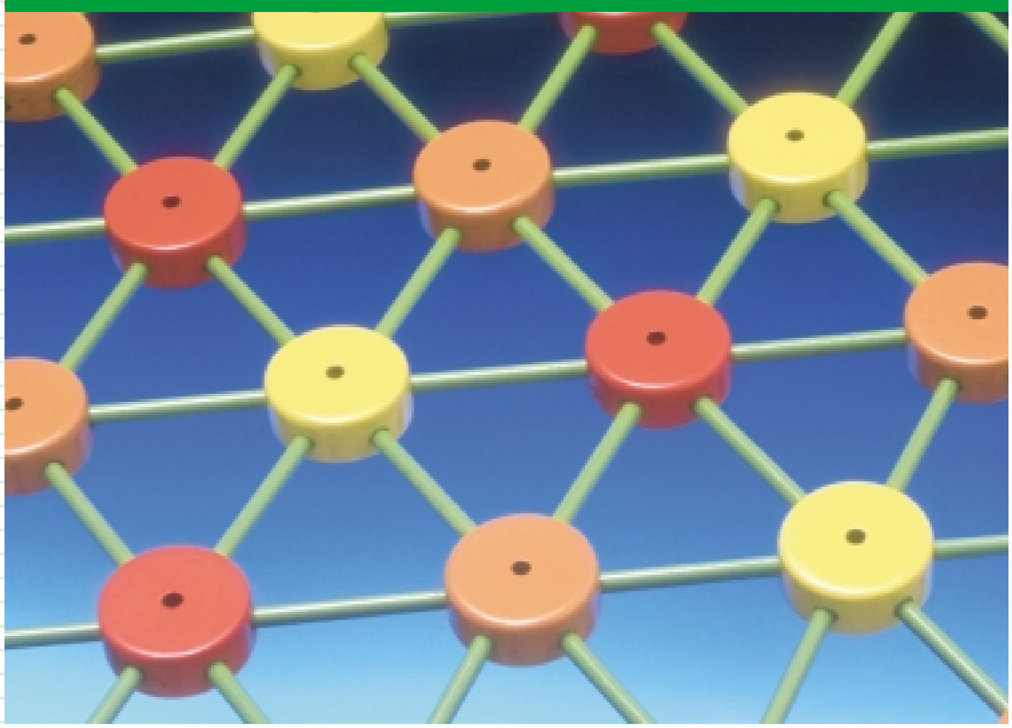
A Guide to Develop Standards-Based Curriculum for K-12 Technology Education



