Technological Literacy for All

A Rationale and Structure for the Study of Technology

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Technology is human innovation in action
Technological Literacy for All:
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Preface

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.

From 1994–1996, the International Technology Education Association (ITEA) received grants from the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) to develop the first edition of this document (ITEA, 1996). The first edition of Technology for All Americans: A Rationale and Structure for the Study of Technology (R&S) (ITEA, 1996) was revised in 2005 to reflect the work of ITEA’s Technology for All Americans Project (TfAAP) in developing Standards for Technological Literacy: Content for the Study of Technology (STL) (ITEA, 2000/2002), Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards (AETL), and the four companion addenda to these standards documents (ITEA, 2004; ITEA, 2005a; ITEA, 2005b; ITEA, 2005c).

Technology for All Americans: 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 built upon this background and is included in STL and AETL. The standards provide a general framework from which schools can develop curricula and programs. This material provides the criteria for student assessment, curricula content, professional development, and program enhancement.

The first part of this document discusses the power and the promise of technology and the need for technological literacy. The next section provides a transition of universal processes, knowledge, and contexts of technology generated in the First edition of R&S to STL and AETL. 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 make technological literacy a national priority.

This document has been prepared by ITEA’s Technology for All Americans Project through assistance from writing consultants. It has been reviewed by hundreds of practitioners of technology, engineering, science, mathematics, 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.
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, among thousands of other innovations. This has created a world of technological products and machines, roadways and buildings, and data and global communications. It has resulted in 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 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, governments, industries, and individuals according to their goals and values. For example, biotechnological 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, evaluate, and understand it.
A major consequence of accelerated 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 implementers 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, which is defined as: the ability to use, manage, evaluate, 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.

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**Technological Literacy**

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

- The ability to **use** technology involves the successful operation of the key products and 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 ensuring that all technological activities are efficient and appropriate.
- The ability to **evaluate** technology involves being able to make judgments and decisions about technology on an informed basis rather than an emotional one.
- Understanding technology involves more than facts and information, but also the ability to synthesize the information into new insights.
ITEA’s Standards for Technological Literacy: Content for the Study of Technology (STL) defines technology as “the innovation, change, or modification of the natural environment in order to satisfy perceived human wants and needs” (ITEA, 2000/2002, p. 242).

Confusion About Technology
Unfortunately, a majority of people do not know what technology is. In 2002 and 2004, the International Technology Education Association (ITEA) conducted Gallup Polls on “What Americans Think About Technology” (Rose & Dugger, 2002; Rose, Gallup, Dugger, & Starkweather, 2004). In both polls, the Gallup Organization found that the public had a very narrow definition of technology as being computers rather than the broader view of technology held by experts in technology, engineering, and science. Another major finding was there was near total consensus among the public sampled that schools should include the study of technology in the curriculum.

What Is Technology?
There are many definitions of technology. ITEA’s Standards for Technological Literacy: Content for the Study of Technology (STL) defines technology as “the innovation, change, or modification of the natural environment in order to satisfy perceived human wants and needs” (ITEA, 2000/2002, p. 242). This is compatible with the definition provided in the National Science Education Standards, which states, “...the goal of technology is to make modifications in the world to meet human needs” (NRC, 1996, p. 24). Similar to these definitions, the American
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Association for the Advancement of Science’s (AAAS) *Benchmarks for Science Literacy* presents the following: “In the broadest sense, technology extends our abilities to change the world: to cut, shape, or put together materials; to move things from one place to another; to reach farther with our hands, voices, and senses” (1993, p. 41). In the National Academy of Engineering (NAE) and National Research Council (NRC) publication, *Technically Speaking*, technology is described as “…the process by which humans modify nature to meet their needs and wants” (2002, p. 2). All four of these nationally recognized definitions of technology are very similar and reinforce each other.

