicated products, the concept can be useful in all production settings (computerized or not). MRP systems simply analyze how many parts are needed for each subassembly in a product and determine when they will be needed in production. Materials and inventory requirements planning are essential production components needing to be studied by production students.

Another curricular area to be studied as part of production is safety. The basic reason for safety programs is to prevent injury or loss of life. However, it is also true that the motivation for safety programming often is economic, due to lost time and increased production costs. Dollars invested by industry in safety can pay subtantial returns due to less down time, increased worker morale and motivation, increased quality and productivity, and in other ways. The major responsibility of the safety program is to provide a safe working environment for workers. As such, safety programming is responsible for four basic functions: 1) establishing an organization for accident prevention; 2) surveying hazards and carrying out engineering; 3) compiling and analyzing accident records; and 4) eliminating hazards through revision of facilities, safety education, and enforcement of safety rules and practices. The size and tupe of production operation and the magnitude of hazards determine the type and size of the safety program. The safety organization is in charge of all safety work including motivation for safety and advising operation executives. Accident prevention should begin on the drawing boards and in the planning stages of production to eliminate possible hazards. At the outset, structural drawings, floor plans and equipment. processes.and product designs must all be periodically reviewed. Students should be taught to periodically inspect operations and facilities to check compliance with safety rules and practices and to remove all hazards. Students should learn to compile accident reports which include such information as persons injured. equipment involved, nature of the work being done, and cause as noted by witnesses. foreman and the injured worker. Production students should study how to personally investigate serious accidents and analyze the report ana statistics as a guide to future prevention since the information often reveals a point of danger and necessary remedial measures.

Summary and Conclusion

Summarizing. production was defined from the practitioner's perspective as providing goods and services. Within the context of production interrelationships several 'functional components,' necessary and universal for all production acts. were presented. Included as 'functional components' were productivity, quality. research. design and development. time and motion, cost analysis, processing, safety, and materials requirements planning.

Concluding, production functions as described in the above writing can, and should, be taught at various levels in our educational system. The study of production content, activity and relationships as outlined in these writings can provide one of the single most powerful curricular areas of study related to industry and technology in our culture.

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Instruction for High School Technology Education Programs and Practices

By Robert A. Daiber

Instructional designs to help high school students learn about technology are in a developmental stage. Professors of the philosophy of technology education have formally met at four symposiums this decade to discuss revising the instructional programs and practices of industrial arts for the post-industrial era. The what to teach question has to a large extent been synthesized and answered. A majority of publications concerning the theory of technology education for high school programs focus upon utilizing a conceptual approach to select content for instruction. This learning process analyzes the study of technology in a multidimensional structure which includes three contexts communication, production, and transportation. Each context is composed of technical and social-cultural components which exist in levels of complexity. McCory (1980) and Bender (1982) have made an attempt to explain in totality this multidimensional perspective of studying technology.

The issue which remains to be dealt with concerns the implementation of instructional programs and classroom practices in school systems. Pioneers in the field of technology education have implemented programs and practices in Illinois (Triad High School), Wisconsin (Wild Rose High School), and West Virginia county schools. These curriculum revisions have attempted to develop instructional strategies to educate students about technology. It is important to identify a sequential method by which other practitioners can accomplish this task in an organized and meaningful format, rather than allow them to haphazardly develop instructional designs.

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Photographs by Jeff Rice, a technology education student at Triad High School.

Programs

The initial step in creating an instructional program for high school students begins with identifying a program rationale. An instructional assessment of current industrial arts programs may provide teachers and administrators with justification to restate the purpose of this subject area. Irrelevant subject materials may be evident by the lack of student motivation and teacher interest to maintain beneficial learning experiences in the classroom. Such deficiencies may be detected through using the Standards for industrial arts programs (Dugger, 1981) as an assessment instrument.

The rationale to revise current programs may imply the importance of meeting the cultural needs of students living in a technological society. This instructional aim may further mention new technological concepts which will help revitalize the teacher burnout syndrome and begin a new meaning for industrial arts--educating students about technology.

Next, a list of program objectives need to be formulated to support the rationale and to provide a basis from which the course of instruction for technology education can be developed. Presently, several major objectives are apparent for high school teachers to consider:

1. Provide students with a general understanding of technology (defining what is technology, identifying what technology is appropriate for human usage, determining the cause and effect of technological change)
2. Develop student's technical skills through hands-on application of modern tools, machines, materials, techniques, and technical information which relate to the technical adaptive systems of communication, production, and transportation
3. Further develop student's social-cultural skills which increase their capabilities to decision-

make, problem-solve, communicate, and cope as consumers, citizens and employees in a changing world
4. Contribute to the growth and development of student's technological literacy in the high school.