Advancing Technological Literacy: ITEA Professional Series

A Guide to Develop Standards-Based Curriculum for K-12 Technology Education

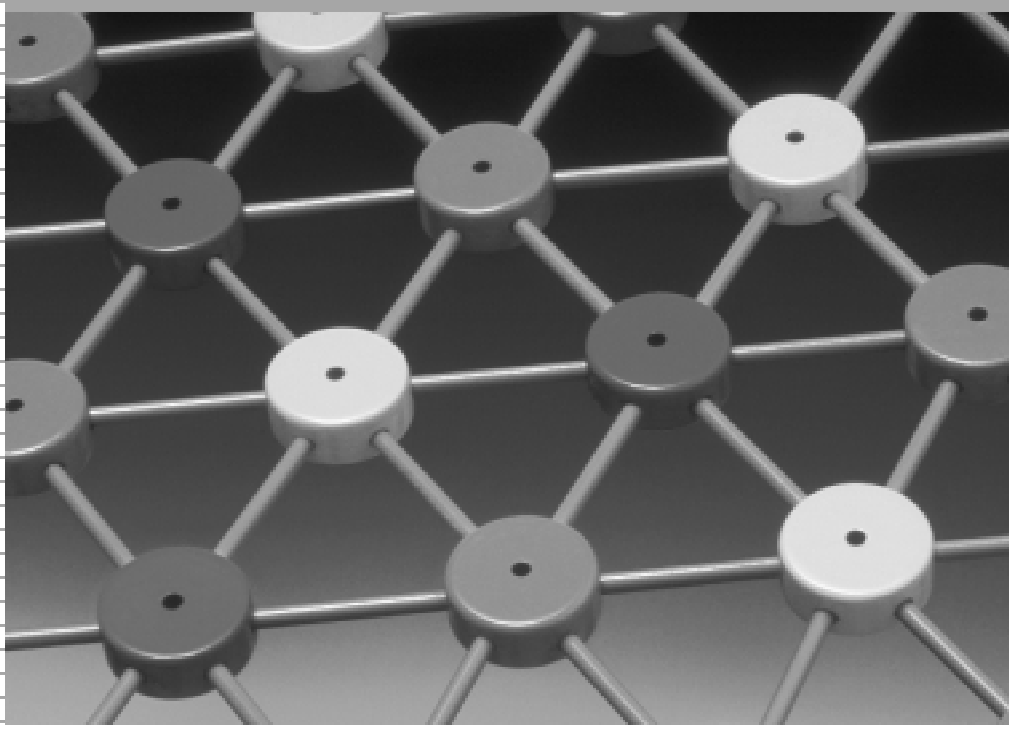


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Table of Contents

Preface v

Introduction vii

Section 1
Technology Education: a Field of Study 1

Section 2
Rationale and Structure 3

Section 3
Framework for the Model Curriculum 6

Section 4
Technology Education Programs in Action 17

Section 5
Strategies for Change 24

Section 6
References 27

Preface

Technology education is more than a curriculum thrust or program emphasis; it is a field of study dedicated to developing technological literacy through education. The purpose of this publication is to provide the guidance for curriculum developers, decision makers, and teachers to develop a contemporary, standards-based curriculum framework for technology education, grades K-12. It is intended to be used in conjunction with *Technology for All Americans: A Rationale and Structure for the Study of Technology* (ITEA, 1996), *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000), and contemporary state/provincial/local standards. The content and curriculum thrusts in this publication reflect the collective vision of leaders in technology education representing different regions and localities.

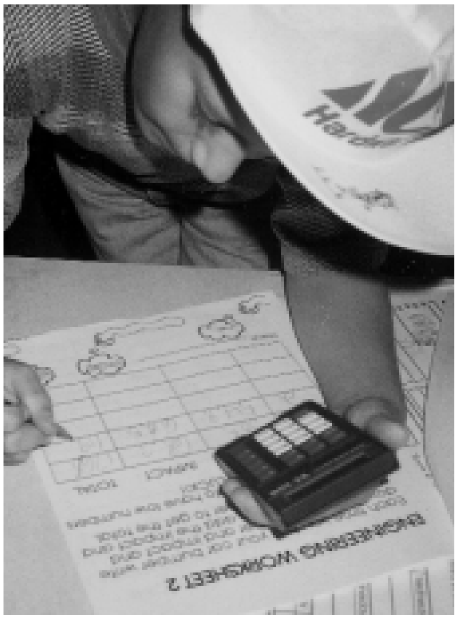
This publication was conceived and developed by members of the ITEA-CATTS Consortium. The ITEA Center to Advance the Teaching of Technology and Science (ITEA-CATTS) was created by the International Technology Education Association (ITEA) in July 1998 to provide professional development support for technology teachers and other professionals interested in technological literacy in education. The ITEA-CATTS Consortium was created to form professional alliances and pool resources to enhance teaching and learning about technology and science. The 1999 ITEA-CATTS Consortium members and participating leaders are: Georgia State Department of Education: Ronald Barker; Idaho Division of Professional-Technical Education: Donald Eshelby; Kentucky Department of Education: Henry Lacy; North Carolina Department of Instruction: Deborah Westbrook; North Dakota State Board for Vocational and Technical Education: Mark Wilson; Michigan State Department of Career Preparation: James Levande; Wisconsin Department of Public Instruction: Bryan Albrecht and Kenneth Starkman. These state department of education leaders provided valuable and continuous input in the development of this publication. Their vision, leadership, and dedication have made this publication possible.

Brigitte G. Valesey, *DTE, Director*
ITEA-CATTS

Introduction

Technology education is a vital field of study and dynamic school subject devoted to the study of technology. The field has evolved from a study of industry and industrial practices to the study of the fundamental nature, dynamic content and activities, and pervasive influence of technology. People create, use, and depend on technology for many purposes. Students' educational experiences must necessarily include technological studies in order to become contributing and productive citizens as well as responsible decision makers. Every student needs to understand and experience technology.