**Other Definitions Relevant to Technology**

The principal discipline being advocated in this document is technology, which is closely related to science, mathematics, and engineering. In literature, it is common for these four areas to be grouped together as science, technology, engineering, and mathematics (STEM) (ITEA, 2003).

Science, which deals with “…understand[ing] the natural world” (NRC, 1996, p. 24), is the underpinning of technology. Science is concerned with “what is” in the natural world, while technology deals with “what can be” invented, innovated, or designed from the natural world.
Rodger Bybee, President of Biological Science Curriculum Study (BSCS), explains more about science and technology:

The lack of technological literacy is compounded by one prevalent misconception. When asked to define technology, most individuals reply with the archaic, and mostly erroneous, idea that technology is applied science. Although this definition of technology has a long standing in this country, it is well past time to establish a new understanding about technology...it is in the interest of science, science education, and society to help students and all citizens develop a greater understanding and appreciation for some of the fundamental concepts and processes of technology and engineering. (2000, pp. 23-24)

“Mathematics is the science of patterns and relationships” (AAAS, 1993, p. 23). It provides an exact language for technology, science, and engineering. Developments in technology, such as the computer, stimulate mathematics, just as 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 might operate.

According to the Accreditation Board for Engineering and Technology (ABET), “engineering is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize economically the materials and forces of nature for the benefit of mankind” (ABET, 2002, back cover). There are strong philosophical connections between technology and engineering. The engineering profession has begun to work with educators of technology to develop alliances for infusing engineering concepts into K–12 education. The alliances will provide a mechanism for greater appreciation and understanding of engineering and technology. The National Academy of Engineering is an avid supporter of technological literacy.

The need for technological literacy, science literacy, and mathematical literacy is an ever important goal for schools now and in the future.
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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 understand technological impacts and consequences, acknowledging that the solution to one problem may create others. 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, mathematics, social studies, language arts, and other content areas as tools for understanding and managing technological systems. Therefore, technologically literate people use a strong systems-oriented, creative, and productive 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 may be 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.
Developing Technological Literacy Through Formal Education

Schools that encourage the study of technology should provide all students with concepts and experiences necessary to develop understanding and abilities for the constantly changing technological world. The study of technology can enhance student learning by highlighting the relationships among technologies and the connections between technology and other fields of study, including science, mathematics, social studies, language arts, and other content areas (ITEA, 2000/2002). Students who are engaged in activities that promote technological literacy through the development of knowledge and abilities become able to make informed decisions regarding the use and management of technology. Comprehensive technological study, incorporating content identified in STL, should be provided by technology teachers as well as learning opportunities that focus on the content in STL. The study of technology should begin in kindergarten and progress through Grade 12, providing continuous learning opportunities to students.

While the study of technology should occur in a continuous, cross-curricular fashion, it should also be promoted in classrooms specifically charged to develop technologically literate students. Technology education plays a crucial role in advancing students toward technological literacy because it is the only school subject dedicated to technological literacy. Students engage in cognitive and psychomotor activities that foster critical thinking, decision making, and problem solving related to the use, management, evaluation, and understanding of the designed world.

Technology education is the school subject specifically designed to help students develop technological literacy. Technology education is not the same as educational technology. Sometimes referred to as instructional technology, educational technology involves the study of computers and the use of technological developments, such as computers, audiovisual equipment, and mass media, as tools to enhance and optimize the teaching and learning process and environment in all school subjects.
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 upon one’s background, education, interests, attitudes, and abilities. As ITEA’s Gallup polls revealed (ITEA, 2002 Insert and ITEA, 2004 Insert), 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 have been ignored, except for those pursuing education and training in engineering and 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.