These objectives will need to be more specifically stated by eAch school program to provide support for a curriculum framework and illustrate consistency with the overall goals of the high school. The program framework which is prepared by instructors should be consistent with the conceptual approach. Ideally, course sequences will be developed for each major context of technology. Figure 1 depicts an example of a sequential model which may provide insights for high school personnel. Instructors may also find it beneficial to refer to the Jackson's Mill industrial arts curriculum theory to analyze program models for small, mid-size, and large school programs.

Practices

A real technology education program will have instructional practices which are meaningful, fulfilling, and reinforcing to the program rationale, objectives, and courses. This statement implies a program transition will be more than a name change of the program and courses. The content of each new course outline will include technical and social-cultural aspects. In developing instructional materials, teachers will need to emphasize:
1. New technical developments which are significant to the re-industrialization process of the 1980's (robotics, microelectronics, computerization, etc.)
2. Terminology which explains the functions of new technical developments (microprogramming, monitors, fiber optics, etc.)
3. The effects technology is having on people (changes in occupations, values, lifestyles, etc.).

Instruction which reflects these key points will help students cope in today's increasing high technology culture.

A question which is commonly asked by many industrial arts teachers is: How do instructors teach subject matter of this nature in traditional industrial arts facilities? This task can be accomplished through well-designed instructional strategies. A variety of teaching techniques may need to be utilized to provide learning experiences which will explain technology-based subject matter to students. The following is a list of instructional strategies accompanied with explanations regarding how the learning units will contribute to student's technology education.

Building Projects - Many different forms of projects can be designed to help students understand communication, production, and transportation technology. The use of modern tools, materials, processes, and component parts in constructing projects of contemporary design will further develop student's cognitive, psychomotor, and affective skills.

Constructing Scale Models - This hands-on approach to learning may be used as an aid in studying past, present, or future technology.

Discussing Technology - Formal and informal conversations with students are very much needed to help students understand new technology. Occasionally special discussion sessions may be held to provide student awareness of new technology and technological issues.

Experimenting - Laboratory experiments conducted by teachers and students provide the learner with an understanding of how different forms of technology are developed and the means by which the innovations operate. Experiments offer learning experiences which illustrate the importance of scientific methods.

Gaming - Utilizing games can provide an enjoyable learning experience for students in studying social-cultural aspects of technology.

Presenting - Classroom presentations which may consist of short reports concerning new technology provide a form of information sharing among students. Presentations also provide students the opportunity to use new technological terms and expand their vocabulary.

Reading - Students can further develop their understanding of technology by reading books, magazines, newspapers, and other literature. A technology bookshelf and bulletin board can be developed and maintained by students collecting and organizing interesting articles which pertain to different areas of technology.

Researching - Research activities involve technical and social-cultural endeavors. Students can conduct technical research to understand new tools, materials, and processes. They may also investigate social-cultural problems which may occur in their community or around the world as a result of the rapid growth of technology.

Role-playing - This strategy is used to help students understand the many different roles people play in today's technological world. The business manager, production worker, multinational corporate investor, and politician are several key roles which frequently appear in daily news reports.

Simulating - The facility in which technology education activities take place may be changed from one school shop setting to another in order to provide different learning environments. Students may need to rearrange work areas to film commercials for advertising products, pretend the facility is a high technology industry, or partition off a work area as if it were a dangerous construction site.

Visualizing - Visual aids help students understand aspects of technology that may otherwise be difficult for the teacher to explain. Filmstrips, slides, movies, and other audiovisual aids help to bring the real world into the classroom.

Writing - Technical reports, scenarios, and other writing tasks may be used to stimulate student's thinking about past, present, and future technological achievements.

Instructional practices for technology education can also utilize such strategies in providing advanced technical learning activities. Pictures 1, 2, and 3 depict a hands-on learning project in an advanced tech-

nology education class. These students are applying technical skills which they acquired throughout their technology education to construct a robotic arm. The project expresses a state-of-the-art development which is a true form of high technology. Although the actual building of the robotic arm involves technical skill development, the application of the robot to perform simple operations which will replace student workers will illustrate the social implications of new technology. Picture 4 illustrates two students presenting a scale model of an automated industry which utilizes robotic arms to manufacture products. The use of multiple instructional strategies in the learning unit

concerning robotics provide students with a clear realization of robot's functions and applications in high technology industries.

Learning Outcomes

If the instructional program and practices are well designed and inclusive of technology, then students who enroll in technology education classes should graduate from high school with a degree of technical and technological literacy. Students will benefit significantly from learning experiences which attempt to aid in the development of technical competency and social proficiency. These learning experiences will have short and long-term value for students throughout their life.