Technological literacy is the goal and vision for technology education curricula, programs, and student achievements. ITEA's Technology for All Americans Project (TfAAP), funded by the National Science Foundation (NSF) and National Aeronautics and Space Administration (NASA), provided clear direction for the study of technology. Phase I of this Project identified the need for studying technology and established a content foundation and structure. This large scale effort to gather input, gain consensus, and document the rationale and content foundation resulted in *Technology for All Americans: A Rationale and Structure for the Study of Technology (Rationale and Structure)* (ITEA, 1996). Phase II focuses on the development of content standards for grades K-12. The document, *Standards for Technological Literacy: Content for the Study of Technology (STL)* (ITEA, 2000) provides a shared vision of what students should know and be able to do to be technologically literate. These documents are not intended to serve as the curriculum for technology education, but to provide guidance to curriculum decision makers. *Rationale and Structure* and *STL* are catalysts for ensuring the development of technological literacy in educational reforms. *Teaching Technology: Middle School*, funded by the Technical Foundation of America, was developed with extensive ITEA-CATTS Consortium input to guide teachers in implementing the standards. Additional guides are envisioned for grades K-5 and 9-12. These efforts provide valuable input concerning content and direction for curriculum decision making in technology education.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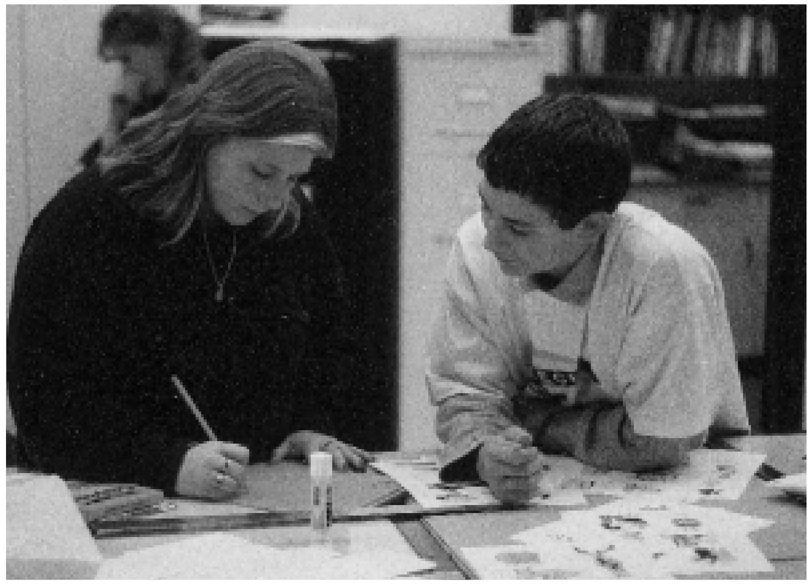
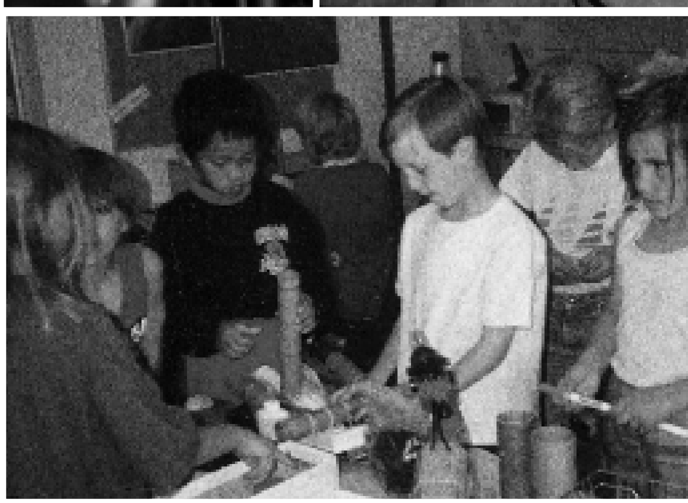




Section 1

Technology Education: A Field of Study

Technology education is a field of study that involves the study of technology and the development of technological literacy. We live and work in a society that embraces technology in every facet of daily living. The study of technology, by its nature, thrusts us into wide-ranging activities; in order to solve problems and improve our world, we engage in designing, developing, making, using, managing, and assessing activities. No wonder technology is viewed as “human innovation in action” (ITEA, 1996). Throughout the K-12 educational process, there is the potential for every student to know and experience the power and the potential of technology.

Students need to understand the nature of technology, be able to use technological devices and processes, and manage their appropriate and effective use. Ultimately, students need to develop technological literacy to participate knowledgeably in personal, local, and global decisions concerning technological issues. Further, students need to develop technological literacy to be successful in the workplace and adapt to changing environments.

By high school graduation, students should have developed a technological literacy sufficient to function in our society, yet with more than minimal knowledge and fundamental skills to be competent and successful in a variety of settings, roles, and contexts. Technology education is necessary to help students to be successful in personal, social, and work realms.

