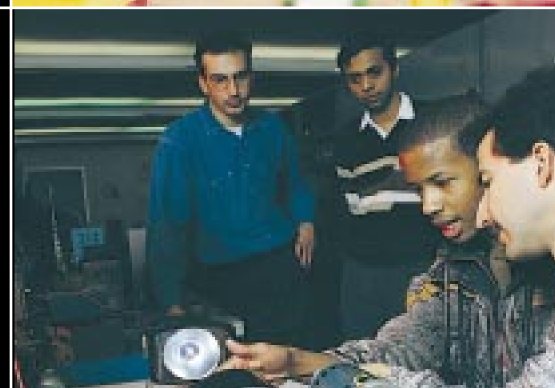
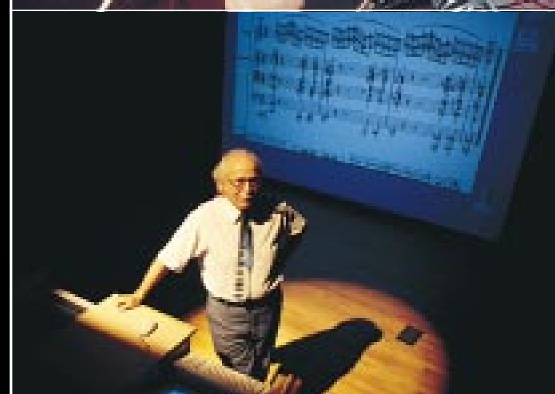
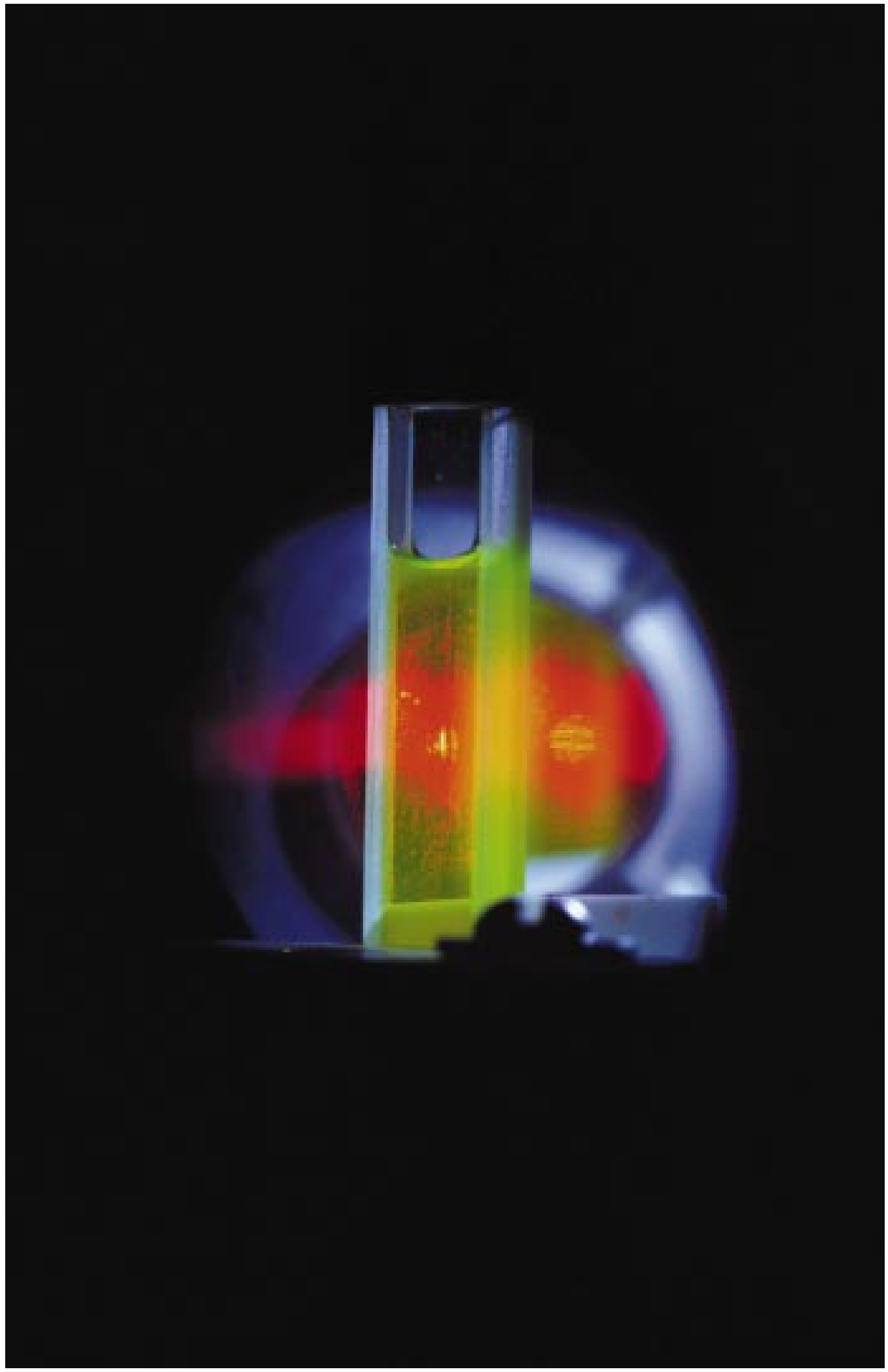
Technology for All Americans



A Rationale and Structure for the Study of Technology



Technology is
human innovation
in action



Technology for All Americans:

A Rationale and Structure for the Study of Technology

Technology for
All Americans Project

International Technology
Education Association

This material is based upon work supported by the following:

National Science Foundation under Grant No. ESI-9355826 and the National Aeronautics and Space Administration under Grant No. NCCW-0064. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation or the National Aeronautics and Space Administration.

ISBN 1-887101-01-02

Copies of this document are being disseminated by the International Technology Education Association

1914 Association Drive
Reston, Virginia 20191
(703) 860-2100 (voice)
(703) 860-0353 (fax)
itea@tmn.com (e-mail)
http://www.tmn.com/Organizations/Iris/ITEA.html (home page)

Contents

Preface

Technological literacy is much more than just knowledge about computers and their application.

This document is about education and a subject vital to human welfare and economic prosperity. It is about invigorating the entire educational system with high interest, student-focused content and methods. It is about developing a measure of technological literacy within each graduate so that every American can understand the nature of technology, appropriately use technological devices and processes, and participate in society's decisions on technological issues.

Technological literacy is much more than just knowledge about computers and their application. It involves a vision where each citizen has a degree of knowledge about the nature, behavior, power, and consequences of technology from a broad perspective. Inherently, it involves educational programs where learners become engaged in critical thinking as they design and develop products, systems, and environments to solve practical problems.

A Rationale and Structure for the Study of Technology is the first publication in a series envisioned to help educators improve and strengthen the preparation of each learner. Subsequent work will build upon this background and present technology education standards. The standards will provide a general framework from which schools can develop curricula and programs. This material will also provide the criteria for student assessment, teacher preparation, and enhancement and improvement of the learning environment.

The first part of this document discusses the power and the promise of technology and the need for technological literacy. The next section outlines the universal processes, knowledge, and contexts of technology. The third part describes how technology should be integrated into the core of the curriculum from kindergarten through secondary and post secondary education. The fourth and final section of this document challenges all concerned to establish technology education standards based on the universals outlined in this document, and to make technological literacy a national priority.

This document has been prepared by the Technology for All Americans Project through assistance from writing consultants. It has been reviewed by hundreds of practitioners of technology, science, mathematics, engineering, and other areas at all levels. Input has been gathered from a group of writing consultants, a National Commission for Technology Education, and educators across the country. Please read the document, study it, and join the International Technology Education Association in calling for and implementing the educational reform necessary to ensure technological literacy for all.

The Power and the Promise of Technology

Through technology, people have changed the world. In the drive to satisfy needs and wants, people have developed and improved ways to communicate, travel, build structures, make products, cure disease, and provide food. This has created a world of technological products and machines, roadways and buildings, and data and global communications. It has created a complex world of constant change.

Each technological advance builds on prior developments. Each advance leads to additional potentials, problems, and more advances in an accelerating spiral of development and complexity. The acceleration of technological change, and the greater potential and power that it brings, inspires and thrills some people, but confuses—even alienates—others. Many people embrace technological change, believing that through technology their lives will be made easier. They see the growing ability to solve age-old problems ranging from food supply to education and pollution. Others see a confusing interconnection of impersonal devices, and fear social, ecological, or military catastrophe. Some people find that through communication and transportation technology they can more easily maintain their personal relationships; others discover that the same technologies can strain relationships. Some believe that

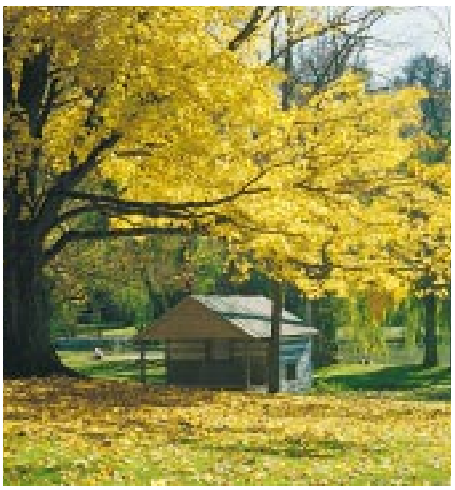
Courtesy of Bob Veltri

through technological advances people create new jobs and new industries; others see automation replacing skilled labor and changing their way of life.

There is truth in all of these views, for technology is created, managed, and used by societies and individuals, according to their goals and values. For example, biotecnological developments can eradicate a plague or cause one. Industrial plants can be used to clean water or to pollute it. Nuclear energy can be used to provide power to heat millions of homes or to destroy millions of lives.

Technological systems have become so interrelated with one another and with today's social systems, that any new development can have far reaching effects. Recently people have seen that one development in microwave technology can alter the eating habits of millions; that an advance in radio telecommunications can create a multi-billion-dollar industry almost overnight; and that a common refrigerant can damage the Earth's protective atmosphere.

The promise of the future lies not in technology alone, but in people's ability to use, manage, and understand it.



Courtesy of Don Massie

Eighteenth century pioneers in the western wilderness of the Virginia and Pennsylvania colonies were able to provide themselves with everything they needed except for iron, lead, and salt. In today's urban society, people are more dependent upon others and upon technological processes and products.

People today inhabit a world of technological products and machines, roadways and buildings, data and global communications. Technology has become one of the major influences in the way people work, relax, interact, and meet their basic needs.

Courtesy of Bob Veltri

It is difficult to escape the effects of technological developments—even when pursuing "natural" activities, such as hiking. Shoes, clothes, and hygiene products are designed and made with computer–controlled machines. This hiker could be using a global positioning system, or possibly a compass, to identify her location.

The condition of the forest is influenced by human endeavors. Will hikers dispose of waste properly? Has the cutting of trees been managed with reforestation in mind? Have manufacturing and transportation systems polluted the air causing acid rain and destroying forests? Have the products carried into the forest been designed to be environmentally compatible?

The Need for Technology Literacy

A major consequence of accelerating technological change is a difference in levels of technological ability and understanding. There is a widening gap between the knowledge, capability, and confidence of the average citizen and that of the inventors, researchers, and implementors who continually revolutionize the technological world. While it is logical and necessary for the developers to have advanced technological capability, it is senseless for the general public to be technologically illiterate.

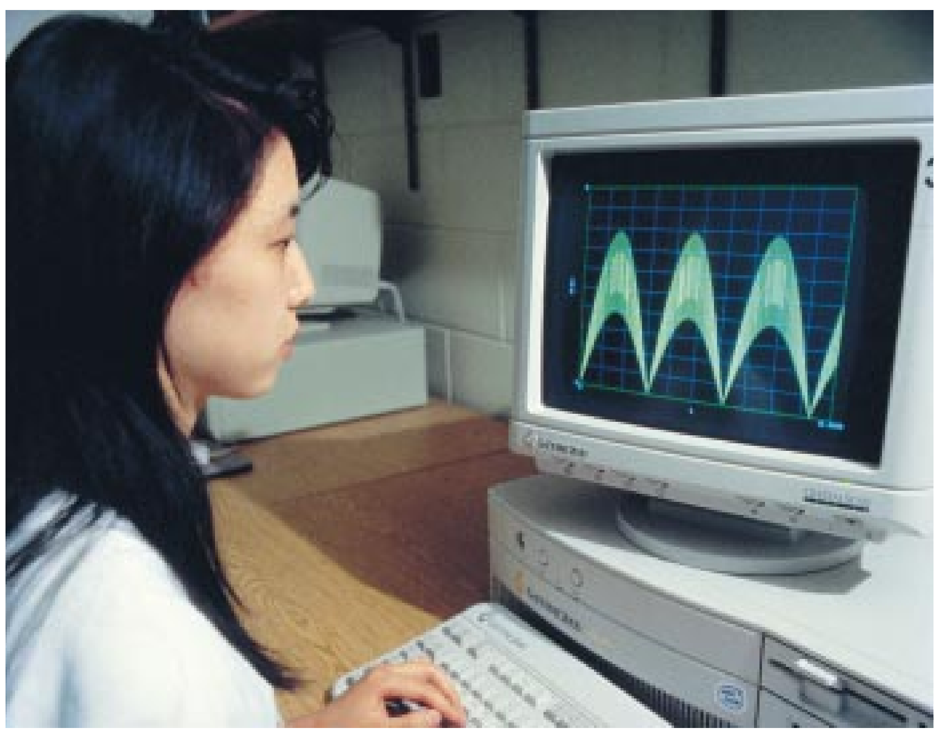
Because of the power of today's technological processes, society and individuals need to decide what, how, and when to develop or use various technological systems. Since technological issues and problems have more than one viable solution, decision making should reflect the values of the people and help them reach their goals. Such decision making depends upon all citizens acquiring a basic level of technological literacy—the ability to use, manage, and understand technology.

Indeed, technological literacy is vital to individual, community, and national economic prosperity. Beyond economic vitality is the realization that how people develop and apply technology has become critical to future generations, society, and even the Earth's continued ability to sustain life.

Technological Literacy

Technological literacy is the ability to use, manage, and understand technology.

- The ability to **use** technology involves the successful operation of the key systems of the time. This includes knowing the components of existing macro-systems, or human adaptive systems, and how the systems behave.
- The ability to **manage** technology involves insuring that all technological activities are efficient and appropriate.
- **Understanding** technology involves more than facts and information, but also the ability to synthesize the information into new insights.



Courtesy of Bob Veltri

Practically every job today depends upon people learning new technological processes and systems.

Courtesy of Alan Brown/Photonics

Retirees have experienced tremendous changes in their lives. The advent of television, satellites, personal computers, genetically altered food, and the threat of nuclear devastation are but some of the changes they have witnessed since they were children. Today's children will experience even greater changes. What will they develop, manage, and adapt to before they retire? Will they have the necessary skills and understanding to direct and adapt to technological change?