Upon immediate graduation from high school, student's technical skills may be the key for them to fulfill a job position. Fifty years in the future the same students may use the concepts of this technical knowledge to perform manipulative hands-on operations in new work roles or leisure activities. Consistently through the course of one's life, social-cultural skills are needed for communicative purposes, decision-making tasks, and problem-solving situations.

Most importantly, technology education helps learners become contributing members of society and maintain and advance the quality of life. The perception each student develops regarding their role in today's society may be directly affected by the education they receive in high school. Such factors as the school's geographic location, social-economic condition, and philosophy will contribute to the nature of learning that will occur in each program. The writers of the Jackson's Mill industrial arts curriculum theory formulated a list of assumptions which pertain to the learner.

1. Learners learn at different rates
2. Learners have different learning styles
3. Learners have different interests
4. Learners have different cultural backgrounds
5. Learners are not passive organisms
6. Learners should be held accountable for learning
7. Administrators, educators, and parents are accountable for facilitating learning (Snyder & Hales, 1981).

These assumptions provide an explanation of the reason learning outcomes will be different among students in technology education programs across the country. However, as stated by Wright (1980) all people should attain a level of technological literacy:

> As the levels of technological literacy are disclosed slowly and deliberately, each student can begin to develop an understanding of a very complex process. As the process continues, students will develop a literacy level which can help them make intelligent decisions about the use and control of technology throughout their lives.

Forward

A great effort is needed to advance the technology education movement at the high school level. Presently there exists an apparent uncertainty among members of the Industrial Arts profession concerning the adoption of new instructional designs. Some teachers in the field question whether or not the new curricula and approaches are correct for use in their state, while other instructors are unaware technology education even exists.

An article entitled 'Thoughts on why we haven't changed' by James LaPorte (1982) explains that material-based programs are still attracting students because they emphasize working on projects which students enjoy. Teachers who feel they have been successful in motivating students through building large wood or metal projects need to try applying such teaching methods to technology-related activities. The first time students feel warm water run from a solar collector they constructed, or witness the operation of a wind generator they built supply electricity which makes light bulbs burn, or watch a robot function that was designed and built in their school shop. the fascination of developing new technology occurs. The exclamation "It works!" and the excitement involved will far surpass the accomplishment of individual wood or metal projects in the student's minds.

The efforts which have been made by individuals this decade to develop instructional programs and practices for technology education cannot be considered complete. As technology continues to change. so must the instructional design of public school programs. If we fail to implement programs to educate students about technology, the United States may not remain a leader of the technology revolution in the future.

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Technology Education: The Question of Content Selection and Curriculum Development

By James Bensen

The Evolvement of an Idea

Technology education is a curriculum area that is attracting wide attention and an increasingly interested following. first being proposed by leaders such as William E. Warner, Delmar Olson and Paul DeVore, the concept has taken on maturity and refinement as a radical enhancement for the traditional industrial arts program. After a slow and halting start, spanning several decades, it appears that the concept is not only viable but is rapidly gaining in both acceptance and momentum.

A significant number of curriculum proposals on the local, state and national level are being made for improving programs through the implementation of technology education, and the future looks bright indeed!

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Technology and Industry: What Are They?

A study of the field of technology has revealed that the term 'technology' has been defined in hundreds of ways. Some of these definitions are quite casual such as 'know-how that extends the human potential' to carefully written comprehensive statements. For use in this discussion, technology is defined as:

> ...the knowledge and study of human endeavors in creating and using tools. techniques. resources, and systems to manage the man-made and natural environment for the purpose of extending human potential and the relationship of these to individuals. society and the civilization process (Hales & Snyder. 1981).

Technology is the dominant knowledge base used in industry. With the definition of industry as follows it is easy to see that the interface between these two is central to a large segment of productive activity in our society:

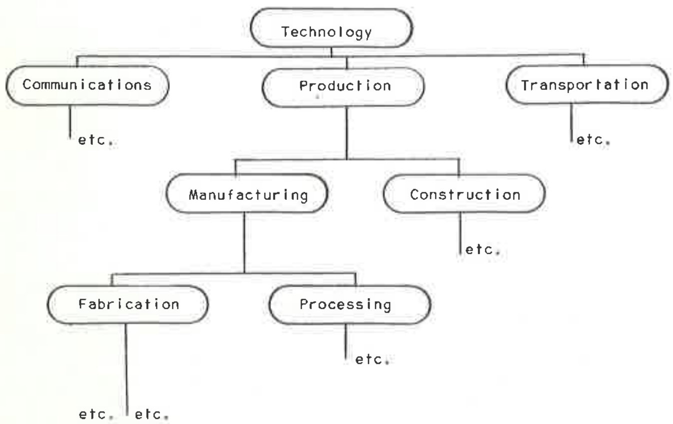
> ...that section of the societal economic institution that utilizes resources to produce goods. services. and information to meet

the needs and wants of individuals and society (Hales & Snyder. 1981).