A study of technology 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 a study of technology 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 programs provide a high-quality study of technology at all levels. The next part of this document describes the structure for the content that should be learned in technology as presented in STL. Later in this book, a discussion is given on how the study of technology can be incorporated into the educational programs of all students from kindergarten through high school and beyond.
In the original edition of ITEA’s *Technology for All Americans: A Rationale and Structure for the Study of Technology (R&S)* (ITEA, 1996), developed in Phase I of the project (1994-1996), the universals of technology were presented as the fundamental concepts for the structure of technology. At the time of their development, the universals of technology were viewed as the initial organizers for the content (what every student should know and be able to do) in developing the technological literacy of all students in Grades K–12.

In Phase II of ITEA’s Technology for All Americans Project (TfAAP) (1996-2000), *Standards for Technological Literacy: Content for the Study of Technology (STL)* was created. The universals of technology from the R&S document were key in developing the twenty standards in STL as well as the five major categories under which these standards were organized. The development of STL was also very much influenced by its Advisory Committee, the Standards Team (made up of educators from elementary, middle school, and high school levels), the National Research Council Standards Review Committee, the National Academy of Engineering Focus Group, the National Academy of Engineering Special Review Committee, the National Research Council’s Technical Review Panel, the field review sites in numerous schools nationwide, and hundreds of reviewers who gave input to the various drafts of the standards.
The Evolution of Taxometric Organizers of Technology (From R&S to STL)

The 1996 R&S publication presented the “Universals of Technology” (see Figure 1). Note that around the triangle, there were three major organizers around which 10 universals were displayed. The three major organizers were based upon the principles that all technological systems are comprised of:

- Knowledge
- Processes
- Contexts

Under each of the three organizers, there were universals given as follows:

Many times the best way to determine what is happening in a system is to take it apart.
Knowledge
A. Nature and Evolution of Technology
B. Linkages
C. Technological Concepts and Principles

Processes
D. Designing and Developing Technological Processes and Systems
E. Determining and Controlling the Behavior of Technological Systems
F. Utilizing Technological Systems
G. Assessing the Impacts and Consequences of Technological Systems

Contexts
H. Biological and Chemical Systems
I. Informational Systems
J. Physical Systems

Note the placement of the 10 universals around the triangle in Figure 1. The crossing lines in the center part of the triangle depict the overlapping nature of all the universals in technology.

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, content elements for the study of technology appropriate for students of different locations and places were developed in STL.

Knowledge Organizer Universals Evolution into STL Standards

The transition of the 10 universals into the 20 STL standards and their five organizing categories are illustrated in Figure 2 by the solid lines (with arrows) and the dotted lines. The solid lines show direct correlations between the universals and the standards/categories. The dotted lines show potential correlations between the universals and standards (categories). For example, under the Knowledge organizer, the universal “Nature and Evolution of Technology” was used to provide the category “The Nature of Technology” as Standard 1, “The Characteristics and Scope of Technology,” in STL. The “Linkages” universal was used as the basis for Standard 3, “Relationships Among Technology and the Connections Between Technology and Other Fields.” The universal “Technological Concepts and Principles” was the foundation for Standard 2, “The Core Concepts of Technology.”
A Structure for the Content of Technology

Figure 1: The Universals of Technology (ITEA, 1996)
A Structure for the Content of Technology

Figure 2: Evolution of Taxometric Organizers

From Rationale & Structure (ITEA, 1996)

From Standards for Technological Literacy (ITEA, 2000/2002)
Also under the Knowledge organizer from R&S, the evolution of technology part of “Nature and Evolution of Technology” provided the basis for the content in the four standards in the “Technology and Society” category in STL (Standards 4, 5, 6, and 7).

**Processes Organizer Universals Evolution into STL Standards**

In the Processes organizer from R&S, the “Designing and Developing Technological Systems” and “Determining and Controlling the Behavior of Technological Systems” universals were used as input in developing Standards 8, 9, 10, and 11 in STL.

Also in the Process organizer from R&S, the universal “Utilizing Technological Systems” was instrumental in the formulation of Standard 12 in STL.

The universal “Assessing the Impacts and Consequences of Products and Systems” provided a direct correlation to the STL Standard 13.