Individual Needs

Participating citizens need to consider issues and take part in decisions regarding transportation, land use, pollution control, defense, and restricting or encouraging technological activities. Sound decisions demand an understanding of the impacts, relationships, and costs of such technological activities.

- Workers need to possess a variety of technological abilities—both the skills to use products and the ability to identify and remedy simple malfunctions. Those directly responsible for technological change, such as engineers, designers, consumers, manufacturers, key decision makers, and architects, require an understanding and ability to assess and forecast the impacts of their actions. Workers today also need to have the tools to adapt to technological change in the workplace.
- Consumers need to make decisions about the purchase, use, and disposal of appliances, information systems, and comfort-enhancing devices. From entertainment to medical decisions, everyday life requires a basic technological literacy.

Courtesy of Maureen Heenan

When making informed decisions about how to spend recreational time, consumers often need to consider issues involving safety, effectiveness, and effects on the environment. Such decisions require basic technological literacy.

Societal Needs

More than personal comfort and satisfaction is at stake. Today's global societies must improve their technological literacy in order to support growing populations and to provide a safe environment in a complex world.

- Effective democracy depends on all citizens participating in the decision-making process. The decision-making process safeguards the country from yielding control to a small, powerful elite. Since so many decisions involve technological issues, technological literacy is required for all citizens.
- Technological activities provide the base for the country's economy. As new advances provide more opportunities, the need grows for technologically skilled engineers, innovators, and workers to develop and maintain a competitive edge in a global economy.
- Democracy demands shared responsibilities and contributions. People who lack the technological knowledge needed to participate in the economy often become noncontributing members of society who must be provided for by others.

Courtesy of Roanoke Times

All citizens should increase their levels of technological literacy so that they can effectively participate in the decisions affecting society. Should new roads be built in agricultural districts? Should logging be restricted in an old-growth forest? How should the airwaves be regulated? Should society underwrite research in developing technologies? These and many more questions can be best answered only if all citizens are capable of participating in the decision-making process.

Environmental Needs

Because various technological processes or abuses can pose ecological dilemmas and create environmental crises, technological literacy is critical to the Earth's continued ability to support life.

- Innovators, developers, governments, and consumers need to consider the consequences on the environment when making decisions about the use and development of different processes.
- Everyone must be concerned with the entire product life cycle. They must consider not only the materials and processes used in production, but also what happens to products at the end of their useful life.
- Designing and developing technological processes and systems that are less threatening to the natural environment has become very important. When it comes to the environment, technology can be viewed optimistically as a means to solve environmental problems, not just create them.

Through technology, people will not solve all of the problems in the future. They will, in fact, create some. But if people develop and use technology in the context of the country's goals and values, they will continue to offer each other even more ways to work, enjoy leisure, communicate, and order their lives.

Courtesy of Bob Veltri

Much technological activity has an impact on the Earth's natural resources. It is imperative that people consider the consequences of their actions on the environment, and strive to minimize damage. People are now working to develop technological processes that can prevent or repair environmental damage.

Characteristics of a Technologically Literate Person

Technologically literate persons are capable problem solvers who consider technological issues from different points of view and in relationship to a variety of contexts. They acknowledge that the solution to one problem often creates other issues and problems. They also understand that solutions often involve trade-offs, which necessitate accepting less of one quality in order to gain more of another. They appreciate the interrelationships between technology and individuals, society, and the environment.

Technologically literate persons understand that technology involves systems, which are groups of interrelated components designed to collectively achieve a desired goal or goals. No single component or device can be considered without understanding its relationships to all other components, devices, and processes in the system. Those who are technologically literate have the ability to use concepts from science, math, social studies, and the humanities as tools for understanding and managing technological systems. Therefore, technologically literate people use a strong systems-oriented approach to thinking about and solving technological problems.

Technologically literate persons can identify appropriate solutions, and assess and forecast the results of implementing the chosen solution. As managers of technology, they consider the impacts of each alternative, and determine which is the most appropriate course of action for the situation.

Technologically literate persons understand the major technological concepts behind the current issues. They also are skilled in the safe use of the technological processes that are lifelong prerequisites for their careers, health, and enjoyment.

Technologically literate persons incorporate various characteristics from engineers, artists, designers, craftspersons, technicians, mechanics, and sociologists that are interwoven and act synergistically. These characteristics involve systems-oriented thinking, the creative process, the aspect of producing, and the consideration of impacts and consequences.

Technologically literate persons understand and appreciate the importance of fundamental technological developments. They have the ability to use decision-making tools in their lives and work. Most importantly, they understand that technology is the result of human activity. It is the result of combining ingenuity and resources to meet human needs and wants.

Technologically literate persons understand and appreciate the importance of fundamental technological developments.

Courtesy of Bob Veltri

Technological Systems

A system is a group of interrelated components that collectively achieve a goal.

The basic building block of technology is the system. A system is a group of interrelated components designed to collectively achieve a desired goal or goals. Systems exist on many levels, as shown by the bicycle.

A basic system involving a bicycle is the guidance and control system, which is made up of handle bars, the wheels, brakes, and a rider who turns the handle bars—all working together to guide the bicycle in the desired direction.

A rider on a bicycle comprises another level of a system. That system is used to transport people from one place to another by muscle power. The components include the rider, subsystems of guidance, power, and support (frame, seat, etc.).

The rider on the bike can be part of yet another level of system. When school children ride bikes to school, they are part of the transportation system that conveys students to schools. Other components of the system include roads, sidewalks, school buses and drivers, bus schedulers, parents who drive children to school, students who walk to school, school crossing guards, and others.

Still another level of system is a macrosystem, such as the country's transportation system, which includes all of the people, machines, information, and infrastructure used to move people and goods from place to place. These macro technological systems are often referred to as human adaptive systems.

Technologically literate persons use a strong systems-oriented thinking approach to solving technological problems.

Courtesy of Bob Veltri

The Goal of Technological Literacy for All

How widespread is technological literacy among Americans today? Levels of technological literacy vary from person to person and depend on one's background, education, interests, attitudes, and abilities. However, most people do not even begin to comprehend the basic concepts of today's technological society. Few can fully comprehend the technological issues in the daily news, perform routine technological activities, or appreciate an engineer's breakthrough.

Understanding of and capability in technology traditionally have been ignored, except for those pursuing education and training in technological fields. For most Americans, technological literacy has been left for individuals to gain through their daily activities. However, technological processes and systems have become so complex that the ad hoc approach has clearly failed most Americans.

A massive effort is needed in order to achieve technological literacy. This should involve the schools, the mass media and entertainment outlets, book publishers, and museums. The country's schools must bear the bulk of this effort, for the educational system is the only means by which each child can be guaranteed participation in an articulated, comprehensive technology education program.

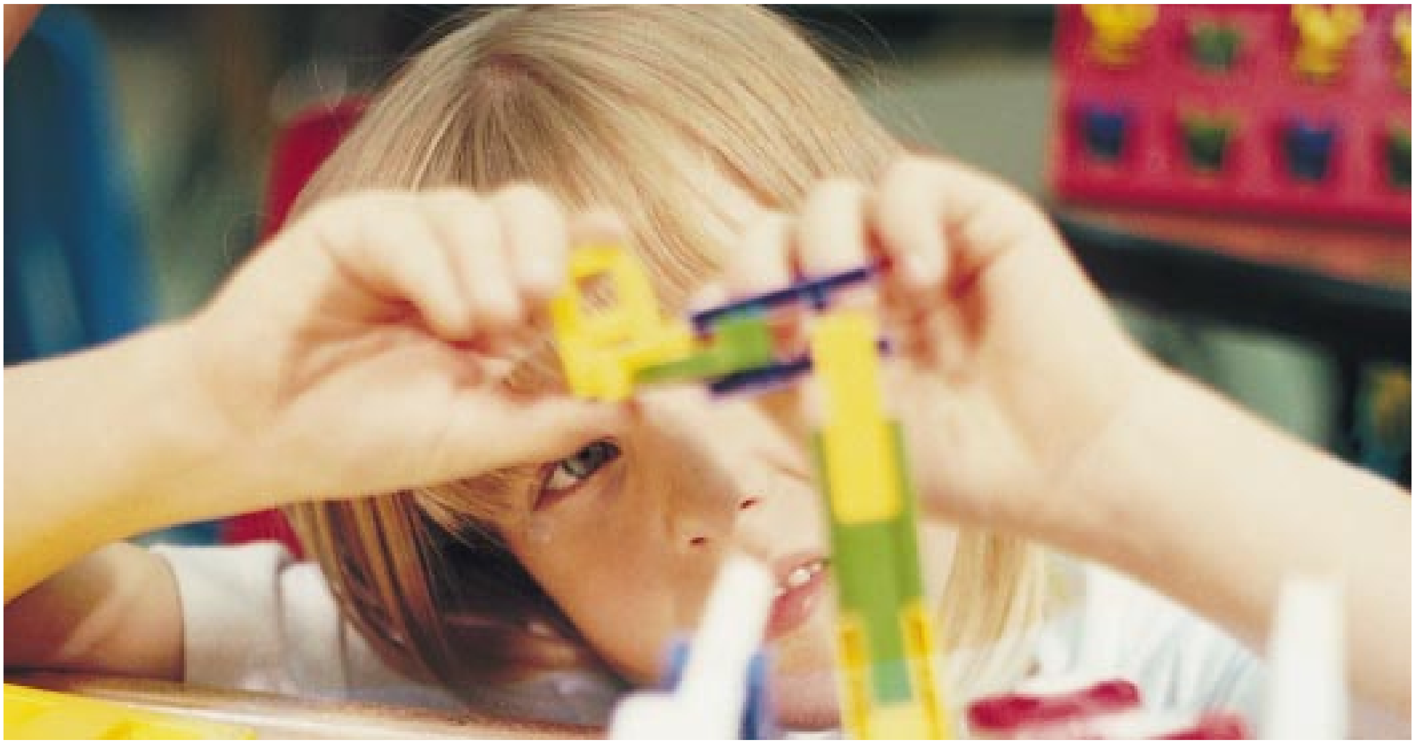
Technology education provides an opportunity for students to learn about the processes and knowledge related to technology that are needed to solve problems and extend human capabilities. Incorporating technology education into every school system will require curriculum development, teacher enhancement, and dedicated teaching and laboratory space. A number of states and school systems have already established technology programs. These schools provide evidence of high—quality technology education at all levels. The next part of this document describes the structure for what should be learned in technology, and discusses how it can be incorporated into the education programs of all students from kindergarten through high school and beyond.

A Structure for the Study of Technology

The Need for a Structure

Agreement on the need for technological literacy is just the beginning. The more difficult problem is determining how to develop this literacy. What experiences, abilities, and knowledge are needed? What exactly should a person know about and be able to do with technology? What should be the content of this literacy effort?

The specific answers change with a person's and community's aspirations, and capabilities. A ranching community in Wyoming encounters totally different issues than a manufacturing community in South Carolina, or a city in the urbanized northeast corridor. The answers also change rapidly with time. Technology is advancing so quickly that knowledge, processes, and systems are becoming obsolete almost as quickly as they are developed. As technology grows more complex, it becomes more important to define and set boundaries for its study.



The following pages describe a structure for study that focuses on the universals of technology that are considered to be significant and timeless—even in an era dominated by uncertainties and accelerated change. These universals form the basis for continuous learning of technology throughout a person's lifetime. They constitute the fundamental concepts that allow individuals to continually learn as conditions change. From this proposed structure, the content elements for the study of technology can be developed that will be appropriate for students of different times and places.

Education programs based on this structure will provide students with the concepts and experience necessary to develop the understanding and capability that they will need in a constantly changing technological world.

The Universals of Technology

Technology is human innovation in action. It involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities.

Technology is human innovation in action. It involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities. As such, technology has a process, knowledge, and context base that is definable and universal.

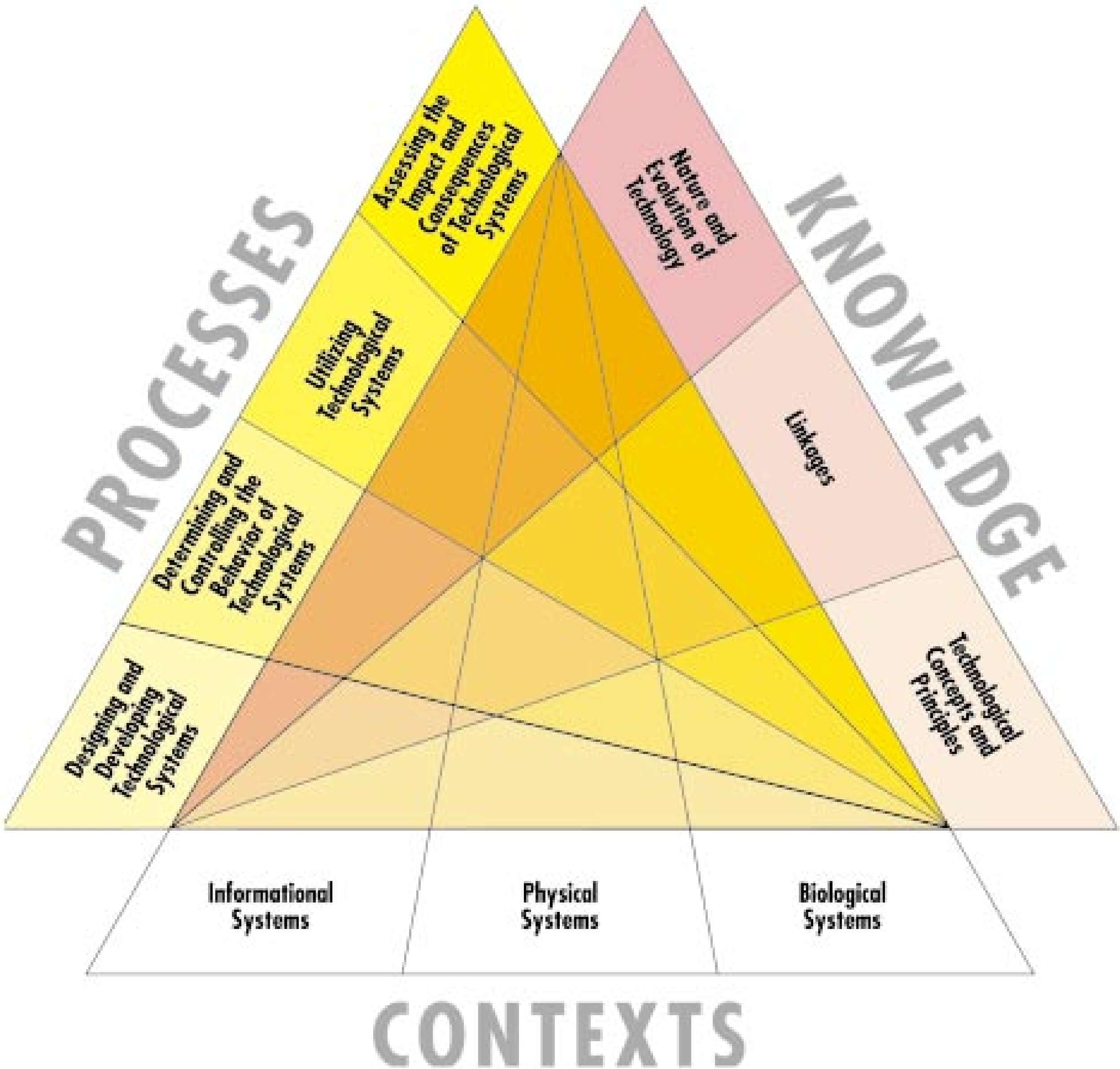
The processes are those actions that people undertake to create, invent, design, transform, produce, control, maintain, and use products or systems. The processes include the human activities of designing and developing technological systems; determining and controlling the behavior of technological systems; utilizing technological systems; and assessing the impacts and consequences of technological systems.