With the framework of using technology within the societal institution of industry it can be readily seen that content selection and the resulting curriculum development process could take several differing approaches.

<u>Approaches to Content Selection</u>

There is a wide array of choices available to the technology education curriculum designer as to the approach that is taken in the selection of content. Each of these approaches, while focusing on the study of technology as it is used in the economic institution of industry, will provide quite a diverse and wide range of actual programs. A quick review of a selected number of these approaches illustrates the potential differences.



<u>The conceptual approach</u>. A well conceived study of technology from its conceptual perspective will lead to a very comprehensive program and one which is holistic and internally consistent. A conceptual approach usually takes the form of a taxonomy or model (two or three dimensional) which identifies the major concepts and a resulting descending order of subconcepts down to several identified levels. An example of a conceptual format is as follows:

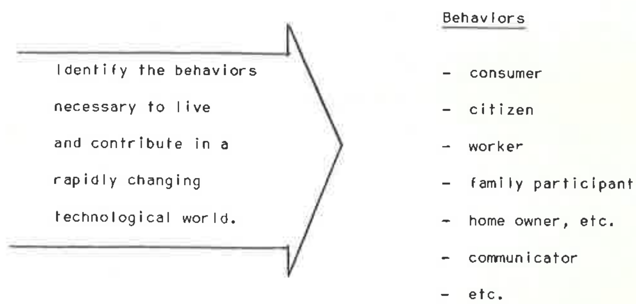
As one keeps analyzing these concepts, each one could be traced down to at least ten to twelve levels resulting in a vast conceptual structure to choose from when selecting content.

The conceptual organizer of content is a popular approach by many curriculum designers as it displays the whole field that is to be studied. It is also an excellent check and balance approach as areas that are over emphasized or left out become easy to spot.

<u>The behavioral approach</u>. The behavioral approach has received considerable attention from curriculum designers as they have followed the leadership in the competency based education movement. The task analysis approach is the primary method used in this process. While the behavioral approach has often been focused on the behaviors of 'work' it can be used for other identified behaviors as well:

We have become quite sophisticated in using this approach over the years in identifying work behaviors. Early roots in the Della Vos and trade and job analysis procedures have evolved into highly precise research oriented methods. Two major detractors from this approach that need considerably more work are 1) to be able to embrace and analyze behaviors other than work and 2) to be able to provide a more 'future focus' on the behaviors that are being identified. To date, we tend to over emphasize the 'what is' rather than 'what should be.'

<u>The engineering fields approach</u>. A study of technology around the engineering fields is a viable approach but one which has received little attention by technology education curriculum builders. Some attempts were made to provide engineering type experiences for young leaders in the <u>Engineering Concepts Curriculum Project</u> and the <u>Man-Made World</u>. These curriculum ventures focused on the engineering process and the societal context within which it is applied rather than placing an emphasis on the engineering fields. One could, however, propose a study of the engineering fields as follows:



mechanical
electrical
civil
industrial
chemical
aerospace
etc.

The selection of content around the engineering fields would provide a natural parallel to the science programs in the school and would tend to reduce any stigma or connection to our heritage of manual training which has tended to tarnish our image. A shortcoming of this approach is that other than the major titles of the field such as 'mechanical' or 'electrical' would have less direction in what actually would be selected as content for these areas.

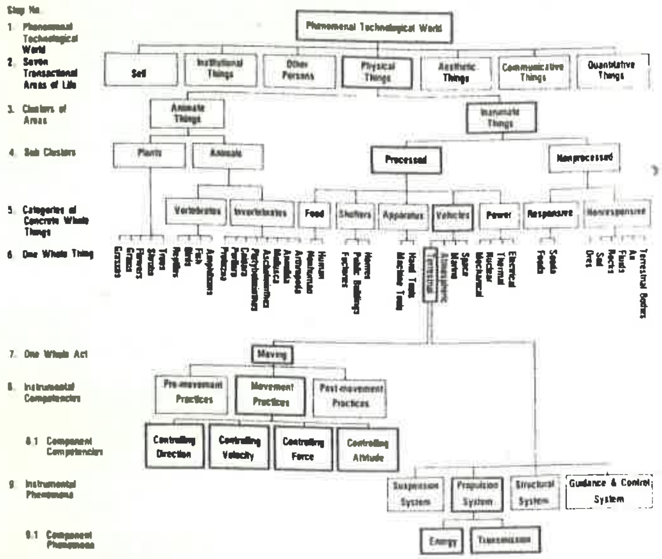
<u>The transactional analysis approach</u>. The attempt of a 'Texas Industrial Arts Curriculum Project.' (Pierson. 1974) was to analyze the transactions that take place between people and their phenomenal technological world.