**Context Organizer Universals Evolution into STL Standards**

Biological systems use living organisms (or parts of organisms) to make or modify products; to improve humans, plants, or animals; or to develop microorganisms for specific use (U.S. Office of Technology Assessment, 1988). Biological systems are used in fields such as medicine and agriculture. Many of these systems are referred to as “biotechnology.” In the R&S Contexts organizer, there are three technological systems given. The biological systems universal provided the foundation for developing Standard 14 and 15 in the Designed World in STL.

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. The information systems universal was used as a basis for creating Standard 17 in STL.

Physical systems are those that are tangible and made of physical resources. Changing the form of materials to increase their value and purpose provides the basis for production in physical systems. Power is considered a major part of the physical systems, since it is important to the operation of them. Physical systems also transport people and things. The physical systems universal provided the foundation for the development of Standards 16, 18, 19, and 20 in the Designed World category in STL.

As previously stated, the 10 universals in R&S were very instrumental in the evolution of the 20 standards and five categories in STL.
Overview of STL

STL begins with a preface that sets the stage for the publication. Chapter 1 provides a broad perspective on preparing students for a technological world while Chapter 2 contains the overview of the features of STL as well as its format. Chapter 2 provides a section that deals with the primary users of the standards as well as recommendations for using the standards for curriculum development. Chapter 2 also lists administrator guidelines for resources based on STL. Chapters 3 through 7 contain major categories under which the standards were developed. Lastly, Chapter 8 is a call to action requesting users to help ITEA implement STL. The document also has an appendix, which includes the history of the project, a compendium that provides a quick overview of the standards and related benchmarks, and an articulated curriculum example for Grades K–12, as well as references, acknowledgements, a glossary, and an index.

Features of STL

Standards for Technological Literacy: Content for the Study of Technology (STL) represents the collective view of hundreds of people regarding the necessary content for the study of technology in Grades K–12. In order to be as broadly valuable as possible, STL was created with the following basic features:

- It offers a common set of expectations for what students should learn about technology.
- It offers specific content that every student should learn about technology.
- It is developmentally appropriate for students.
- It provides a basis for developing meaningful, relevant, and articulated curricula at the local and state/provincial levels.
- It promotes content connections with other fields of study in Grades K–12.

In laying out the essentials for the study of technology, STL represents recommendations from educators, engineers, scientists, mathematicians, and parents about the skills and knowledge needed to become technologically literate. It is not, however, a federal policy or mandate. STL does not prescribe an assessment process for determining how well students are meeting the standards, although it does provide criteria for this assessment.

Format of STL

The individual standards presented in STL are organized into five major categories:

- The Nature of Technology (Chapter 3)
- Technology and Society (Chapter 4)
- Design (Chapter 5)
- Abilities for a Technological World (Chapter 6)
- The Designed World (Chapter 7)

Under the five major categories, there are 20 standards. See Figure 3 for a listing of the categories and standards.
A Structure for the Content of Technology


The Nature of Technology
Standard 1. Students will develop an understanding of the characteristics and scope of technology.
Standard 2. Students will develop an understanding of the core concepts of technology.
Standard 3. Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society
Standard 4. Students will develop an understanding of the cultural, social, economic, and political effects of technology.
Standard 5. Students will develop an understanding of the effects of technology on the environment.
Standard 6. Students will develop an understanding of the role of society in the development and use of technology.
Standard 7. Students will develop an understanding of the influence of technology on history.

Design
Standard 8. Students will develop an understanding of the attributes of design.
Standard 9. Students will develop an understanding of engineering design.
Standard 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World
Standard 11. Students will develop the abilities to apply the design process.
Standard 12. Students will develop the abilities to use and maintain technological products and systems.
Standard 13. Students will develop the abilities to assess the impact of products and systems.