Technological knowledge includes the nature and evolution of technology; linkages based on impacts, consequences, resources, and other fields; and technological concepts and principles. This includes much of the knowledge of how the technological processes are developed, applied, and used.

The context of technology involves the many practical reasons why it is developed, applied, and studied. People develop technological processes and knowledge for a reason—they want to develop and use systems that solve problems and extend their capabilities. The systems that are developed can easily be categorized as informational systems, physical systems, and biological systems.

The processes, knowledge, and context are all equally critical to the existence and advance of technology. One cannot exist without the others, for they are mutually dependent. With technological knowledge people engage in the processes, yet it is through the processes that technological knowledge is developed. All technological activity is for a reason, or done within a context.

Processes, knowledge, and context, then, are the universals of technology, and must be the foundation of the structure for the study of technology. Each of the universals is discussed in greater detail in the following pages.


PROCESSES
Assessing the Impact and Consequences of Technological Systems
Utilizing Technological Systems
Determining and Controlling the Behavior of Technological Systems
Designing and Developing Technological Systems
KNOWLEDGE
Nature and Evolution of Technology
Linkages
Technological Concepts and Principles
Informational Systems
Physical Systems
Biological Systems
CONTEXTS

PROCESSES

Designing and Developing Technological Systems

Much technological activity is oriented toward designing and creating new products, technological systems, and environments. The technological design process involves the application of knowledge to new situations or goals, resulting in the development of new knowledge. Technological design requires an understanding of the use of resources and engages a variety of mental strategies, such as problem solving, visual imagery, and reasoning. Developing these mental capabilities and strategies so that they can be applied to problems is a significant aspect of technological literacy. These abilities can be developed in students through experiences in designing, modeling, testing, troubleshooting, observing, analyzing, and investigating.

After a product, system, or environment is conceived, it is designed or developed. The development processes include those activities that are used to carry out the plans, create solutions, or to test ideas that are generated through a design process. The development of physical systems involves many of the common manufacturing and production processes. The development of information systems includes basic data manipulation and enhancing actions, such as encoding and decoding.

Courtesy of Jack Mellott

Architects develop models of their designs in order to communicate the concepts and to identify any conceptual flaws.

In biological systems, the development processes include genetic engineering, agricultural cultivation, manipulating the human immune system, and improving the predictive technologies for diseases. Technological literacy includes an understanding of development processes involved in physical, biological, and informational systems.

Courtesy of Bob Veltri

Designers and developers of wireless communications use computer simulations to test the signals.

Determining and Controlling the Behavior of Technological Systems

People need an understanding of technological systems that is based on experience and analysis. This understanding forms the basis of systems-oriented thinking that underlies all technological activity. All technological systems — whether they are subsystems of larger units, such as the steering system on a bicycle, or macrosystems made up of many levels of smaller systems — are composed of inputs, processes, and outputs that work together to achieve what could not be achieved individually.

A technologically literate person should not only know what technological systems are, but also how they operate, how they are controlled, and why they are used. Although there are cases where systems work for unknown reasons, systems understanding usually requires a knowledge from a variety of fields, especially science, mathematics, and technology. This knowledge is central to the investigation and determination of the behavior of the individual component parts and devices that are used within a system. Once the behavior of a system is understood, the technologically literate person is able to assess the complete system to judge what necessary control adjustments are needed as variables change or inputs become known.

Courtesy of Gary Colbert

Analysis is required in order to determine how many systems work. Analysis often uses information from science and mathematics.

Courtesy of Virginia Tech

Many times the best way to determine what is happening in a system is to take it apart.

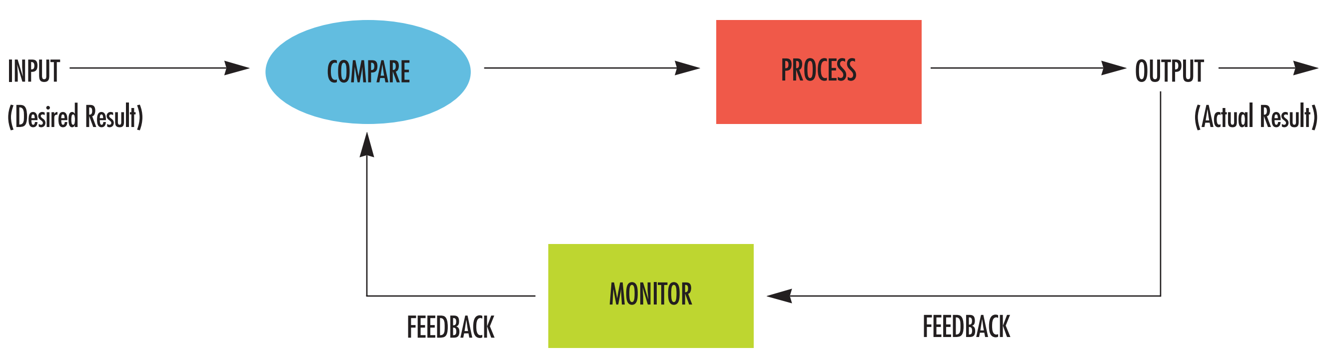
PROCESSES

Classifying Systems

People classify systems in order to discuss them or study them more easily. The classification system used depends upon the purpose. Very often systems are classified according to their underlying scientific principles, such as electrical, mechanical, or chemical. At different times, systems may be classified according to their purpose, such as communication systems, production systems, and others. Sometimes, systems are classified according to their general makeup, such as physical, informational, or biological. Technologically literate people should be able to use and understand a variety of classification systems, so that they can operate within whichever system is most appropriate for the purpose at hand.

Controlling the Behavior of Technological Systems —The Feedback Systems Model

Technological systems involve the interaction of the key components: input, process, output, and feedback. A system's input is the entry of resource materials into the total system. Sometimes it may be viewed as the desired result or action that a system should achieve. The process is the performance of the system, or how the desired results will be achieved by the system. The output is the actual result or what the process produces. A sample of the output is fed back to the comparison device and compared to the desired result to achieve control. This feedback process involves measuring the difference between the actual result and the desired result. If the output and input are different, then an adjustment is made to the process to keep the output at the desired value for which it is designed.



Utilizing Technological Systems

People use technological systems to satisfy their needs and wants. This could be as fundamental as preserving life with food and shelter, to enhancing health and enjoyment. People also use systems that provide them with improved materials, mobility, and communications. Each person should know how to use technology safely and effectively as a means to solve problems and to extend their capabilities.

In order to become safe, effective users of technological systems, people must have experience with the systems that they will commonly encounter at home, play, and at work. Because of the pace of technological change, new developments are quickly absorbed into work and home environments. This means that students will often need exposure to the newest, developing technologies, because the new technologies during their school years will be the common technologies by the time they graduate. In the study of technology, students will need ongoing experiences using various human adaptive systems so that they can:

- Select appropriate technologies for the situation,
- Use tools, materials, devices, and processes in a correct and safe manner,
- Acquire and use information to solve problems and create new technologies,
- Analyze system malfunctions,
- Adapt to the use of new technologies throughout their life,
- Or, in some cases, choose not to employ technological systems in a given situation.

People encounter many different technological processes at work and at home. Effective utilization depends upon safe, appropriate use of systems.

Courtesy of Bob Veltri

Courtesy of Maureen Heenan

Thanks to many technological systems, preparing food can be a quick, easy task. However, in order to select the most appropriate cooking method, the cook must answer a number of questions. Should natural gas, electric, or propane be used for an energy source? Which would be faster, the microwave, convection, or toaster oven? Which process would consume the fewest resources? What is available in the kitchen at the time?

PROCESSES

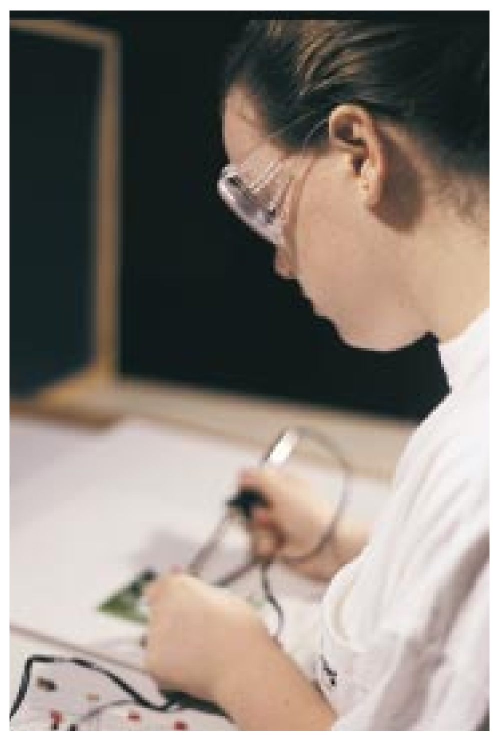
Assessing the Impacts and Consequences of Technological Systems

People make decisions about technological activities every day. However, the growing complexity of technological systems means that all technological decision-making should include an assessment of the impacts and consequences of an implemented or proposed technological system. All technological activity impacts humans, society, and the environment. Moreover, technological activity involves tradeoffs and risks. Decision makers should understand real vs. implied risks associated with technological developments. Erich Bloch, past Director of the National Science Foundation, said that, "Technologically literate people should be able to read a newspaper or magazine article and react to those articles related to technology on a basis of some understanding, not on a basis of emotion." (Bloch, 1986)

Therefore, those involved in the study of technology need experience assessing various technological systems that will affect individuals, society, and the environment. They need to understand the process of assessment so that they can develop their own forecasts. Forecasts are not definite predictions, but are "best guess estimates" based on a variety of techniques, such as trend analysis, modeling, cross impact analysis, Delphi surveys, and scenario development.

Assessing and forecasting processes involve:

- Reflecting on historical events and connections,
- Determining quality and costs,
- Evaluating risks, both real and imagined,
- Making decisions on near-term results of current technological activity,
- Evaluating the results of changes in current technological activity,
- Projecting trends and future developments, and
- Anticipating possible consequences.



Not all malfunctions need to be sent to repair professionals. Technologically literate people need to be able to cope with system malfunctions and determine the appropriate course of action.

The automobile has had great impact on today's society. The automobile has changed where and how people live, enabling them to create suburbs in areas previously considered out-of-the-way. A huge infrastructure has been developed that includes roads, bridges, service stations, insurance systems, scrap yards, and regulations. The automobile has provided employment for thousands of people who build cars, roads, and bridges. Another consequence of adopting the auto as the primary mode of transportation has been thousands of deaths and injuries each year. Environmental damage from the automobile has been a major problem, especially in more populated areas of the country.

Courtesy of Bob Veltri

Refrigeration for long-haul trucks eliminated the problem of food spoilage during long shipping times—and changed the American consumers' eating habits. The first automatic refrigeration system for long-haul trucks was invented in 1938 by Frederick McKinley Jones, who received more than 60 patents in his career. Jones was inspired to invent the refrigeration unit after talking to a truck driver who lost a shipment of chicken due to heat.

PROCESSES

Courtesy of Henry Ford Museum and Greenfield Village

The first industrial robot, called the Unimate, was put on line in 1961 in Trenton, New Jersey. By the 1990s, robots had been developed to perform many industrial functions , including tasks in hazardous environments such as toxic waste dumps and nuclear facilities.

Courtesy of NY Convention and Visitors Bureau

Construction of the Brooklyn Bridge was completed in 1983 and designed by John Roebling. It was the first great suspension bridge in the U.S.

The Nature and Evolution of Technology

People need knowledge and an understanding of the nature and a historical perspective of technology. This will help them to understand and analyze current situations and issues, and to challenge and test their decisions about technology.

The nature and evolution of technology is influenced by many factors, including the following:

- Needs of society and individual or group desires,
- Information base,
- Intellectual and social climate,
- Education of the citizens,
- Social acceptance and compatibility,
- Level of development of related technological components, devices, and systems,
- Level of talent and expertise available,
- Economic capability and desire of society to support technological development, and
- Human invention and innovation.

The nature of technology is described by a variety of its characteristics. Technology is developed and applied by people. Its success or failure is usually determined by social acceptance and success in the marketplace. It has helped to satisfy some of the fundamental human needs of hunger, shelter, comfort, health, mobility, and communication, while at the same time it has helped to create weapons of war and environmental degradation. Technology is ever changing. However, it has grown at an exponential rate over time with many of its major developments taking place in the last few centuries.

Part of the historical perspective of technology is an understanding of significant technological accomplishments throughout history. This can be an immense and significant undertaking. Moreover, what is considered significant may change according to the context in which it is placed. However, substantive technological milestones usually result in a combination of the following:

- An alteration of the way people create new products, systems, and environments,
- An incorporation of new ways of doing work and recreation,
- A widespread and dramatic impact on individuals, social systems, or the environment, and
- A significant impact on the progress in other subject fields.

It is important that the nature and evolution of technology be included in the cognitive basis of the study of technology. The nature and meaning of technology has evolved over thousands of years and its understanding is important for each person.

Part of the historical perspective of technology is an understanding of significant technological accomplishments throughout history.

KNOWLEDGE

Linkages

Technology transfer occurs when a product, system, or environment developed for one setting or application gets utilized in another setting or application.

Decisions concerning the development and the use of technology cannot be made in today's world without an understanding of how technology influences and is affected by society and the environment. Individuals, societies, the environment, and academic disciplines all affect technology and, in turn, are changed by new technological developments. These influences and impacts can be positive or negative, anticipated or unanticipated, depending upon the situation.

Understanding the linkages between technology, society, and the environment is particularly important with technology transfer activity. Technology transfer can involve applying a product, system, or environment to a setting or application that is different from the situation for which it was developed. As technological systems are moved from culture to culture, country to country, organization to organization, or government laboratory to private enterprise, what considerations must be made for the interrelated and reciprocal behaviors of technological, social, and natural systems? How will the transfer of knowledge and processes affect the relationships that currently exist between individuals, societies, and the environment?