As can readily be seen. the transactional analysis approach is a very comprehensive scheme for curriculum building. It is likewise somewhat cumbersome for the curriculum designer in building one articulated set of courses in establishing the overall program.

<u>The societal problems approach</u>. This is a very fluid and student centered approach to the study of technology. Problems are identified in society in such areas as transportation. communications. housing or shelter, etc. and students go to work on them to develop solutions. This approach has been widely used in various aspects of the Maryland Plan (Maley. 1973) and is usually directed to the various aspects of the time line of the past, present and future.

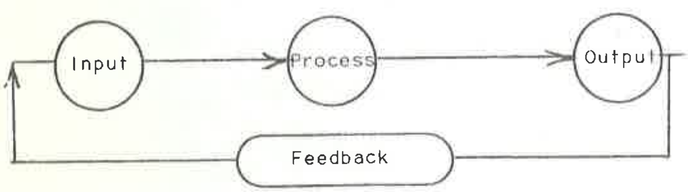
ANALYSIS OF TRANSACTIONS

(EXAMPLE OF THE CURRICULM DERIVATION PROCESS)



Since students approach the study from a research. experimentation, design and development perspective, the actual content that is 'covered' is somewhat dictated by the type and depth of the problems that have been identified and the ability of the individuals. There is virtually no ceiling on the curriculum and this approach does an exceptional job in meeting individual needs. Work is accomplished by the students on an individual. team or group basis.

__The systems approach.__ The systems approach is rapidly gaining in popularity as a way of structuring content And organizing the experiences of the technological process. Common subsystems which have



been identified in this approach are communications. construction. manufacturing and transportation. The power of the systems approach is that it can teach the universal process of technical systems as follows:

An additional feature of the systems approach is that it is an ideal vehicle to resolve the dicotomy that exists between programs which are based on the study of industry and those that are based on the study of technology. This unifying feature is illustrated below:

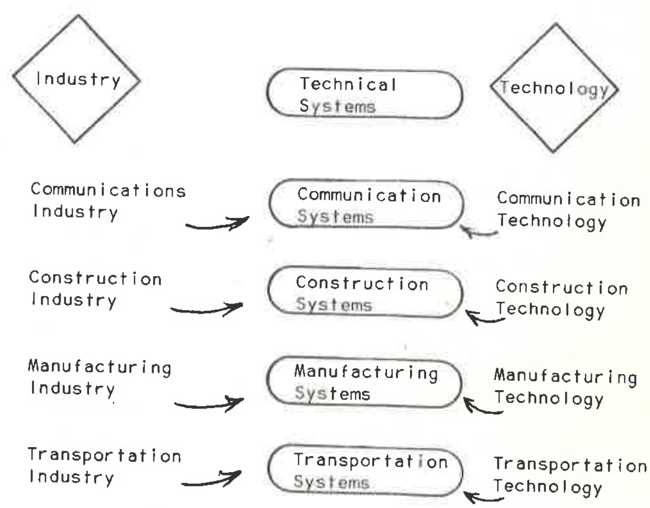
The systems approach is growing in popularity because it evolves in a close parallel to what is actually happening in the 'real world.' Systematic human activity is planned, organized. directed, and controlled. It is also dynamic and very representative of how we as humans continue to evolve our adaptive systems and technical means.

__The process of technology.__ Technology has a universal process that is transferable to the many situations that it is used to 'extend the human potential.' The processes were identified and validated by practitioners in technical fields through a Delphi process (Halfin. 1973). The processes are as follows:

- Defining the problem or opportunity operationally
- Observing
- Analyzing
- Visualizing
- Computing
- Communicating
- Measuring
- Predicting
- Questioning and hypothesizing
- Interpreting data
- Constructing models
- Experimenting
- Testing
- Designing
- Modeling
- Creating
- Managing

Content selected in this process approach would be similar to that of the 'societal problem' approach as described earlier except that the processes would be taught specifically rather than let them evolve from the problems. It is. hence. sort of 'universal' in approach. It is also noted that the process of technology has many similar elements to that of the processes of science.

The processes of technology can be structured into manageable 'sub-processes' which will focus on productive human activity. An organizational structure that is being used is the 'Curriculum implementation project' (Wright & Sterry) that brings together the universal processes of technology and the systems of



construction, communications, manufacturing and transportation.

This model also places emphasis on the consumer/user of technology as we interact in our technological world. Without this dimension. it would be difficult to function as truly technologically literate people.