The Designed World
Standard 14. Students will develop an understanding of and be able to select and use medical technologies.
Standard 15. Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.
Standard 16. Students will develop an understanding of and be able to select and use energy and power technologies.
Standard 17. Students will develop an understanding of and be able to select and use information and communication technologies.
Standard 18. Students will develop an understanding of and be able to select and use transportation technologies.
Standard 19. Students will develop an understanding of and be able to select and use manufacturing technologies.
Standard 20. Students will develop an understanding of and be able to select and use construction technologies.
A Structure for the Content of Technology

Standards

Standards for Technological Literacy: Content for the Study of Technology (STL) has written statements about what is valued in the study of technology that can be used for judging quality. The document specifies what every student should know and be able to do in order to be technologically literate and offers criteria to judge progress toward a vision of technological literacy for all students. STL contains requirements for students to become technologically literate as a result of their education from kindergarten through Grade 12.

STL is not a curriculum. It provides the content, which is the material to be taught and learned in the curriculum. A curriculum provides the specific details of how the content (STL) is to be delivered, including organization, balance, and the various ways of presenting the content in the classroom, while standards describe what the content should be. Curriculum developers, teachers, and others should use STL as a guide for developing appropriate curricula, but the standards do not specify what should go on in the classroom.
Benchmarks play a vital role in STL. They provide the necessary elaboration of the broadly stated standards. Benchmarks, which are statements that enable students to meet a given standard, are provided for each of the 20 standards at the K–2, 3–5, 6–8, and 9–12 grade levels. (See Figure 4 for a sample of the benchmarks.) The benchmarks are followed by supporting sentences that provide further detail, clarity, and examples. Like the standards, the benchmarks are required for students to meet the standards.

Teachers should feel free to add to the benchmarks to further enhance the ability of the student to meet a given standard, but teachers should not eliminate or disregard standards or benchmarks.

From research in education, it has been found that if previously learned knowledge is tapped and built upon, it is likely that children will acquire a more coherent and thorough understanding of these processes than if they are taught them as isolated abstractions (NRC, 1999). With this in mind, the benchmarks are articulated or “ramped” from Grades K–12 to progress from very basic ideas at the early elementary school level to the more complex and comprehensive ideas at the high school level. Certain content “concepts,” such as systems, resources, requirements, optimization, trade-offs, processes, and controls, are found in the benchmarks, which extend across various levels to ensure continual learning of an important topic related to a standard.

Figure 4. A Representative Standard and Benchmarks

Standard 8 - Students will develop an understanding of the attributes of design.

In order to realize the attributes of design, students in Grades 3–5 should learn that

C. The design process is a purposeful method of planning practical solutions to problems. The design process helps convert ideas into products and systems. The process is intuitive and includes such things as creating ideas, putting the ideas on paper, using words and sketches, building models of the design, testing out the design, and evaluating the solution.

D. Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design. Technological designs typically have to meet requirements to be successful. These requirements usually relate to the purpose or function of the product or system. Other requirements, such as size and cost, describe the limits of a design.
Other Standards and Publications

**Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards**

In Phase III of TfAAP (2000-2005), *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards* (AETL) was developed. AETL consists of three separate but interrelated sets of standards.

- Student Assessment Standards
- Professional Development Standards
- Program Standards

The standards in AETL are based upon STL. AETL is designed to leave specific curricular decisions to educators. Teachers, professional development providers, and administrators should use STL and AETL as guides for advancing technological literacy for all students.

**New Technology Standards-Based Addenda**

Educational standards provide criteria for learning and ensure quality in educational programs. Standards-based technology programs can deliver technological literacy. The purpose of STL and AETL is to advance the technological literacy of all students. Together, they identify a vision for developing a technologically literate citizenry.