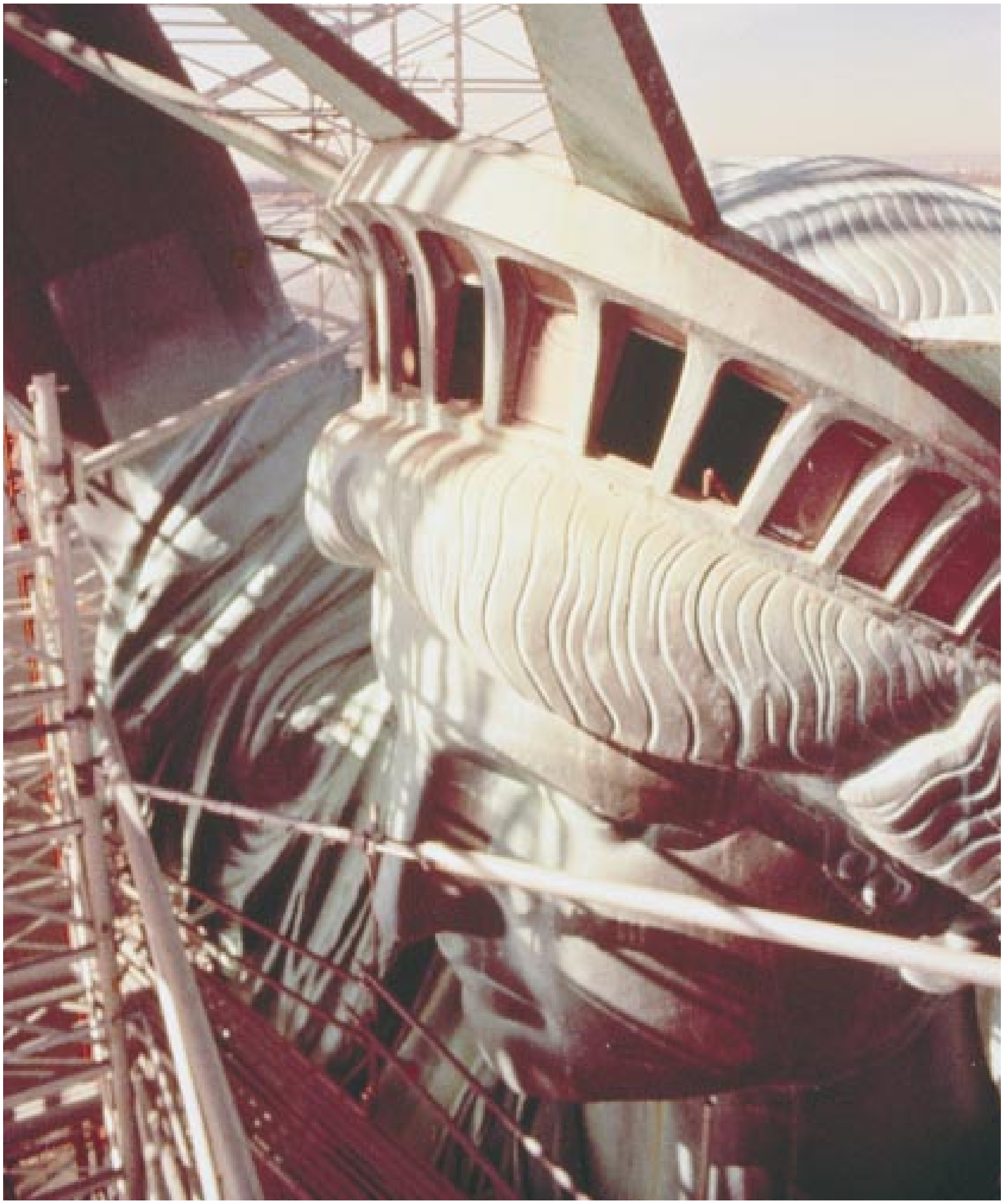
Technology and Society

TECHNOLOGY AFFECTS SOCIETY AS IT:

- Serves as an economic engine,
- Increases human capabilities,
- Creates new linkages between people, groups, and nations or between people and the environment,
- Introduces ethical and political issues,
- Solves and introduces health and safety issues, and
- Increases environmental problems.

SOCIETY AFFECTS TECHNOLOGY AS IT:

- Influences and limits development and use,
- Provides skills and ideas, and
- Provides the need/demand for bigger, better, faster, more efficient systems.



Courtesy of NASA Center for Space Information

Technology transfer occurs whenever systems or processes developed in one setting are used in another. For example, in the early 1970s, NASA had a special coating developed that would protect the launch structures from salt corrosion, rocket exhaust, and thermal shock. More than 10 years later, the same coating was applied to the interior structure of the Statue of Liberty, in order to prolong the statue's life.

KNOWLEDGE

Technology and Other Fields of Study

Progress in all fields of study has been enhanced by technological tools, such as measuring devices or information processing and communication systems. At the same time, technological activity draws on information and theoretical tools from every other field of study. Theoretical tools are basic rules of truth, such as laws, formulae, fundamental principles, axioms, or theorems. Technology has a particularly strong relationship with science and mathematics.

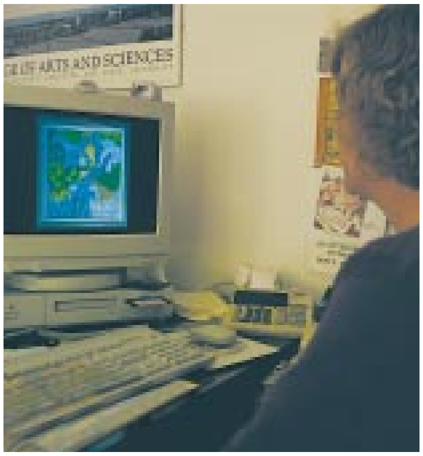
Science is a study of the natural world (National Research Council, 1992), and technology extends people's abilities to modify that world. Science and technology are different, yet symbiotic. Technology is much more than applied science and science is quite different from applied technology. When people use technology to alter the natural world, they make an impact on science. Science is dependent upon technology to develop, test, experiment, verify, and apply many of its natural laws, theories, and principles. Likewise, technology is dependent upon science for its understanding of how the natural world is structured and functions.

Mathematics is a study of all conceivable abstract patterns and relationships (American Association for the Advancement of Science, 1993, Project 2061 Benchmarks for Scientific Literacy). It provides an exact language for technology and science. Developments in technology, such as the computer, stimulate mathematics, just as

Courtesy of Bob Veltri

Music written using a computer is discussed through the use of audio-visual equipment.

KNOWLEDGE



Courtesy of Rick Griffiths

Artists use technological systems to produce their works of art. Shown above, an artist creates an image (right) using a computer system.

Courtesy of Rick Griffiths

developments in mathematics often enhance innovations in technology. One example of this is mathematical modeling that can assist technological design by simulating how a proposed system may behave.

Technology also has interdisciplinary linkages with social studies, language arts, humanities, art, music, and many other fields of study. For example, the sociological and historical aspects of technology are very important in social studies. Likewise, technology has revolutionized the fields of music and visual arts with the recent ability to convert from analog to digital signals.

There are strong philosophical connections between technology and engineering and architecture. Historically, engineering and architecture have had some limited involvement with education in the primary and secondary schools. These professions need to work with technology educators to develop alliances for infusing engineering and architectural concepts at these levels. The alliances will provide a mechanism for greater appreciation and understanding of engineering, architecture, and technology.

Each technologically literate person should know some of the underlying basic science, mathematics, engineering, and architectural concepts and their relationship to technology. Also part of this literacy includes an appreciation and understanding of the interdisciplinary connections between technology, language arts, the humanities, and social sciences.

Technology Education and Educational Technology

Technology education is different from instructional technology, also called educational technology. Educational technology, which involves using technological developments, such as computers, audio-visual equipment, and mass media to aid in teaching all subjects, is concerned with creating the optimum teaching and learning environment through the use of technology. Technology education is a school subject designed to develop technological literacy, while educational technology is used as a tool to enhance teaching and learning. The role of educational technology in technology education is the same as it is in mathematics, science, the humanities, or any other field of study.

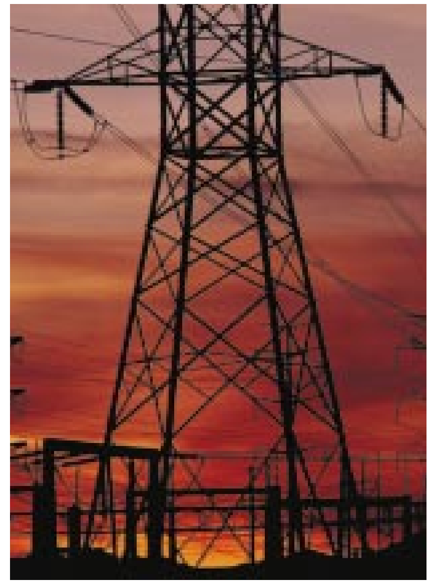
KNOWLEDGE

Technological Concepts and Principles

A number of concepts and principles can be identified that are central and unique to the study of technology. These concepts must be defined in any technological literacy effort, for they serve as the cornerstones in a field with constantly changing boundaries.

The following concepts and principles are presented as examples, and are not intended to be a comprehensive list.

- Technology results from human ingenuity.
- Technological activities require resources.
- People have created technological systems to satisfy basic needs and wants.
- Technological activities have both positive and negative impacts on individuals, society, and the environment.
- Technology provides opportunities and triggers requirements for careers.
- The current state of technological sophistication is the result of the contributions of diverse cultures.
- The rate of technological change is accelerating.
- Complex technological systems develop from simpler technological systems.



Technological activities require resources, such as energy—whether it comes from the sun, electricity, or other sources.

These concepts are comparable to the basic principles of any field. For example, in science, the key concepts and principles include that organisms use matter and energy for growth and maintenance; that observation and experimentation are the bases of scientific inquiry and discovery; and that the processes that changed the Earth in the past still exist today—the principle of uniformity.

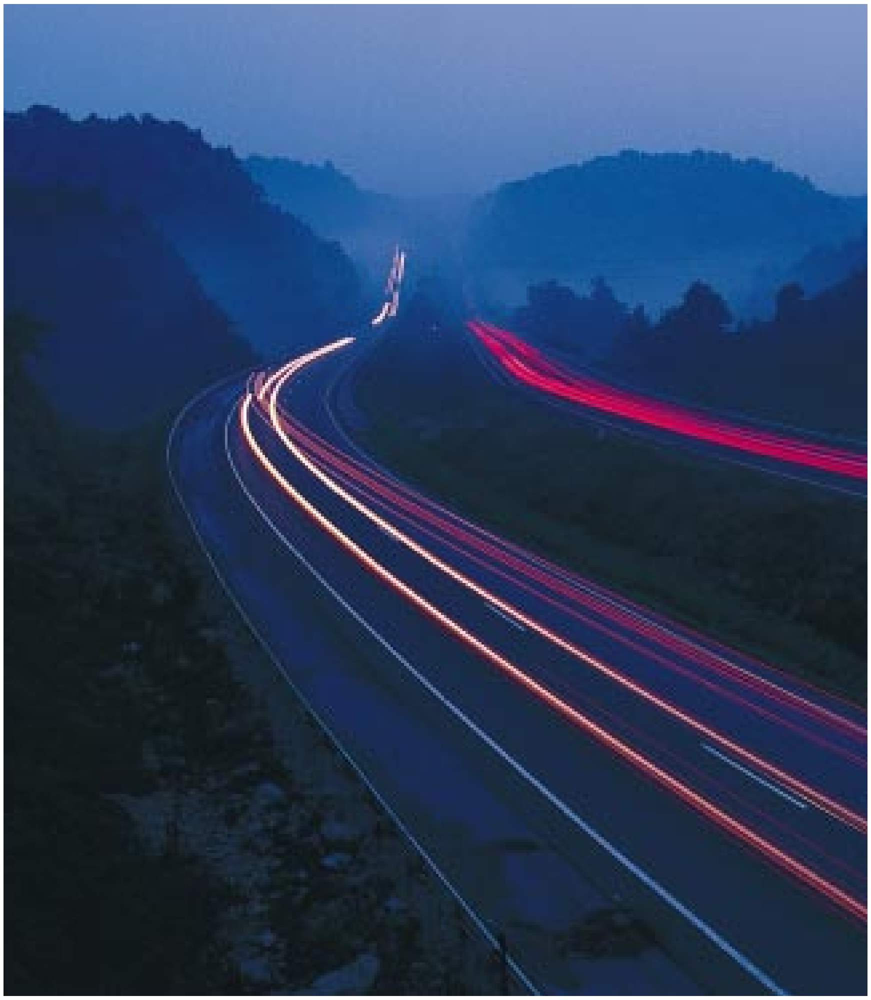
Courtesy of Virginia Tech

KNOWLEDGE

Technology is the result of human innovation—creativity, knowledge, and skills. Ingenuity depends on a firm understanding of existing technology and the ability to conceive something that does not currently exist.

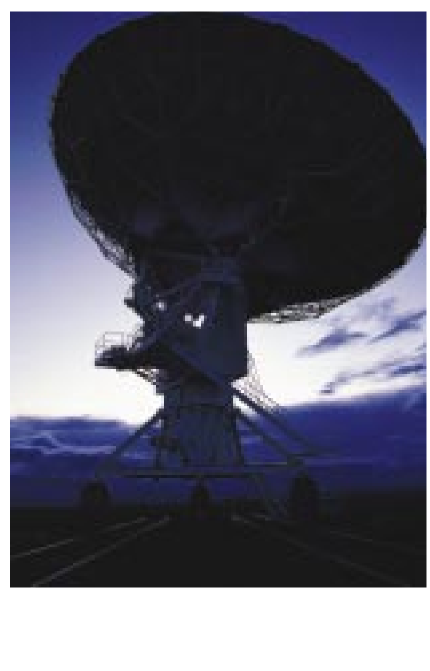
Since its invention in the eighteenth century, the hot-air balloon has symbolized human ingenuity. With standard materials and creativity, people were able to soar with the birds. Ingenuity is not always appreciated, however. A hydrogen balloon invented about the same time as the hot air balloon stayed up for 45 minutes and covered 15 miles. Then it was destroyed on the ground by terrified observers.

CONTEXT



Courtesy of Gary Colbert

Physical systems are among the more obvious results of technological activity. Whether used for transportation, shelter, entertainment, production, or study, physical systems require resources and involve changing the form of materials.