Other Forces

__Technology factors.__ In addition to the variety of ways that we have available to us in content selection, we have other technological forces and phenomenon that must be taken into account when working as a curriculum designer. These factors need attention and will need to be blended into whatever selection approach is used.

Among these factors are:

- History of technology (heritage)
- Level of technology (high-intermedite-low)
- Appropriate technology (best use)
- Technology futures (alternatives to choose from)
- Technology assessment (impacts, problems, prospects)
- Technology transfer (other applications)
- Technology evolution (invention-innovation-diffusion)
- etc.

Methods of teaching. As the content is being selected, we need to be also asking ourselves the question of how the curriculum is going to be 'delivered' to the student. As each day progresses, we are seeing the communications revolution presenting new and highly useful ways to teach people. Tying together interactive systems of micro-main frame computers, satellites, fiber optics, laser read disks, television and software systems. we have a tremendously exciting future ahead.

Central to any delivery system or method of teaching in our field is the opportunity for our students to learn by doing. Interacting with tools, machines, ideas and materials is crucial and mandatory. Learners need to be making 'smoke, sparks and chips' every day in a meaningful way. Methodology, whether teacher directed or student centered. will have much to say as to the success of any program, regardless of the approach used for content selection.

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The "Illinois Plan" and Technology Education

By Thomas L. Erekson and Jule Dee Scarborough

A major state-wide curriculum development/implementation effort has been in operation in Illinois for the last four years. The focus of this effort has been to develop and field test a 'state-guide' for industrial education for grades K-adult. The Illinois Plan is a sequential, laboratory-based curricula that includes technical practices, industrial organization, and the role of technology in today's industrial society. In effect, the Illinois Plan is a major state-wide effort to implement many of the concepts of technology education in the public schools of the state.

The major goals of the Illinois Plan include:

1. To foster an awareness of the effects industrial and technical development have upon society,

2. To develop student's abilities to live and function in an industrial/technical society,

3. To teach students the skills necessary for participation in industrial/technical activities and

4. To prepare interested students for employment and/or upgrading in industrial/technical occupations.

There are five major components in the Illinois Plan for industrial education (see Figure 1). At the elementary level, the plan focuses on 'Industrial Studies Units.' These units will be stand-alone units of instruction to help elementary students become aware of the role of industry in our highly technical society. Suggested activities will be included as part of these units to assist elementary teachers in integrating industrial studies units into the regular curricula.

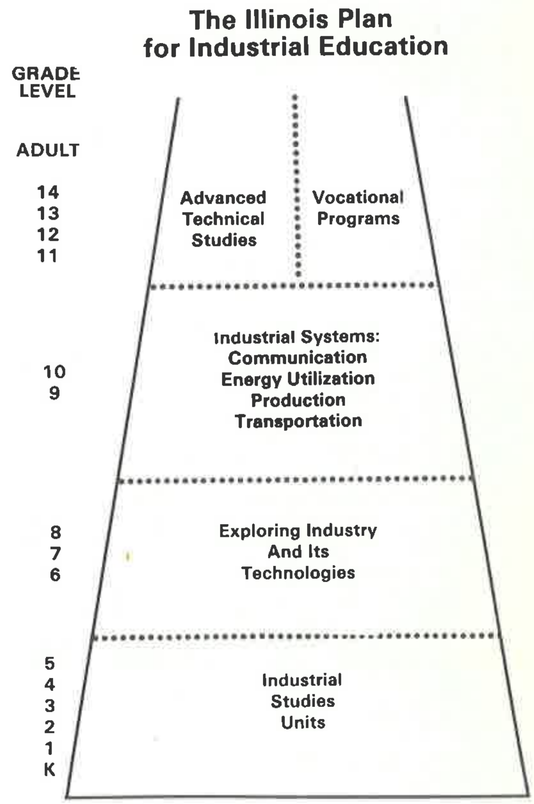
The focus of the Illinois Plan at the middle school/junior high school level will be on 'Exploring Industry and Its Technologies.' This exploration will come through instruction in materials and processes, manufacturing, and construction. Over 20 different three-week units of instruction will be developed for use by teachers at this level. Some titles for these units include:

printing messages
recycling industrial materials
communicating through drafting
conserving energy sources
identifying industrial careers
using the computer in industry
heating and refrigerating spaces
traveling through space
servicing industrial materials
researching and developing projects

The junior high teacher will be able to select from three-week units and structure a technology education experience for his/her students based upon the local needs and resources.

At the ninth and tenth grade levels, the Plan offers four semester-long courses to provide an orientation to industry through 'Industrial Systems.' The industrial systems that have been identified and developed as part of the Illinois Plan include Production Systems, Communication Systems, Energy Utilization Systems, and Transportation Systems. These courses have been structured focusing on the system's approach to allow for the curriculum materials and plans to be updated as technology changes.