Technology Education: A State, Provincial, and Local Perspective

States, provinces, and localities face many challenges and opportunities as they develop and refine technology education curriculum. Systemic reforms, state, provincial, and national standards, assessments, instructional methods and facilities, and public acceptance are shaping and impacting the curriculum.

Core content considerations influence curriculum decisions. Curriculum developers must consider technology education as core content and how it contributes to the common core of learning. Developers and teachers alike must be prepared to understand content uniqueness and core content connections. The integrative, holistic nature of technology contributes to and reinforces the basic academic disciplines and actively engages students in applying knowledge and skills in a range of school subjects.

Technology education methods and facilities are changing. Teachers are challenged with using student-centered approaches and incorporating instructional technology to facilitate learning. Inclusion and other educational trends necessitate teaching and learning strategies that truly promote the technological literacy for all students.

Technology education provides opportunities for students to solve practical problems, apply information from different subjects and to use a wide range of knowledge and skills. Performance-based assessment is readily accomplished in a technology education setting. Approaches to measuring student progress and achievement have been explored, debated, field tested, and implemented.

Facilities range from traditional to contemporary designs. Curriculum must be available that enables teachers to implement technological studies regardless of the present layout of the facilities. States, provinces, and localities need to ensure that appropriate settings are provided to facilitate a wide range of technological activities.

Teacher recruitment and training must be considered in the curriculum development process. Teachers are needed who can effectively implement the curriculum, work with students with a wide range of abilities, and integrate content of other subjects with the study of technology. Ongoing teacher training is a necessary component to ensure that curriculum is consistently implemented and continuously improved.

Public acceptance of curriculum is both a challenge and an opportunity. Technology education’s mission is sometimes misconstrued as educational technology, instructional technology, or computer science. Key decision makers (i.e. state superintendents, board of education personnel, business executives, parent groups, and student organizations) need to be educated in the mission, goals, and curriculum content for technology education. A simple, easily articulated vision must be communicated to describe the role of technology education in mathematics, science, technology, and engineering education in our schools. Advocates are needed at various educational levels to support curriculum development and implementation.

"...students will be equipped with foundational skills, knowledge, and confidence to create new and better products, enhanced forms of communication and entertainment, and provide us with more efficient means for mobility in our ever shrinking world and outer space."

William E. Dugger, DTE
ITEA Technology for
All Americans Project

Section 2

Rationale and Structure

Technology education's knowledge base comes from the study of technology and is guided by the need for technological literacy. Critical issues concerning technology education have surfaced. What does every student need to know and what should he or she be able to do in technology? How do we organize an articulated K-12 program? What is the structure for the study of technology that will endure change? The ITEA Technology for all Americans Project developed *Technology for All Americans: A Rationale and Structure for the Study of Technology* (ITEA, 1996) to respond to these questions. The succeeding sections summarize the content of this document.

Technological Literacy

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

- The ability to use technology involves successful operation of the important systems of the time. This includes knowing the components of existing macrosystems, or human adaptive systems, and how systems behave.

- The ability to manage involves ensuring 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.

The Need for Technological Literacy

A major consequence of accelerating technological change is a growing gap in levels of technological ability and understanding. There is a continuous 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, the general population needs to be technologically literate to make responsible decisions that impact life and environment. 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 people's values and help them reach their goals. Such decision making depends on 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 to the Earth's continued ability to sustain life.

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 tradeoffs, 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. No single component or device can be considered without understanding its relationship to all other components, devices, and processes in a 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.

- Understand the major technological concepts behind the current issues. In addition, they are skilled in the safe use of the technological processes that are lifelong prerequisites for their careers, health, and enjoyment.

- Incorporate various characteristics from engineers, artists, designers, craftspersons, technicians, and sociologists that are interwoven and act synergistically. These characteristics involve systems-oriented thinking, the creative process, aspects of producing, and the consideration of impacts and consequences.

- 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.

Individual Needs

Citizens need to consider issues and take part in decisions regarding transportation, land use, pollution control, defense, and restricting or encouraging 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 knowledge and skills to make responsible 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 technological literacy.

- 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 global economy often become noncontributing members of society who must be provided for by others.

Environmental Needs

Because various technological processes and abuses can pose ecological dilemmas and create environmental crises, technological literacy is critical in the efforts to ensure 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 life cycle.