The ITEA Addenda series (to STL and AETL) is part of the standards package for technological literacy. They were produced by the TfAAP staff with special assistance from ITEA’s Center to Advance the Teaching of Technology and Science (CATTS). These addenda are based on the standards but include concrete processes or suggestions for incorporating national, state, and/or local technological literacy standards into the programs of all students throughout Grades K-12. Additionally, all of the...
documents contain worksheets for educators to use to make changes specific to their locality and situation. The new addenda series marks another pioneering effort in educational reform, as it provides a supplement to educational standards that focuses on the entire picture of program reformation rather than concentrating solely on curricula. The new addenda are:

- **Measuring Progress: Assessing Students for Technological Literacy** (ITEA, 2004)
- **Realizing Excellence: Structuring Technology Programs** (ITEA, 2005)
- **Planning Learning: Developing Technology Curricula** (ITEA, 2005)
- **Developing Professionals: Preparing Technology Teachers** (ITEA, 2005)

**ITEA-TIDE**

In 2005, ITEA started using the new slogan: Technology Education: Technology, Innovation, Design, Engineering (TIDE), which reflects what the association is all about. It clearly describes what the content, nature, breadth, and scope of the study of technology is and can be. This acronym, TIDE, indicates that the study of technology is much more encompassing than computers and information technology (although they are still a part of technology). TIDE provides a good, succinct description of what ITEA is trying to accomplish as the association representing the study of technology as a core school subject.

**Challenges for the Future**

The closing of TfAAP’s doors did not represent an end, but a beginning. We appreciate the financial support from NSF and NASA over the duration of the project. Also we thank all of the hundreds of people who contributed and gave input to us. In other fields of study, developing standards has often proven to be the easiest step in a long, arduous process. Therefore, getting these technology standards accepted and implemented in Grades K–12 in every school will be far more difficult and daunting than developing them was. Only through the combined efforts of educational decision makers everywhere will we be able to ensure that all students develop higher levels of technological literacy.
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 STL, 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 STL 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 subjects. 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 a study of technology 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 a study of technology 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.
Throughout the elementary years, a study of technology 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, a study of technology 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 activities can be used to integrate the study of technology with related concepts from other disciplines, such as mathematics, science, social studies, language arts, and other content areas.

A study of technology should be a part of integrated thematic units that explore the relationship of technology to humans, societies, or the environment, or incorporated into the elementary curriculum as a valued subject with designated time slots. The materials and resources required for the elementary technology curricula 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 in-service training, these teachers perform exceptionally well and excel at integrating technological concepts across the curriculum. However, if the study of technology is to enhance what and how children learn, all elementary teachers will need in-service and pre-service opportunities in technology education. Further, all teacher preparation institutions will need to include the study of technology as a part of their undergraduate degree requirements.

The materials and resources required for elementary technology education are minimal.
A Study of Technology During the Middle School Years

Middle school technology 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.

The study of technology should be a part of the core curriculum for all learners throughout their middle school years. Middle school programs at this level can be implemented through interdisciplinary teams that include a certificated technology teacher. In some cases, the technology education program will be taught by a certificated technology teacher in a non-team-teaching environment. Middle school technology 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 technology on society.

In the middle school, the students gain further understanding of the nature of technology. Middle school students will deepen their level of understanding and increase abilities related to the technological world. Middle school students continue to be given opportunities to see how technology has contextual relationships with all systems in the designed world.

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 in the middle school, students will discover and develop personal interests, talents, and abilities related to technology.
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.
A Study of Technology During the High School Years and Beyond

A study of technology in high school 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 arts, social studies, geography, art, music, and physical education. In some applications, a study of technology 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 technology courses that extend their studies in the development, integration, and evolution of technological systems. Courses such as “Engineering Design” can be taken by 11th- and 12th-grade students in some schools.

High school students’ needs for a study of technology are more diversified than younger students’ since their interests and potential career choices are expanding. As a result of taking technology, 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 teachers, individually or in a team-teaching environment.

The ultimate goal for every student who graduates from high school is technological literacy. 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.