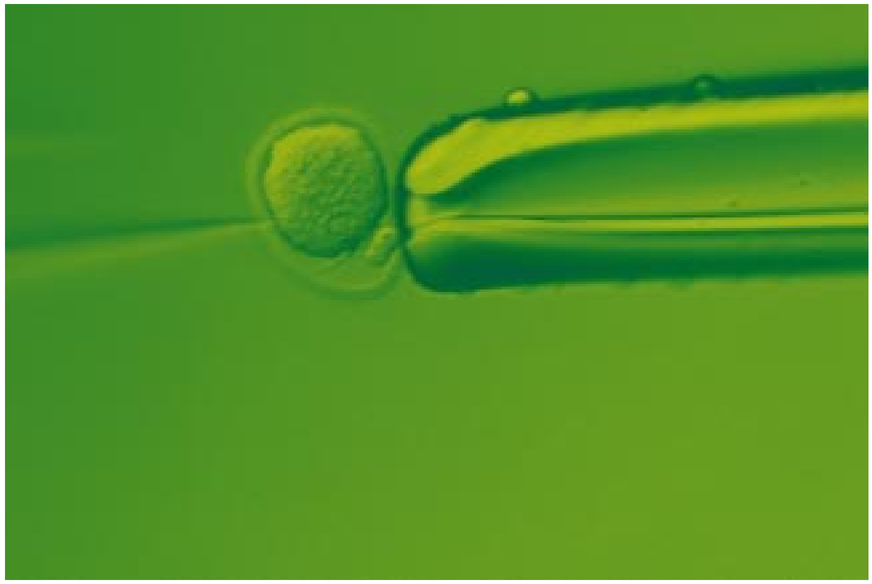
Systems have been developed by people to help them communicate across long distances. The first satellite was launched in 1959, and within 10 years satellites had become a standard method of transmitting voice, data, and video.

CONTEXT

Systems

The processes and knowledge related to the study of technology must be placed in the context for their development and use. The technological contexts can be categorized as information systems, physical systems, and biological systems. All three types of systems rely on the processes and knowledge outlined in the previous pages.

Informational Systems are concerned with processing, storing, and using data. Such systems provide the foundation for today's "information age." Knowledge of and experience with these systems gives people the ability to quantify, qualify, and interpret data as a basis for developing new knowledge. Communication technology is an information system that provides the interface between humans and humans, between humans and machines, and between machines and machines.



Courtesy of Virginia Tech.

The ability to alter the molecular structure of living organisms has given society great medical advances. However the ability has also caused ethical debates about altering the genetic structure of humans and animals.

Physical Systems are those that are tangible and made of physical resources. Changing the form of materials to increase their value and purpose provide the basis for production in physical systems. Power is considered as a major part of the physical systems since it is important to the operation of them. Physical systems also transport people and things.

Biological Systems use living organisms (or parts of organisms) to make or modify products, to improve humans, plants, or animals, or to develop micro-organisms for specific use (U.S. Office of Technology Assessment, 1988). Many of these systems are referred to as, "biotechnology." Biological systems are used in fields such as agriculture, medicine, sports, and genetics.

Courtesy of Bob Veltri

Teaching Technology

During a period of educational reform in the 1980s, the late Ernest Boyer, president of the Carnegie Foundation, stated that America needed to develop technological literacy in all students.

> *The great urgency is for "technology literacy," the need for students to see how society is being reshaped by our inventions, just as tools of earlier eras changed the course of history. The challenge is not [just] learning how to use the latest piece of hardware, but asking when and why it should be used (Boyer, 1983, p 111).*

Boyer's prescription is even truer today. School systems across the country must establish effective technological literacy efforts, beginning in kindergarten and continuing each year through high school and beyond. By using the structure outlined in the last section, communities can incorporate the necessary concepts and experiences so that all students have the opportunity to develop the necessary knowledge and abilities to become technologically literate. By incorporating the universals of technology throughout the curriculum and in technology courses, schools can provide experiences that instill insight and problem-solving capabilities. Including the study of technology in the core curriculum will not only raise the technological literacy of the community, but also help students perform better in other sub-



Courtesy of Rick Griffiths, Courtesy of TIES Magazine

jects. In addition, technological literacy will create a more diverse and larger pool of graduates who are able and motivated to pursue education and careers in the various technological professions.

The first priority of technology education is to provide technological literacy to all students. This includes all of those students who traditionally have not been served by technology programs.

Technology must be a required subject for every student at every level of their education. Incorporating technology education into the country's school systems will require curriculum development, teacher training, and in some cases, dedicated teaching and laboratory space. However, it is an effort that will reap rewards for every person in every community, and society as a whole.

Technology Education During the Elementary School Years

Throughout the elementary years, technology education should be designed to help pupils learn and achieve the educational goals of the total elementary curriculum. These experiences develop the students' perceptions and knowledge of technology, psychomotor skills, and provide a basis for informed attitudes about the interrelationship of technology, society, and the environment.

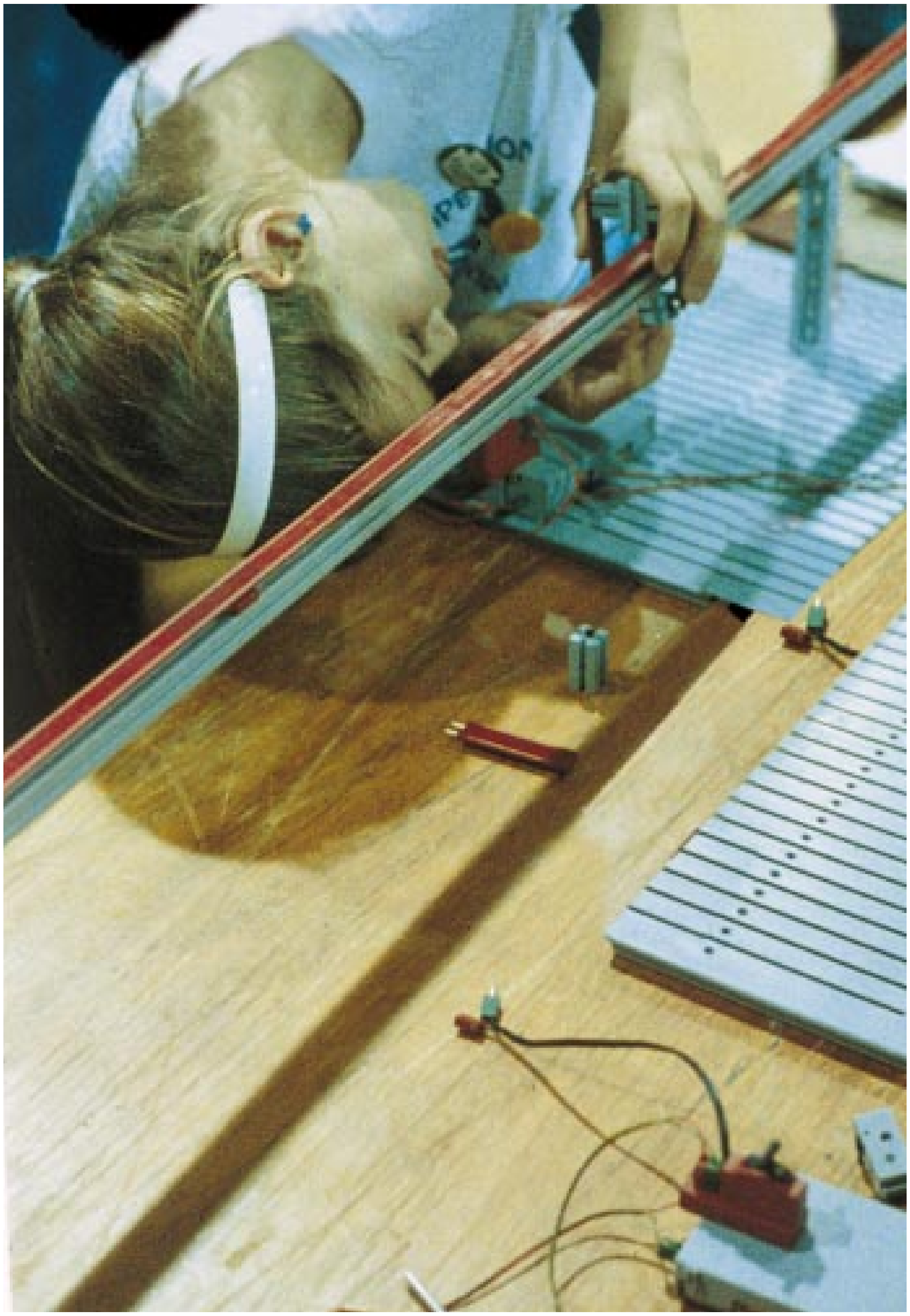
Beginning in kindergarten, technology education can help deliver the kind of active learning that children need and enjoy. Children should be engaged in the design of products, systems, and environments requiring them to gain new knowledge about technology, and to use the knowledge they have learned from related subjects. Pupils apply their knowledge when drawing, planning, designing, problem solving, building, testing, and improving their solutions to problems. According to research results from cognitive science, this process of critical thinking and creative activity can help children construct what they are learning into more meaningful knowledge structures. Technology education activities can be used to integrate the study of technology with related concepts from other disciplines, such as mathematics, science, social studies, and the humanities.

Technology education should be a part of integrated thematic units that explore the relationship of technology to humans, societies, or

Technology education provides the active learning on which students thrive at all ages.

Courtesy of Bob Veltri

The materials and resources required for elementary technology education are minimal.



Courtesy of TIES Magazine

Elementary school pupils should apply their knowledge through drawing, planning, building, testing, and improving their solutions to problems.

the environment, or incorporated into the elementary curriculum as a valued subject with designated time slots. The materials and resources required for elementary technology education are minimal and include student- and teacher-prepared items, along with basic supplies typically used at these grade levels.

Technology can and should be taught in the regular classroom, by a qualified elementary teacher. Initially, many elementary teachers feel unqualified to teach technology, but experience has shown that with appropriate inservice training, these teachers perform exceptionally well and excel at integrating technological concepts across the curriculum. However, if technology education is to enhance what and how children learn, all elementary teachers will need inservice and preservice opportunities in technology education. Further, all teacher preparation institutions will need to include technology education as a part of their undergraduate degree requirements.

Technology Education During the Middle School Years

Middle school technology education programs should be designed to provide active learning situations that help the early adolescent explore and develop a broader view of technology. Instructional experiences should be organized in ways that correspond to the distinct developmental needs of learners in grades five through eight.

Technology education should be a part of the core curriculum for all learners throughout their middle school years. Programs at this level can be implemented through interdisciplinary teams that include a certificated technology education teacher. In some cases the technology education program will be taught by a certificated technology teacher(s) in a non-team-teaching environment. Middle school technology education programs assist students in learning about the processes that apply to the design, problem solving, development, and use of technological products and systems. Also, students begin to develop the ability to assess the impacts and consequences of these systems on individuals, society, and the environment.

In the middle school, the students gain further understanding of the nature and evolution of technology. Middle school students will deepen their level of understanding related to the technological concepts and principles which are considered important for the generation of new knowledge and processes surrounding technology. Middle school students continue to be given opportunities to see how technology has contextual relationships with other fields of study, such as science, mathematics, social studies, language arts, the humanities, and society and the environment.

Middle school students can produce models and develop real technological products, systems, and environments. They learn how to apply principles of engineering, architecture, industrial design, and computer science to gain a better understanding of technology. By taking core courses in technology education at the middle school level, students will discover and develop personal interests, talents, and abilities related to technology.

As middle school students develop greater capability in science, mathematics, and social studies, they are able to delve deeper into the workings of technological systems.

At the middle school level, activity-based technology education leads to a deeper understanding and capability. Students can better understand the components of many structures, including bridges and buildings by designing and building trusses. The students can also gain experiences in analysis, by measuring and comparing the strength of their various structures. Finally, they can explore forecasting by predicting when their structure will fail so that they can learn from this and build even better structures in the future.

Technology Education During the High School Years and Beyond

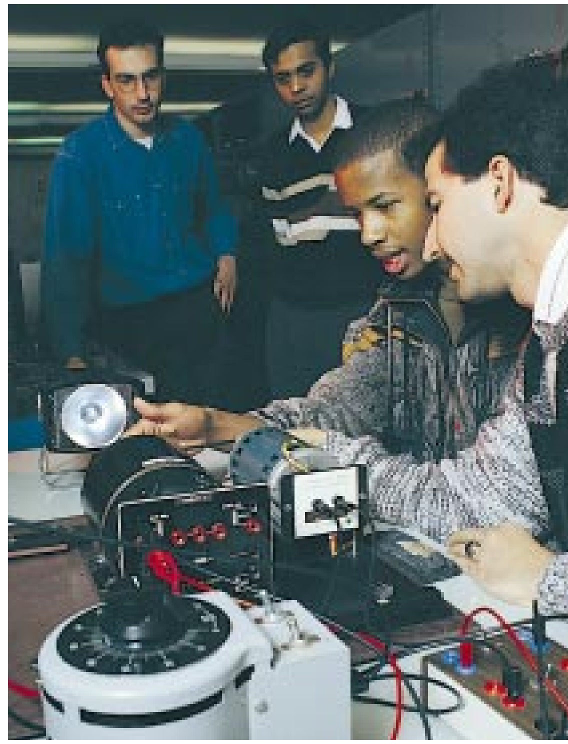
Technology education at the high school level enhances the learner's understanding of technology and develops a richer sense of the relationships between technology and other school subjects. This is especially appropriate with courses in which there is a direct application with technology, such as science and mathematics. Other relevant courses could be language, social studies, geography, art, music, and physical education. In some applications, technology education can assist the high school student to learn in an interdisciplinary nature by providing relevance to many other school subjects. Curriculum options should allow students to choose from sequences of courses that extend their studies in specific processes and knowledge in technological systems. Courses such as "Introduction to Engineering" can be taken by 11th- and 12th-grade students in some schools.

High school students' needs for technology education are more diversified than younger students' since their interests and potential career choices are expanding. As a result of taking technology education, students need to:

- Evaluate technology's capabilities, uses, and consequences on individuals, society, and the environment,
- Employ the resources of technology to analyze the behavior of technological systems,
- Apply design concepts to solve problems and extend human capability,
- Apply scientific principles, engineering concepts, and technological systems in the solution of everyday problems, and
- Develop personal interests and abilities related to careers in technology.

High school students engaged in discussion, problem solving, design, research, and the development and application of technological devices need to study and learn in a technology laboratory. This will ensure a learning environment for efficient and safe work. The technology program at the high-school level should be taught by certificated technology education teachers, individually or in a team-teaching environment.

The ultimate goal is to have every student who graduates from high school to be technologically literate. Some students who study technology in high school will pursue technological careers after graduation, such as engineering, architecture, computer science, engineering technology, and technology teacher education.



At the high school level, students should have the opportunity to take technology education courses that delve deeply into various areas that involve the development, utilization, and assessment of technological systems. Courtesy of Rick Griffiths.

Beyond High School

The technological literacy level of high school graduates should provide the foundation for a lifetime of learning about technology. As graduates pursue post secondary study, they will meet many opportunities to delve more extensively into technology studies.

At the community college level, there are specialized engineering technology programs. These programs may consist of electronics technology and design technology,

Courtesy of Rick Griffiths

Many high school students will pursue technological careers after graduating, such as engineering, architecture, computer science, engineering technology, and technology teacher education.

as well as many other associate degree programs.