- Designing and developing technological processes and systems that are less threatening to the natural environment is 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 solve and create future problems. When people develop and use technology with an understanding of its consequences and impacts, goals and values, then people will continue to offer each other more ways to work, enjoy leisure, communicate, and order their lives. More opportunities will evolve for those persons who learn to utilize technology in the solution of societal problems.

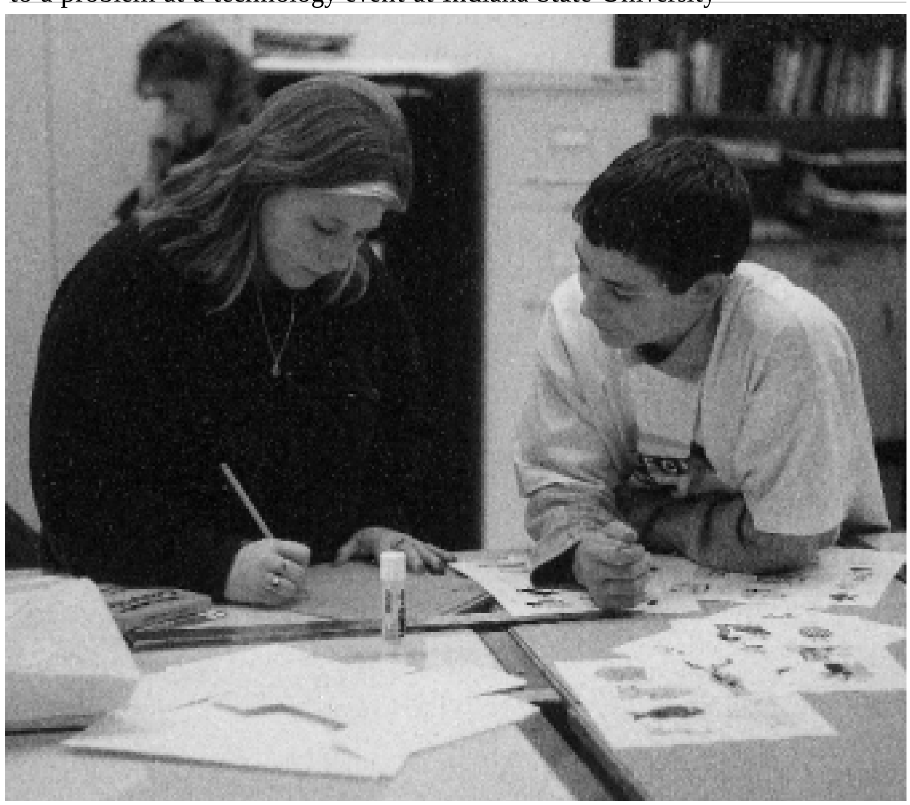
The Goal of Technological Literacy for All

How widespread is technological literacy among citizens 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 has been ignored, except for those pursuing education and training in technological fields. For most citizens, 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 citizens.

A massive effort is needed in order to achieve technological literacy. This should involve the schools, 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 a cohesive technology education.

Technology for All Americans: A Rationale and Structure for the Study of Technology (ITEA, 1996) identifies the knowledge base and presents the need for the study of technology. The subsequent development of *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) provides educational focus and direction concerning what young people should know and be able to do to be technologically literate. Both documents set the stage for development of curriculum that prepares students for the influence, opportunities, impacts, and consequences of technology in their future.

LHS students Priscilla Young (l) and Nick Phillips (r) apply their design skills to a problem at a technology event at Indiana State University



Section 3

Framework for the Model Curriculum

Curriculum Considerations

Technology education content and experiences reflect the foundations and influences on the study of technology. Key curriculum considerations affect decisions concerning the focus and delivery of technology curriculum. Curriculum trends from performance-based learning to cross-disciplinary curriculum influence focus and emphases. Systemic reforms, local priorities, assessments, and even personnel changes drive curriculum developments.

Technology education curriculum is based on fundamental curriculum considerations. See Figure 1. Curriculum inputs, such as philosophical, psychological, and sociological considerations, and understanding of various trends provide the guiding vision for developing curriculum. Philosophical frameworks and views of decision makers, curriculum developers, and teachers need to be considered. Psychological needs of students and relevant research in education affect the mission and focus of curriculum development. Sociological considerations such as population diversity, school equity, and student access, enter into curriculum decision making. Educational, societal, and political trends influence curriculum directions. Each curriculum input affects the overall development of the technology education curriculum framework.