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,
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 teacher 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.
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 are compatible with STL and AETL. It is hoped that this will encourage technology education leaders to develop new curriculum materials at the state and local levels. A study of technology, 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 a study of technology within their local school system. Technology teachers should also work with other teachers in their school to assist them in teaching the content of technology in their classes (i.e., a social studies class could teach a unit on the industrial revolution). State and local school administrators and curriculum leaders must also mobilize to promote the idea that a study of technology 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, such as the Technology Student Association (TSA), the Technology Education Collegiate Association (TECA), and Junior Engineering Technical Society (JETS), should provide activities that are available to all students to develop leadership at the local, state, and national levels. These activities should reflect STL and AETL.

Professional associations and groups both inside and outside the technology education profession must work to develop and implement STL and AETL. 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 the study of technology 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 the study of technology in the schools.

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

The vision of the study of technology, embodied in this document, and in STL and AETL, 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 the study of technology becomes an essential subject for all students.
References and Resources


References and Resources


References and Resources


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Appendices

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.
- Use design, engineering, and technology in solving societal problems.
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 was spearheaded by the International Technology Education Association (ITEA) and was called “Technology for All Americans (TfAAP).” The project’s goal was 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 goal in Phase I (1994-96) of TfAAP was to produce this document (Technological Literacy for All: A Rationale and Structure for the Study of Technology) (R&S).

Development of 1996 Edition of R&S

The Technology for All Americans Project set out in Phase I 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 represented the fields of engineering, science, mathematics, the humanities, education, government, professional associations, and industry. The 25-member Commission served in an advisory capacity to the project staff and functioned independently of both the project and the ITEA. The Commission 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 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 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 1996 version of this document represents the broad support and input that was provided throughout this consensus process.

Revision of R&S in 2006

This revised edition of R&S was accomplished to reflect changes pursuant to publications created by ITEA/TfAAP since 1996 (when the original version of R&S was published). TfAAP staff made the revision in the summer of 2005 for a 2006 copyright of R&S.
The Center to Advance the Teaching of Technology & Science (CATTS) was established by the International Technology Education Association to improve student achievement in technology education, science, and mathematics at all grade levels, and to strengthen, broaden, and deepen the disciplinary and pedagogical knowledge of teachers.

The Center’s mission is to provide teachers with professional development support that enables the pursuit of technologically literate citizens. Thus, the goal of CATTS is to engage in significant research, development of standards-based curricular materials, and standards-based teacher enhancement through planned professional learning communities.

CATTS provides leadership and support to improve the results of learners studying technology and science as it engages in four continuing goals:

1. Research on Teaching and Learning
2. Standards-based curriculum development
3. Standards-based professional learning communities
4. Standards-based curriculum implementation and diffusion

**CATTS Consortium**

The CATTS Consortium has provided the Center with leadership through the collaboration of States that are committed to the development of curriculum, professional development, and the pursuit of pertinent research projects to promote technological literacy.

The Consortium leadership is responsible for development of the Engineering By Design — A National Standards-based Model for the implementation of Standards for Technological Literacy (STL). It has also been responsible for the development of professional learning communities created through eTIDEonline.net, a teacher’s web-based professional development opportunity.

The Engineering By Design, Standards-based Program consists of a vertically and horizontally developed set of resources for teachers based on STL:

**Engineering By Design Model Program Series**

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<tr>
<th>Grade</th>
<th>Program</th>
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<td>K–2</td>
<td>Integrated units and lessons</td>
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<tr>
<td>3–5</td>
<td>Integrated units and lessons</td>
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<td>Grade 6</td>
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<td>Grade 8</td>
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<td>Grades 10–12</td>
<td>Technological Issues</td>
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<td>Grades 10–12</td>
<td>Impacts of Technology</td>
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<tr>
<td>Grades 11–12</td>
<td>Engineering Design (Capstone)</td>
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These resources are available to the profession by visiting http://www.iteaconnect.org
Appendices

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