The study of technology at the college and university level is extensive and multidimensional. Typical majors in engineering, architecture, health sciences, and computer science are directly involved with the study of technology. Additional courses related to technology may include agriculture, industrial design, science-technology-society (STS), and technology education.

Some universities offer broad courses in the study of technology as a part of their liberal arts or core offerings to undergraduate students. The courses help to provide students with technological literacy at the baccalaureate levels. Finally, the preparation of technology teachers is an important component of higher education.

Taking Action

The Need for Standards

To help achieve technological literacy for the nation, standards should be developed based on the universals of technology and structure described in this document. National educational associations and organizations have developed measures to define and delineate standards for mathematics, science, English, language arts, geography, music, art, social studies, foreign languages, and other subjects. The process of defining such standards is worthwhile because it creates a positive discussion about improving the overall quality of education.

The technology education standards will provide a general framework from which state and local school systems can develop curricula and programs best suited to their students. Standards can provide a guidance for teachers to improve their teaching and their technology education programs. Also, these standards will provide the criteria for student assessment, teacher enhancement and teacher preparation, and improvement of the learning environment.

In developing standards for the study of technology, the fundamental premises are:

1. That standards are needed to establish the requirements for technological literacy for all students from kindergarten through 12th grade;
2. That standards must articulate a shared vision for what the teachers, teacher educators, and supervisors of technology education expect students to achieve through technology education;

Courtesy of Jeff Haeger/Apple Computer Inc.

3. That standards are necessary to establish qualitative and quantitative expectations of excellence for all students; and
4. Standards can be a means to help those from other fields learn more about technology education.

It is very important that standards be set high enough to ensure that all students can participate fully in society. Special considerations must be made in the standards to assure that all learners benefit from technology education.

Technology educators must hold high expectations for each student and every school. Standards, by themselves, cannot erase the results of poverty, or ethnic and cultural discrimination. It is essential that all students have equal opportunities to study technology and that inequalities in school resources be addressed. It is also important that safe and supportive environments be provided for the teaching of technology and that schools have an adequate supply of knowledgeable teachers who are motivated and qualified to provide exceptional learning experiences.

In the future, the Technology for All Americans Project plans to develop, validate, and gain consensus on four sets of standards for technology education. These include:

1. Curriculum content standards for students in grades K-12 (with benchmarks at grades 4, 8, and 12);
2. Student assessment standards that include cognitive and process achievement indicators, teacher assessment, and appropriate formative and summative evaluation techniques;
3. Teacher enhancement and preparation standards; and
4. Program standards for school systems and individual schools within that system.

A Call to Action

Technological literacy must become a central concern of the educational system. This will require significant effort involving the schools, individuals, parents, concerned citizens, business and industry leaders, government agencies, and those in the technological professions, such as engineering and architecture, and others concerned about the study of technology.

A rationale and structure for the study of technology has been presented here that should assure that everyone can gain the foundation they need to participate in and adapt to today's ever-changing technological world. These materials should be compatible with the emerging standards for technology education. It is hoped that this will encourage technology education leaders to develop new curriculum materials at the state and local levels. Technology education, as presented here, must become a valued subject at every level.

This document addresses technology education professionals and other educators. Technology teachers must realize their full potential as the key people who can increase awareness of the need for technology education within their local school system. State and local school administrators and curriculum leaders must also mobilize to promote the idea that technology education can become a liberating force as a new basic and multi-disciplinary form of education. Technology teacher educators at the college/university level must expand their teacher preparation and research in the field of teaching technology so that many issues can be addressed with knowledge and understanding. Finally, student organizations, should provide activities that are available to all students to develop leadership at the local, state, and national levels. These activities should reflect the standards of technology education.

Professional associations and groups both inside and outside the technology education profession must work to develop and implement standards for technology education. These standards can be used by state and local school systems to develop high-quality technology curricula and programs, to prepare teachers, and to assess whether or not students are meeting the standards.

Parents need to become familiar with technology education and the benefits it can provide their children. They should become proactive in promoting the study of technology as a core subject. The support from the business and industry community is crucial for the full implementation of technology education in the schools.

Key government decision makers, from the local to the state and federal levels, need to be informed about the benefits of technology education for all students so that their support can be obtained.

The vision of technology education, embodied in this document, and later in the standards, must be shared by all of those who have a stake in the future of all children—not just teachers, but also administrators, policy makers, parents, and members of the general public. This material represents not an end, but a beginning. It is a starting point for universal action within states, districts, and local schools across the country so that technology becomes an essential subject for all students.

References and Resources

Addenborough, D. (1975). *Life on earth*. Boston: Little and Brown.

American Association for the Advancement of Science, Project 2061. (1990). *Science for all Americans*. New York: Oxford University Press.

American Association for the Advancement of Science, Project 2061. (1993). *Benchmarks for science literacy.* New York: Oxford University Press.

Anderson, J. R. (1993). Problem solving and learning. *American Psychologist, 48,* (1), 35-44.

Ballentyne, D. W. G., & Lovett, D. R. (1970). *A dictionary of named effects and laws*. London: Chapman and Hall.

Barnett, H. G. (1953). *Innovation: The basis of cultural change*. New York: McGraw-Hill.

Barson, S. L., Ascoli, E. P., DeCroix, & Sindir, M. M. (1995, March). *Computational system for rapid CFD analysis in engineering* (NASA Tech Briefs p. 22, 24).

Benjamin, A. C. (1965). *Science, technology, and human values*. Columbia, MO: University of Missouri Press.

Bensen, M. J. (1993). *Positioning and marketing technology education: Joining forces with the establishment*. Reston, VA: International Technology Education Association.

Bloch, E. (1986). Scientific and technological literacy: The need and the challenge. *Bulletin of Science, Technology and Society, 6,* pp. 138-145.

Booth, D. E. (1994). *Valuing nature: The decline and preservation of old-growth forests*. Lanham, MD: Rowman and Littlefield.

Bouwman, M. J. (1983). Human diagnostic reasoning by computer: An illustration from financial analysis. *Management Science, 29,* (6), 653-672.

Boyer, E. L. (1983). *High school*. New York: Harper & Row.

Brandt, R. (Ed). (1993). *Educational leadership: The challenges of higher standards*. Alexandria, VA: Association for Supervision and Curriculum Development.

Bunge, M. (1983). Technology as applied science. In C. Mitcham and R. Mackey (Eds.), *Philosophy and technology.* New York: Free Press. (Original work published in 1974).

Bybee, R. W. (1989). *Science and technology education for the elementary years: Frameworks for curriculum and instruction*. Andover, MA: The National Center for Improving Science Education.

Carin, A. A. (1993). *Teaching science through discovery*. New York: Macmillan.

Center for Civic Education. (1994). *National standards for civics and government*. Calabasas, CA: Author.

Chomsky, N. (1966). *Cartesian linguistics*. New York: Harper and Row.

Clarke, J. (1990). *Patterns of thinking: Integrating learning skills in content teaching*. Boston: Allyn and Bacon.

Cohen, R. J., Swerdlik, M. E., & Smith, D. K. (1992). *Psychological testing and assessment: An introduction to tests and measurements*. Mountain View, CA: Mayfield.

Consortium for Policy Research in Education. (1995, May). *Reforming science, mathematics, and technology education: NSF's state systemic initiatives*. New Brunswick, NJ: Author.

Conwell, J. C., Catalano, G. D., & Beard, J. E. (1993). A case study in creative problem solving in engineering design. *Journal of Engineering Education,* (October), 227-231.

Desmond, K. (1986). *A timetable of inventions and discoveries*. New York: M. Evans.

DeVore, P. W. (1964). *Technology: An intellectual discipline*. [Bulletin No. 5]. Washington DC: American Industrial Arts Association.

DeVore, P. W. (1980). *Technology: An introduction*. Worcester, MA: Davis.

DeVore, P. W. (1987). Technology and science. *Conducting technical research*. 36th Yearbook Council on Technology Teacher Education. Mission Hills, CA: Glencoe.

Drucker, P. F. (1994). *Post-capitalist society.* New York: Harper-Collins.

Dugger, W. E., Jr. (1988). Technology—The discipline. *The Technology Teacher, 48,* (1), 3-6.

Dugger, W. E., Jr., Bame, A. E., Pinder, C. A., & Miller, D. C. (1985). *Standards for technology education programs*. Reston, VA: International Technology Education Association.

Dunlap, D. D. (1990). *Comparing attitudes toward technology of third and fourth grade students in Virginia relative to their exposure to technology.* Unpublished doctoral dissertation, Virginia Tech, Blacksburg, Virginia.

Dyrenfurth, M. J., & Kozak, M. R. (Eds.). (1991). *Technological literacy.* 40th Yearbook Council of Technology Teacher Education. Peoria, IL: Macmillan-McGraw.

Eide, A. R., Jenison, R. D., Mashaw, L. H., & Northup, L. L. (1986). *Engineering fundamentals and problem solving*. New York: McGraw-Hill.

Federal Coordinating Council for Science, Engineering, and Technology (FCCSET). (1992). *Pathways to excellence: A federal strategy for science, mathematics, engineering, and technology education.* Washington, DC: National Aeronautics and Space Administration.

Fiebleman, J. K. (1966). Importance of technology. *Nature, 209,* (5019), 122-125.

Ford, G. W., & Pugno, L. (Eds.). (1964). *The structure of knowledge and the curriculum*. Chicago: Rand McNally.

Forman, S. (1987). *The civilized engineer.* New York: St. Martin's Press.

Fowler, W. S. (1962). *The development of scientific method*. London: Pergamon Press.

French, M. J. (1988). *Invention and evolution: Design in nature and engineering*. Cambridge, MA: Cambridge University Press.

Geography Education Standards Project. (1994). *Geography for life: National geography standards*. Washington, DC: National Geographic Society.

Glimm, J. G. (1991). *Mathematical sciences, technology, and economic competitiveness*. Washington, DC: National Academy Press.

Gradwell, J., Welch, M., & Martin, E. (1991). *Technology shaping our world*. South Holland, IL: Goodheart-Willcox.

Grayson, L. P. (1993). *The making of an engineer.* New York: John Wiley & Sons.

Halfin, H. H. (1973). *Technology: A process approach*. Unpublished doctoral dissertation, West Virginia University, Morgantown.

Halpern, D. F. (1984). *Thought and knowledge: An introduction to critical thinking*. Hillsdale, NJ: Erlbaum.

Harvey, G. (1995, April). *Status report of voluntary national standards in education*. Andover, MA: The Regional Laboratory.

Householder, D. (1979). *Curriculum movements of the 1960's. Industrial arts education: retrospect, prospect*. 28th Yearbook American Council of Industrial Arts Teacher Education. Bloomington, IL: McKnight.

Hutchinson, J., & Karsnitz, J. R. (1994). *Design and problem-solving in technology.* Albany, NY: Delmar.

Hyde, A. A., & Bizar, M. (1989). *Thinking in context: Teaching cognitive processes across the elementary school curriculum*. New York: Longman.

International Technology Education Association. (1988). *Technology: A national imperative*. Reston, VA: Author.

International Technology Education Association. (1985). *Technology education: A perspective on implementation*. Reston, VA: Author.

Johnson, J. R. (Ed.). (1989). *Technology: A project 2061 panel report*. Washington, DC: American Association for the Advancement of Science.

Johnson, S. D. (1996, January). Learning concepts and developing intellectual skills in technical and vocational education. In *Learning in Technical and Vocational Education*. Symposium 12 conducted at the second Jerusalem International Science and Technology Education Conference, Jerusalem, Israel.

Johnson, S. D., Foster W. T., & Satchwell, R. (1989, July). *Sophisticated technology, the workforce, and vocational education*. Springfield, IL: Department of Adult, Vocational and Technical Education, Illinois State Board of Education.

Johnson S. D., & Satchwell, R. E. (1993). The effect of functional flow diagrams on apprentice aircraft mechanics' technical system understanding. *Performance Improvement Quarterly, 6,* (4), 73-91.

Jones, R. E., Salinger, G. L., Wright, J. R., Foster, W. T., & Scarborough, J. D. (1995) *Technology education outcomes*. Chicago: Chicago Public Schools.

Keefe, J. W., & Walberg, H. J. (Eds.). (1992). *Teaching for thinking*. Reston, VA: National Association of Secondary School Principals.

Kendall, J. S., & Marzano, R. J. (1995). *The systematic identification and articulation of content standards and benchmarks*. Aurora, CO: Mid-continent Regional Education Laboratory.

Kieras, D. E., & Bovair, S. (1984). The role of a mental model in learning to operate a device. *Cognitive Science, 8,* 255-273.

Kimbell, R. (1993). *Technology in the school curriculum* (a contractor report prepared for the U.S. Congress, Office of Technology Assessment). London: Author.

Kuhn, T. S. (1962). The structure of scientific revolutions. In O. Neurath, R. Carnap, & C. Morris (Eds.), *Foundations of the unity of science* (pp. 53-272). Chicago: The University of Chicago Press.

Lajoie, S. P. (1986). *Cognitive task analysis: Implications for intelligent tutor development*. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Lehrer, K., & Wagner, C. (1981). *Rational consensus in science and society: A philosophical and mathematical study.* Dordrecht, Holland: D. Reidel.

Lemann, N. (1991). *The promised land*. New York: Alfred A. Knopf.

Logan, D. G., & Eastman, R. W. (1986, April). *Mental models of electronic troubleshooting*. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Lux, D. (1981). *Industrial arts redirected. An interpretative history of industrial arts*. 30th Yearbook American Council on Industrial Arts Teacher Education. Bloomington, IL: McKnight.

Maley, D. (1985). *Math/science/technology projects*. Reston, VA: International Technology Education Association.

Markert, L. M. (1993). *Contemporary technology, innovations, issues, and perspectives*. South Holland, IL: Goodheart-Willcox.

Maryland State Board of Education. (1995). *Quality indicators for technology education programs in Maryland*. Baltimore, MD: Author.

Marzano, R., Brandt, R., Hughes, C., Jones, B., Presseisen, B., Rankin, S., & Suhor, C. (1988). *Dimensions of thinking: A framework for curriculum and instruction*. Alexandria, VA: Association for Supervision and Curriculum Development.

McLaughlin, M. W., Shepard, L. A., & O'Day, J. A. (1995). *Improving education through standards-based reform*. Stanford, CA: The National Academy of Education.

Mitcham, C. (1994). *Thinking through technology.* Chicago: The University of Chicago Press.

Morgall, J. M. (1993). *Technology assessment: A feminist perspective*. Philadelphia, PA: Temple University Press.

Mottier, I., Raat, J. H., & deVries, M. J. (Eds.). (1993). Technology education and the environment: Improving our environment through technology education, *Proceedings of PATT-6 Conference*. Eindhoven, The Netherlands: PATT Foundation.

Mumford, Lewis. (1966). *The myth of the machine: Technics and human development*. Harcourt, Brace and World.

Music Educators National Conference. (1994). *National standards for arts education*. Reston, VA: Author.