At the 11th and 12th grade levels, and on into adulthood, the Illinois Plan offers two directions for industrial education students. One of the directions is the traditional vocational education programs, or trade and industrial education. These programs and courses are intended to develop skills to prepare the students into entry level employment in various industrial occupations.



The other avenue for study at the 11th and 12 grade levels and on into adulthood as proposed in the Illinois Plan is 'Advanced Technical Studies.' The advanced technical studies part of the curricula will allow students to pursue in greater depth those technical and technological aspects of industry in our society. The developers of the Illinois Plan describe the advanced technical studies as:

> the upper senior high through adult level courses that are proposed to provide students with the opportunity and technical knowledge and skills to solve problems related to industry and technology. These courses are

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envisioned and being individualized laboratory-based offerings that will help students move into high technology areas as they continue their education.

The inclusion of advanced technical studies as part of the Illinois plan for industrial education is significant because industrial education has often assumed the capstone experiences to be trade and industrial education. The Illinois Plan formally recognizes that there are other capstoning educational experiences in industrial/technology education in addition to the traditional trade and industrial experiences.

Implementing the Illinois Plan

It is generally recognized that people tend to resist change. This resistance to change, along with the usual gap between theory and practice. has created some problems for implementing the Illinois Plan. However. there have been some very successful implementation efforts. These include Teutopolis High School in Teutopolis. Illinois. and Glenwood High School in Chatham, Illinois. In both of these schools the teachers have implemented the ninth and tenth grade level industrial systems courses in in to their programs. These program implementation efforts have been described in articles by the local teachers in the Illinois Industrial Educator (Reynolds et al.. 1983; Koester. 1983). Implementation at these two high schools has been very successful. but at the same time. it took a lot of work to accomplish these successes. The industrial teachers at Glenwood High School made the following statements about their activities in implementing the Illinois plan:

> One of the best outcomes of this effort for our own department has been a renewed zeal and spirit of cooperation. We three teachers have a combined teaching experience of 49 years. Needless to say, much routine had brought about some boredom and stagnation. This new approach has renewed our strength and 'turned us on.' It is making this one of the most exciting school years we have ever had (Reynolds et al.. 1983).

These statements are indications by local teachers about what can happen when they truly get 'turned on' by teaching industrial education from the technology education perspective.

In addition. Dennis Koester from Teutopolis High School stated the following about his experience of implementing the Illinois Plan:

> According to students, parents, and administrators at Teutopolis. the Illinois Plan is an appealing program that provides students with the opportunity to put 'theory' of general education to practice. It provides 'hands-on' learning. a feature envied by much of the school curriculum. My students are pleased and satisfied with this new program. They are more aware of various technologies and how they touch their environment. society and industry. They are not afraid to tackle problems as they arise. and view a new activity or problem as a challenge instead of a threat (Koester, 1983).

These testimonials by local industrial teachers about the effect and impact that the Illinois Plan can have when it is implemented are heartening. However. to truly implement the Illinois plan throughout the state. it will require a total team effort by industrial teachers, local school administrators, university teacher educators. and others involved with industrial and technology education. These team efforts have already started and will continue throughout the next few years as Illinois strives to move industrial education from the 1890's into the 21st century. Technology education will become an integral component of education in Illinois.

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Technology Education: An Outlook

By Donald Lauda

The title of this article is Technology education: An outlook. It is fitting that the concept of Technology Education appear in a journal with the title of Thresholds. The three terms: technology education, outlook and thresholds all imply a point of beginning, an opportunity for renewal and countless other opportunities for those who dare to be innovative. Given the realities of contemporary culture it is imperative that such innovation become the norm rather than mired in tradition. To turn one's back on reality is to deny the existence of the pervasive changes that are taking place in every segment of the human drama.

Where does one begin a discussion of future potential? Due to the mystique placed on the concept of Technology Education. it seems imperative that we begin with the beginning of the human drama which has its antecedents extending to 20 billion years ago. Planet earth was formed with finite resources and ultimately with a form of life. The human as known today is a very recent actor who was forced to find ways to adapt to the environment due to genetic endowments that were not good enough to tolerate the realities of that environment. The human body has not changed in 30,000 years which necessitated the development of contrivances to extend human potential. Therefore, the interaction of the human and the natural environment necessitated the use of some technical means if the human was to survive. Today this technical means has been popularized under the term technology.