Music Educators National Conference. (1994). *The vision for arts education in the 21st century.* Reston, VA: Author.

National Aeronautics and Space Administration. (1993). *NASA's strategic plan for education—A strategy for change: 1993-1998*. Washington, DC: Author.

National Council for the Social Studies. (1994). *Curriculum standards for social studies: Expectations of excellence*. Washington, DC: Author.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (1995). *Assessment standards for school mathematics*. Reston, VA: Author.

National Education Goals Report. (1994). *Building a nation of learners—1994*. Washington, DC: National Education Goals Panel.

National Education Standards and Improvement Council. (1993). *Promises to keep: Creating high standards for American students*. Washington, DC: National Goals Panel.

National Research Council. (1995). *National science education standards*. Washington, DC: National Academy Press.

National Science Foundation. (1995). *NSF in a changing world: The national science foundation's strategic plan*. Washington, DC: Author.

Neuroth, O., Carnap, R., & Morris, C. (Eds.). (1939). *Foundations of the unity of science*. Chicago, IL: The University of Chicago Press.

New York State Department of Education. (1994). *Curriculum instruction and assessment framework for mathematics, science and technology.* Albany, NY: Author.

New Zealand Ministry of Education. (1995). *Technology in the New Zealand curriculum*. Wellington, New Zealand: Learning Media Limited.

Newell, A., & Simon, H. A. (1972). *Human problem solving*. Englewood Cliffs, NJ: Prentice-Hall.

Ornstein, R. (1991). *The evolution of consciousness*. New York: Prentice Hall.

Orpwood, G. (1995). *Assessment of science and technology achievement project*. North Zonk, Ontario: York University.

Owen, C. (1994). Interview. *Journal of Technology Studies, 20,* (2).

Pacey, A. (1990). *Technology in world civilization*. Cambridge: The MIT Press.

Parker, J. C. (1964). *The structure of knowledge and the curriculum*. Chicago: Rand McNally.

Pinker, S. (1994). *The language instinct*. New York: William Morrow.

Proctor, R. W., & Dutta, A. (1995). *Skill acquisition and human performance*. Thousand Oaks, CA: Sage.

Raizen, S. A., Sellwood, P., Todd, R. D., & Vickers, M. (1995.) *Technology education in the classroom: Understanding the designed world*. San Francisco: Jossey-Bass.

Rapp, F. (Ed.). (1974). *Contributions to a philosophy of technology: Studies in the structure of thinking in the technological sciences*. Holland: D. Reidel.

Ravitch, D. (1995). *National standards in American education*. Washington, DC: The Brookings Institution.

Reif, F. (1985). Acquiring an effective understanding of scientific concepts. In L. H. T. West, & A. L. Pines (Eds.), *Cognitive structure and conceptual change* (pp. 133-150). New York: Academic Press.

Rennie, J. (Ed.). (1995, September). Key technologies for the 21st century. *Scientific American, 273,* (3).

Ritz, J. M., & Swail, W. S. (1992). *Design and technology II—Technology assessment*. Richmond, VA: Virginia Department of Education.

Ropohl, G. (in press). What technologists know and how they know it. In M. J. deVries and A. Tamir (Eds.) *Shaping concepts of technology.* Dordreche, The Netherlands. Kluwer Academic Publications.

Rosenberg, N., & Birdzell, L. E. (1990). Science, technology, and the western miracle. *Scientific American, 262,* (5), 42-54.

Saunders, P., & Gilliard, J. (1989). *A framework for teaching the basic concepts.* New York: National Council on Economic Education.

Savage, E., & Sterry, L. (1991). *A conceptual framework for technology education.* Reston, VA: International Technology Education Association.

Scientific American, (1995). *Key technologies for the 21st century. 273,* (3). New York: Scientific American, Incorporated.

Scottish Consultative Council on the Curriculum. (1994). *A framework for technology education in Scottish schools: A paper for consultation and discussion.* Dundee, Scotland: Scottish CCC.

Seels, B., & Richey, R. (1994). *Instructional technology: The definition and domains of the field.* Washington, DC: Association for Educational Communications.

Smith, D. (1981). *Industrial arts founded. An interpretative history of industrial arts.* 30th Yearbook American Council on Industrial Arts Teacher Education. Bloomington, IL: McKnight.

Snyder, J. F., & Hales, J. A. (Eds.). (1981). *Jackson's Mill industrial arts curriculum theory.* Reston, VA: International Technology Education Association.

Swerdlow, J. L. (1995, October). Information Revolution. *The National Geographic.* Washington, DC.

Tidewater Technology Associates. (1992, March). Forecasting for the future. *The Technology Teacher,* 23-29.

U.S. Department of Labor, Bureau of Labor Statistics. (1992, August). *Work and family: jobs held and weeks worked by young adults* (Report No. 827). Washington, DC: U.S. Government Printing Office.

U.S. Department of Labor, Bureau of Labor Statistics. (1994, April). *The American work force: 1992-2005* (Bulletin No. 2452). Washington, DC: U.S. Government Printing Office.

U.S. Department of Labor, The Secretary's Commission on Achieving Necessary Skills. (1992). *Skills and tasks for jobs, A SCANS report for America 2000.* (DOL Publication No. 1992 0-307-898 QL3). Washington, DC: U.S. Government Printing Office.

U.S. Department of Labor, The Secretary's Commission on Achieving Necessary Skills, Pelavin Associates, Inc. (1992). *SCANS in the schools.* Washington, DC: Author.

U.S. Department of Labor, The Secretary's Commission on Achieving Necessary Skills. (1991). *What work requires of schools, A SCANS report for America 2000, A letter to parents, employers, and educators.* Washington, DC: Author.

U.S. Department of Labor, The Secretary's Commission on Achieving Necessary Skills. (1991). *What work requires of schools, A SCANS report for America 2000, Executive summary.* Washington, DC: Author.

U.S. Office of Technology Assessment (1988). *U.S. investment in biotechnology - special report.* Boulder, Colorado, Westview Press.

Usher, A. P. (1959). *A history of mechanical inventions.* Boston: Beacon Press.

Vela, C. E. (1995, September), On the Nature of Technology. *TIES Magazine, 1,* 33.

Vincenti, W. G. (1990). *What engineers know and how they know it: Analytical studies from aeronautical history.* Baltimore, MD: The Johns Hopkins University Press.

Waetjen, W. B. (1995). Language: Technology in another dimension. *Journal of Technology Studies, 21,* (2).

Waetjen, W. B. (1992). Shaping the future of the profession. *Critical issues in technology education, camelback symposium, a compilation of papers.* Reston, VA: International Technology Education Association.

Waetjen, W. B. (1989). *Technological problem solving: A proposal.* Reston, VA: International Technology Education Association.

Waetjen, W. B. (1990). *Technology and human behavior.* Reston, VA: International Technology Education Association.

Walton, J. W. (1991). *Engineering design: From art to practice.* St. Paul, MN: West.

Welsh Office Education Department. (1995). *Design and technology in the national curriculum.* London, England: HMSO

White, B. Y., & Frederiksen, J. R. (1987). *Causal model progressions as a foundation for intelligent learning environments* (Report No. 6686). Cambridge, MA: BBN Laboratories.

Wiens, A. E. (Taskforce Chairperson) (1994). *Technology as liberal education.* Reston, VA: International Technology Education Association.

Wright, R. T., Israel, E. N., & Lauda, D. P. (1993). *A decision maker's guide to technology education.* Reston, VA: International Technology Education Association.

Zais, R. S. (1976). *Curriculum principles and foundations.* New York: Thomas Y. Crowell.

Zwicky, F., & Wilson, A. G. (Eds.). (1967). *New methods of thought and procedure.* New York: Springer-Verlag.

Appendices

TECHNOLOGY
FOR ALL AMERICANS

Technology for All Americans Project

Introduction

In an effort to increase the technological literacy of all Americans, the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) funded this project to develop a nationally viable rationale and structure for technology education. This effort has been spearheaded by the International Technology Education Association (ITEA) and is called "Technology for All Americans." The project's goal is to offer those who are interested in technology education a clear vision of what it means to be technologically literate, how this can be achieved at a national level, and why it is important for the nation.

The Technology for All Americans Project set out to achieve this goal by establishing a National Commission composed of persons who were especially aware of the need for a technologically literate society. Members represent the fields of engineering, science, mathematics, the humanities, education, government, professional associations, and industry. The 25-member Commission has served in an advisory capacity to the project staff and has functioned independently of both the project and the ITEA. The Commission has served as a vital resource of experts knowledgeable about technology and its interface with science, mathematics, engineering, and education.

A team of six writing consultants was formed from the National Commission. Throughout the process, the writing consultants have represented a wealth of knowledge, extensive background, and a unique diversity that played an important role in the development of this document.

Building Consensus

This document, in draft form, went through a dynamic development evolution as a result of a very structured consensus process. The consensus process has involved a series of workshops, along with individual reviews and comments, that ultimately involved the scrutiny of more than 500 reviewers inside and outside the profession of technology education.

The first workshop was held at the ITEA Conference in March, 1995 in Nashville to gain input from the profession on the formative items in this document. During the initial review process, that took place during August 1995, a draft document was mailed to and reviewed by more than 150 professionals, who were selected via a nomination process. Each state supervisor for technology education and president of state associations for technology education were asked to nominate mathematics, science, and technology educators from elementary through high school levels to participate in a series of consensus-building workshops. The workshops were hosted by seven NASA field centers around the country. The draft document was disseminated to the participants prior to the consensus-building workshop. They were asked to review the draft document, respond to several prepared questions, and provide comments directly on their copy of the draft. At the workshops, participants from 38 states and one territory were divided into heterogeneous groups that represented the interest groups of those involved (i.e., elementary school, middle school, high school, mathematics, science, technology). These small groups were then asked to respond to prepared questions as a group and come to consensus on the content of the draft document.

Input and reactions from the field were very valuable during the consensus process. Perspectives were shared that had not been discussed in prior writing consultants' meetings. Ideas for improving the draft document were generated from the group synergism and regional philosophies or viewpoints were acknowledged. This input was analyzed to determine the needed changes for its content. Changes then were made to reflect the data from the summer workshops. In addition, these changes were "tried out" with groups throughout the fall of 1995 at state and regional conferences. The project staff found that by focusing on areas of concern identified from the summer review process, the changes that were made in subsequent versions of the draft document were well received.

Changes and revisions go hand-in-hand with the consensus process. This process continued throughout the fall until a second version of the draft document was disseminated for review in October–December, 1995. This second draft was disseminated to more than 250 people at eight regional locations in the United States. This group contained a large number of administrators. It was felt that an important part of the consensus process includes a "buy-in" component. In other words, if technology education is to become a core subject in the nation's schools, then those who hold the power to enable this vision to become real must be involved in the front end of this process.

Additional efforts were made to expand the audience that reviewed this document by making it available to anyone having access to the Internet. Throughout this project, a World Wide Web home page was maintained in an effort to disseminate timely material. Access to the draft document became part of the home page in December 1995, and reviewers were invited to fill out a comment and review form on-line and submit it to the project for consideration prior to the final revisions. The final version of this document represents the broad support and input that was provided throughout this consensus process.

Technology for All Americans Project in the Future

After developing a consensus-based rationale and structure for the study of technology, the goal for the Technology for All Americans Project is to develop standards for technology education. This will include kindergarten through 12th grade curriculum content standards with benchmarks at 4th, 8th and 12th grade; teacher enhancement and teacher preparation standards; student assessment standards; and program standards. When these standards are developed and implemented, they will improve the quality of technology education programs in schools in the future.

International Technology Education Association

History

The International Technology Education Association (ITEA) was created in 1939 by a group of educators who sought to promote their profession and to provide a national forum for their ideas. Today, the ITEA pursues that same purpose on the international level and has become a powerful voice across North America and around the world.

Since its beginning, the ITEA has been dedicated to ensuring that all children get the best education possible. It serves the professional interests of elementary through university technology educators and promotes the highest standards.

Organization

The Delegate Assembly is the ITEA's basic governing body. Delegates are selected by affiliated state/province/national associations and meet annually at the ITEA International Conference. A 12-member Board of Directors, elected by the membership, oversees the fiscal and program management of the association and adopts policies and procedures accordingly. A professional headquarters staff, located in Reston, Virginia, carries out the day-to-day operations of the association.

Mission

The ITEA's mission is to advance everyone's technological capabilities and to nurture and promote the professionalism of those engaged in these pursuits. The ITEA seeks to meet the professional needs and interests of its members, and to improve public understanding of the profession and its contributions.

No generation of educators has ever needed to be as up-to-date on technology trends as today's practitioners. The ever-accelerating changes in current technologies and the influx of new technologies present major challenges to those teaching about technology.

The ITEA strives to:

- Provide a philosophical foundation for the study of technology that emphasizes technological literacy.
- Provide teaching and learning systems for developing technological literacy.
- Serve as the catalyst in establishing technology education as the primary discipline for the advancement of technological literacy.
- Increase the number and quality of people teaching technology.
- Receive enrichment and reinforcement on the concepts in the sciences, mathematics, language arts, and other subject areas.
- Work with tools, materials, and technological concepts and processes.
- Develop technological answers.

Foundation for Technology Education

The Foundation for Technology Education (FTE) supports efforts to ensure that schools prepare students to live effectively in an increasingly complex society. Its emphasis is on educating a citizenry to think and act from a technological perspective for therein lies strength for the individual, society, and the economy. The Foundation is committed to providing supporting programs for technology education which:

- Enhance the knowledge and skills of technology teachers.
- Promote collaboration between schools and other sectors of the community to enrich educational resources and support school improvement.
- Strengthen effective learning about technology in schools.

The FTE is a nonprofit organization established in 1986 by the International Technology Education Association and governed by a Board of Trustees, which includes educators and leaders from business and industry. The Foundation's program of giving and development is devoted to improving and strengthening the education of each learner through high quality technology education.

The Foundation generates a capability to award scholarships and grants to teachers and future teachers to strengthen technology education. It strives to build a financial base that will provide additional means and encouragement to address technological literacy in schools.

For more information pertaining to the International Technology Education Association or the Foundation for Technology Education, contact 1914 Association Drive, Reston, VA 20191; (703) 860-2100.