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The literate translation of the term technology can be found by looking at the prefix and suffix separately. Techno - the technical means. Logy - the study of. Technology education therefore, is that portion of the educational system that seeks to help individuals comprehend the technical means that has and will continue to impact their lives. The technical means can be intelligible, both for the technologist and the non-technologist. Both will have an increasing responsibility to use it intelligently in the future. The study of the technical means then the unrealized potential within the curriculum at all levels of education, including general education at the university level.

If we trace the transitions that took place throughout the lineage of this planet, we find that for the radical majority of the history of this planet, human intervention was absent. If the history of this planet was written into a 1000 page book, the human would first appear on page 997. Beginning with energy and moving through many transitions the planet experienced a variety of forms of life. What is important is that the transition from one form of life to a higher level only took place when the former reached maximum maturity. As a result, each transition resulted in a life form that was more variegated, more mature, more complex and richer. Once the human entered the scene, we moved from a mere biological transformation to one that is much more dynamic. Biological evolution is extraordinarily slow but the new pattern was a cultural revolution and that is thousands of times faster than a biological one. It is the human that can think abstractly, extend to the unknown and utilize rational processes to strive for a better future.

Cultural separates the human from other forms of life. It is this ability to symbol that is indigenous to the human race. In the 20th century, the complexity of culture is overwhelming with prospects for the future much more complex. A primary function of education is to help students understand their culture, to become culture re-builders as well as inheritors. It is imperative that each discipline identify which part of the culture it can help transmit. Technology education seeks to help students understand one of the primary determinants of cultural change, that is, the technical means used for thousands of years. As a result, the discipline has oriented itself to the highest order possible and is on safe ground academically and realistically. Who could deny a student the right to comprehend one of the most pervasive forces impacting human life?

Like biological evolution, cultural revolution also is characterized by increased complexity. This mandates a concomitant increase in responsibility. Transitioning from the industrial revolution to very recent decades illustrates the increase in complexity. It is the past thirty years however, a miniscule period of time in the human drama, that has created a primary need for technological literacy. Today the technical means has advanced so rapidly that an attempt to comprehend its mass and complexity seems unachieveable. yet, all persons must have the opportunity to place it in perspective and their own lives within its parameters. This places technology education on very safe ground.

The educational system in this country responded to the increasing complexity of the technical means through industrial education, science education, etc. However, the change soon outdistanced both philosophy and practice within the discipline of industrial education. Students of today are born into a 'high' technology culture and must be introduced to the intricacies of such a culture if we expect them to be pro-active rather than reactive as decisions need to be made concerning the impact of the technical means in their lives. The technical means exists to amplify the human, not replace or stifle it. In essence, rapid technical change has necessitated another round of rehabilitation effort within the discipline. Within this context educators cannot underestimate the impact of technical progress as they design their curriculum.

Changing a discipline requires changes in the way people view society and culture, even the way they view themselves. Add-ons, appendages and remediation will not work as we try to improve the curriculum. Yet we cannot become so open-minded that we become mindless. So we must determine what the transition from industrial arts education to technology education really means. It means that we must face head-on the fact that today's students are a product of today rather than yesterday. We cannot afford to allow them to back into the future with the help of a rear view mirror. We inherited a natural environment, we then created a human environment and it is up to us to perpetuate the human race through means that are compatible with both systems. Our strongest inhibitor will be tradition.

Today the call for 'scientific and technological' literacy is overwhelming. The call comes from the school system, from congressional efforts and from students themselves. In 1982, over twenty bills were introduced at the federal level which were aimed at such literacy. In this fiscal year, the call has reached increased intensity. Technology education as a discipline is a partial answer. Granted, the discipline cannot assume full responsibility for total technological literacy. By its very nature, such literacy is multi-disciplinary and requires input from all other disciplines. But it is with the application of the technical means that we can make our impact. Solving problems, creating new inner and outer spaces, assessing our creations and fulfilling our responsibilities for the natural and human environment is our task.

The time for technology education has come. The potential for such study is not only essential for an understanding of a technological culture but must be required of all students. This transition within the educational system perhaps has more potential than the field of industrial education has ever contemplated.

If both biological and technological systems transition themselves when they reach a maximum level of maturity, it holds that subsequent steps are inevitable. What might these be? The transitions in technological prowess are perhaps in their infancy. The blending of science and technology provides options that are virtually unlimited. If there is a limit, it is imposed by a lack of invention and innovation. But what of the human? What is this next step which is to be characterized by a higher order of complexity? The next step is not a biological transition but a cultural one. It will be characterized by a philosophy of compassion for the human and natural environment. Enhancing this philosophy will be continued use of the technical means but in a manner conducive to equilibrium of the total system. In other words, the human will finally realize that there are no individual tickets to the future, just one big one. Within this context, technology education has unrealized potential. Opportunity abounds but this requires responsibility, concern for students and commitment. What greater challenge could any educator want?

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