The National Commission for Technology Education

Dr. G. Eugene Martin
Chairperson
Dean of the School of Applied Arts and Technology
Southwest Texas State University

Dr. J. Myron Atkin
Professor of Education
Stanford University

Dr. E. Allen Bame
Associate Professor of Technology Education
Virginia Tech

Dr. M. James Bensen
President
Bemidji State University

Dr. Gene R. Carter
Executive Director
Association for Supervision and Curriculum Development

Dr. Robert A. Daiber*
Technology Education Teacher
Triad High School—Illinois

Dr. James E. Davis
Professor of English
Ohio University

Dr. Paul W. DeVore*
President
PWD Associates

Mr. Ismael Diaz
Educational Consultant
Fordham University

Dr. William E. Dugger, Jr.
Project Director
Technology for All Americans Project

Dr. Frank L. Huband
Executive Director
The American Society for Engineering Education

Mr. Thomas A. Hughes, Jr.
Director of Development
Foundation for Technology Education

Dr. Patricia A. Hutchinson
Editor
TIES Magazine
Trenton State College

Dr. Thomas T. Liao
Professor and Chairperson
Department of Technology and Society
State University of New York at Stony Brook

Dr. Franzie L. Loepp*
Co-Director
Center for Mathematics, Science, and Technology

Ms. Elizabeth D. Phillips
Specialist
Department of Mathematics
Michigan State University

Dr. Charles A. Pinder
Professor and Chairperson of Technology
Northern Kentucky University

Dr. William S. Pretzer*
Technology for All Americans Writing Consultants Coordinator
Director of School Programs
Henry Ford Museum and Greenfield Village

Dr. John M. Ritz
Professor and Chairperson
Occupational and Technical Studies Department
Old Dominion University

Dr. Richard E. Satchwell
Assistant Director
Technology for All Americans Project

Dr. Kendall N. Starkweather
Executive Director
International Technology Education Association

Dr. Charles E. Vela
Technical Support Staff
MITRE Corporation

Dr. Walter B. Waetjen*
President Emeritus
Cleveland State University

Dr. John G. Wirt
Senior Research Associate
Institute for Education and the Economy
Teachers College
Columbia University

Dr. Michael D. Wright*
Assistant Professor of Technology Education
University of Missouri-Columbia

*Technology for All Americans Writing Consultants

Technology for All Americans Project Staff

Dr. William E. Dugger, Jr.
Project Director

Dr. Richard E. Satchwell
Assistant Project Director

Support Staff
Jodie Altice
Elizabeth Chabala
Lisa Driscoll
Michelle Griffith
Jeff Meide
Lisa Thorne

Visiting Scholars

Dr. Laverne Young-Hawkins
Associate Professor, Texas A&M University

Dr. Hidetoshi Miyakawa
Associate Professor, Aichi University of Education
Aichi, Japan

International Technology Education Association Board of Directors

Mr. William "Ed" Ball
Dr. R. Thomas Wright, DTE
Mr. John Monroe, DTE
Mr. Thomas A. D'Apolito
Mr. Barry N. Burke
Mr. Jeffrey E. Grimmer
Dr. Jay C. Hicken, DTE
Ms. Tina E. Hayden
Dr. David H. Devier, DTE
Mr. Lemuel E. "Chip" Miller
Dr. Everett N. Israel, DTE
Dr. William Wargo
Mr. Harold E. Holley
Dr. Gerald G. Lovedahl
Dr. Michael D. Wright
Dr. Kendall N. Starkweather

The ITEA and the TAA Project wish to thank the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) for their support during Phase I of the project. Special appreciation is given to Gerhard Salinger, Coleen Hill, Franzie Loepp, and Rodney Custer who provided help from NSF. Also, we would like to thank Frank Owens, Pam Mountjoy, and Malcolm Phelps from NASA for their advice and input. The ITEA and TAA would also like to express appreciation to the Technical Foundation of America for their assistance in funding certain activities during Phase I of the project.

Special thanks are given to Ottobine Elementary School, Rockingham County (Virginia) Schools; Hidden Valley Junior High School, Roanoke County (Virginia) Schools; and Christiansburg Middle School, Montgomery County (Virginia) Schools for photographs.

The project would like to thank Eileen Baumann, Susanna Kibler, and John O'Connor for initial editing and preparation and Ed Scott of Harlowe Typography for the design of this document. It would also like to express special appreciation to Maureen Heenan of the ITEA staff for all of the editorial and publishing assistance she provided in the production of the final copy of this doument.

International Technology Education Association Staff

Dr. Kendall N. Starkweather
Executive Director

Mr. Thomas A. Hughes, Jr.
Director of Development
Foundation for Technology Education

Support Staff

Janice Bruns
Linda DeFranco
Maureen Heenan
Catherine James
Jayne Newton
Lari Price
Karen Ulatowski
Lorena Vasquez

Evaluators

Dr. Jack R. Frymier
Senior Fellow
Phi Delta Kappa

Dr. Jill F. Russell
Assistant Professor
College of Education
University of Nebraska at Omaha

Evaluation Administrator
Dr. Larry W. Barber
Director, Center for Evaluation, Development and Research
Phi Delta Kappa International

Reviewers

Demetrio Acevedo
Ambrose Adams
Shawn Agnew
Daniel Airoldi
Robert Albert
Creighton Alexander
Cynthia Allen
Chris Almeida
Frederick Almquist
Meredith Altshuler
Richard Alvidrez
Richard Ambacher
Andrea Anderson
Jack Anderson
John Antrim
Harry Armen
Thomas Asplin
Eric Austin
Rick Avondet
Larry Bacchi
Becky Baker
Joe Baker
Jerry Balistreri
William Ball
Deborah Ballard
Gary Baltozer
Marilyn Bannon
Kim Barany
Ronald Barker
Hilda Barnett
Timothy Barrett
Joe Barry
Sandra Barry
Lynn Basham
Brad Basil
Robert Bateman
Thomas Baughman
John Bear
Mac Beaton
Charles Beatty
Heinz Beier
Gary Bell
Myron Bender
Roger Benedict
Christine Bengston
Russell Bennett
Barbara Bernard
David Berns
Al Birkholz
Joseph Blum
Del Boedeker
Carlalee Boettger
Barbara Bolin
Paul Bond
Barry Borakove
Pauline Bottrill
Niki Bourke
David Bouvier
Donovan Bowers
Debra Bozarth
Frank Braman
John Breck
Lillian Brinkley
Dan Brook
Charles Brooks
Sharon Brusic
Stanley Bucholc
Walter Buczynski
Nancy Bugler
James Bujak
Debra Burdick
Barry Burke
Verner Burkett
Stephen Burkholder
John Burns
Ted Burton
Donna Bush
Jeffrey Bush
Robert Caldwell
Kristin Callender
Nick Cammarano
John Casey
Kevin Castner
Jodi Cavanaugh
April Cave
Christopher Chamuris
Jonathan Charles
Arlene Chasek
Dennis Cheek
Eldon Chlumsky
Brad Christensen
Dean Christensen
Jim Christensen
Karen Christopherson
Craig Clark
Marcus Clarke
Thomas Cline
Sam Cobbins
Geanea Coleman
Thomas Collins
Syliva Connolly
Charles Cook
Steve Cook
Charles Corley
Steve Cottrell
Dale Coulson
Jodie Coulson
Wes Coulter
Alan Cox
Douglas Craig
Terry Crissey
Paul Cuetara
David Culver
Scott Currie
Rodney Custer
Thomas D'Apolito
Richard Dahl
Michael Daugherty
Sara De Carlo
John Decaire
Kenneth DeLucca
Ed Denton
William Derry
David Devier
Mary Devin
Richard Dieffenderfer
Frank DiNoto
Dennis Dirksen
John Doyle
Pasquale Drago
Larry Dunekack
Robert Dunn
Lorraine Durrill
Robert Dwyer
Michael Dyrenfurth
Glenn Edmondson
Jane Eisemann
John Emmons
Neil English
Thomas Erekson
Neil Eshelman
Cindy Etchison
Richard Fein
Victor Feliciano
Dennis Ferrari
Keith Finkral
Edward Fitzgerald
John Flanagan
Michael Flanagan
E. P. Flemyng
Gioia Forman
Alice Foster
Tad Foster
Gary Foveaux
Marilyn Fowler
Philip Frankenfeld
David Frankenhauser
Kathy Franco
Harold Fullam
Dennis Gallo
Hervey Galloway
William Garzke
Charlie Gaulden
Perry Gemmill
Mary Genova
Bradford George
John Gibbons
Anthony Gilberti
James Giordano
Roberta Glaser
Edward Goldman
James Good
Mary Good
Harold Gotwald
Rodney Graf
Gary Graff
Sandi Graff
Carmen Granto
Theodore Gratts
Gary Gray
Robert Gray
Clark Greene
Walter Greer
David Greer
James Griffin
Edward Grimaldi
Jeffrey Grimmer
Richard Grimsley
Shawn Gross
Jerry Grover
Joseph Guidice
Leroy Gurnle
Mark Haas
Michael Hacker
Larry Hagmann
Doris Hamm
Leo Hanifen
Cindy Hannon
John Hansen
Robert Hanson
Linda Harpine
Edward Hartmann
Mark Hartshorne
Craig Haugsness
Maureen Heenan
Richard Hellthaler
Michael Helmick
Al Henrion
Barry Hessinger
Tom Hession
Mark Hiendlmayr
Colleen Hill
Jane Hill
Roger Hill
Warren Hitz
Larry Hoelscher
Marie Hoepfl
Harold Holley
Rich Holliday
David Holmes
Sid Holodnick
Dundee Holt
David Hood
Lynn Hoover
Peter Horoschak
Daniel Householder
Kenneth Hoyt
Philip Hublitz
James Hudock
Jeremy Hughes
Van Hughes
Jeffrey Hunt
John Hutchinson
Joseph Huttlin
Clinton Isbell
Everett Israel
Leovincey Iwiyisi
Chuck Jacobs
Paul Jacobs
Tricia Jacobs
Patrick Janssen
James Jelkin
Jim Jenkins
Gerald Jennings
Michael Jensen
William Jodz
Scott Johnson
James Johnson
Cheryl Jong
James Justice
Jon Kahle
Gregory Kane
John Karsnitz
Ralph Kilgore
Richard Kimbell
Michael Klann
Suzanne Knapic
Donald Knepler
Louisa Kniivila
Stephan Knobloch
Jane Konirad
Robert Kosztowny
John Kovel

John Kraljic
Charlie Krenek
Benjamin Krothe
Richard Kruyer
Gerald Kuhn
Dan Kunz
Thomas LaClair
Henry Lacy
Kevin Lally
Christine Landry
Wayne Lang
Joanne Langabee
James LaPorte
Connie Larson
Thomas Latimer
Donald Lauda
Barry LeBarron
Ta-Wei Lee
Hal Lefever
James Levande
Theodore Lewis
Jane Liedtke
Jeff Lindstrom
Mike Lindstrom
Ethan Lipton
Charles Little
Jolene Litton
Gerald Lovedahl
Peter Lowe
Brian Luce
Richard Luce
Peter Lund
Ron Lutz
Michael Magliacano
David Magnone
Gary Mahoney
David Manard
Vickie Markavitch
Linda Markert
Peter Martin
Benjamin Martin
Brian McAlister
Joseph McCade
Dave McCready
David McCrory
David McGee
Jack McGinnis
Richard McManus
Scott McMillin
Sean McSheehy
Jim Meinert
Joseph Meroda
Wilson Mewborn
Marilyn Meyer
Pete Meyer
Anne Mikesell
Ginney Milbourne
Chip Miller
David Miller
David W. Miller
Jonathan Miller
Judy Miller
Kevin Miller
Dave Milliken
Michael Mino
Carl Mitcham
John Mitchell
William Moats, III
Mike Monaghan
Richard Mondragon
John Monroe
Jim Moon
Harvielee Moore
Steve Moorhead
Mike Mosley
Al Mothersele
Roger Mousseau
James Mundy
Heidi Munz
Cynthia Nava
Carolyn Newsome
Gail Niedernhofer
Chris Nielsen
Diane Novak
J. T. Nuzzo
Don O'Connor
Timothy Obermier
Thomas Ogle
Linda Organ
Elaine Osterman
Bob Ozga
Matthew Pagnani
Carll Pallokat
John Pannabecker
Scott Papenfus
Kevin Pendergast
James Petzold
Randal Pierce
Tommy Pitchford
John Plias
Douglas Ploeser
Paul Post
Neil Postman
Theresa Powe
Roger Prewitt
Beth Price
Steven Price
Crystal Priest
Susan Pryor
David Pucel
David Purington
Nathaniel Quintana
Sid Rader
Senta Raizen
Felix Ramirez
Gene Ranger
Robert Ransome
Kathy Raymond
Eldon Rebhorn
Cherry Redus
Charlotte Rice
Betty Rider
Jerry Ridgeway
John Rigden
Sam Ritts
Gene Ritz
Kenneth Robinson
Dwight Rogers
George Rogers
Kevin Rose
Ron Rossman
Thomas Rothacker
James Russett
James Rutherford
Sharon Ryan
Thomas Ryerson
Gerhard Salinger
Joseph Samela, Jr.
Mark Sanders
David Sawyer
Ernest Savage
Laurie Schmitt
Max Schoenhals
Tonia Schofield
Todd Scholl
John Schumacher
Anthony Schwaller
David Seidel
Richard Seymour
Edward Shine
Thomas Shown
Deborah Shumate
Jeffrey Sicher
Ron Siebach
John Singer
Bernard Singer
Alfred Skolnick
Dennis Skurulsky
Roy Slater
Lee Smalley
Dave Smith
Harley Smith
Kenneth Smith
Ora Smith
Loren Smitt
Greg Smothers
Richard Souter
Joseph Spadavecchia
Gari Spagnoletti
Emilio Spino
Donatus St. Aimee
William Staman
John Staudenmaier
Gregg Steele
Leonard Sterry
Gary Stevenson
Gary Stewardson
Howard Stob
Colleen Stone
John Stoudt
Henry Strada
Arnold Strassenburg
Jerry Streichler
Larry Strom
Douglas Sullivan
Kaye Sullivan
Laura Sullivan
Donald Suplee
Darlina Swartz
Robert Swisher, Jr.
Dennis Swyt
Ed Taylor
Armand Taylor
Tom Termes
Dennis Tesolowski
Donald Testa
John Thomas
Maurice Thomas
Danny Thompson
Sylvia Tiala
Ron Todd
Sherri Torkelson
Donna Trautman
Lisa Tremblay
Joan Tucker
Dennis Turner
John Vaglia
Brigitte Valesey
Eric Van Duzer
Arvid Van Dyke
Dorothy VanLooy
Bruce Ventura
Bob Viara
Ron Vickers
Frank Viscardi
John Vogelsang
Kenneth Volk
Marc deVries
Charles Wallace
Mark Wallace
Bill Wargo
Scott Warner
Gordon Warren
Steve Wash
John Watson
Chad Weaver
Alfred Weiss
Jack Wellman
Ken Welty
Edward Wenk
Ted Werner
Tracy Westra
Vincent Wheatley
Jane Wheeler
Rosanne White
Doug Wickham
Robert Wicklein
Emerson Wiens
Flint Wild
George Willcox
William Wolfe
Deborah Woodman
Wayne Worner
John Wright
Tom Wright
Gary Wynn
Dottie Yager
LaVerne Young-Hawkins
Ron Yuill
Norman Zaniboni
Michael Zapantis
David Zinn
Karen Zuga

Technology for All Americans Project

International Technology Education Association

Technology is human innovation in action

ISBN 1-887101-01-2

90000

9 781887 101011