The knowledge base, identified in *Rationale and Structure*, builds on the curriculum considerations and provides a rationale for the study of technology. Content and direction, found in *Standards for Technological Literacy,* specifies what students should know and be able to do as a result of participating in formal technological studies. Technology education curriculum is influenced by local factors such as student abilities, teacher capabilities, core requirements, articulations, and state and provincial standards. These factors, along with content and curriculum inputs, shape technology education curriculum, instruction, and assessment.

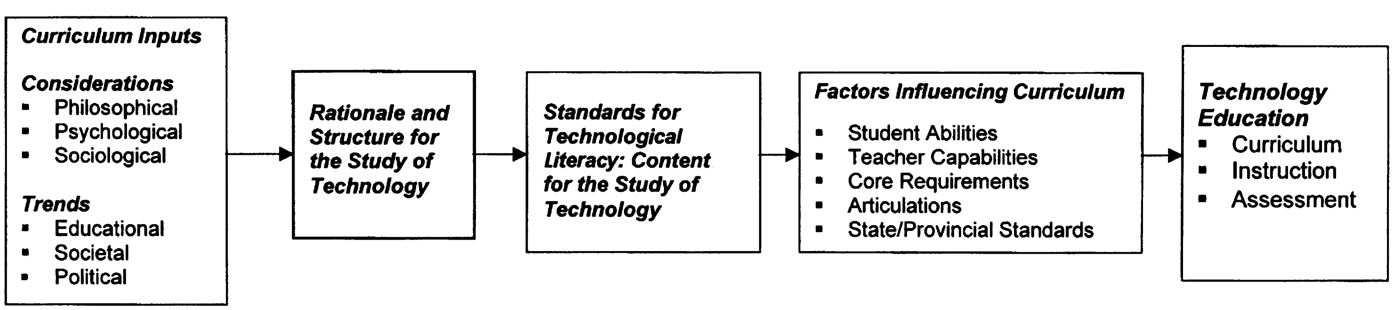
Criteria for Structuring Technology Curriculum

Underlying curriculum decision making are basic criteria that guide the direction of curriculum efforts. Selected criteria that have been identified by technology education professionals are:

- *The entire picture of technology is more important than any of its parts.*
  Focus on relationships between technological content or parts of the design process, for example, provide a holistic picture of the scope of technology and its pervasive influence.

- *The standards should stay in the forefront.*
  The technology education standards identify major concepts and ideas for the study of technology. Focus on major themes provides a broad curriculum perspective.

Figure 1. Curriculum Considerations



- *Strive for balance of technical, social, views/values, and knowing and doing contexts.*
  Selected programs focus on technical skill development or social issues surrounding technology. A more comprehensive view of technology is developed when balance among views is achieved.

- *Technology education can be taught in existing facilities.*
  Curriculum that requires new or renovated facilities may not be implemented across the state, province, or locality; school and other educational systems may lack funding to make such wholesale changes.

- *Courses should be taught by qualified and certified teachers.*
  The unique nature of technology education content and activities requires teachers who have the requisite background and professional experiences to successfully implement technology education curriculum.

- *Use every opportunity to involve students in multisensory, student-centered activities.*
  Students benefit from collaborative practical experiences that draw upon students' unique abilities and enhance technological capabilities.

- *Name courses and use descriptions that describe teaching and learning rather than only technical characteristics.*
  Course titles such as woodworking, production processes, or technical drawing reflect an emphasis on technical skills development. Course titles like invention and design, foundations of technology, or technological innovation balance content, development of responsible views of technology, and the ability to use, manage, and control technology.

- *Use a variety of instructional methodologies.*
  Teachers benefit from curriculum guidance concerning appropriate and effective instructional strategies and the development of curriculum materials and resources that encourage varied instructional strategies. Resource delivery plans should include staff development opportunities for teachers to learn about and model strategies.

- *Structure of the content is dynamic and should reflect our changing technological society.*
  Curriculum content needs to be informed by standards, current events, and technological trends. Curriculum should be designed to be flexible enough to accommodate change, or risk becoming quickly outdated.

- *Curriculum and instruction should capitalize on the abilities and interests of students.*
  Students need topics that are of inherent interest and within the realm of their experiences and abilities. Students also benefit from activities that stretch their capabilities and enable them to explore what is technologically possible.

Along with curriculum development decision making, these criteria provide guidance to administrators in the evaluation of curriculum materials. Also, commercial curriculum developers should consider these guidelines in developing contemporary technology education curriculum.

Mission

The mission for technology education, as presented in *Rationale and Structure*, is "to provide an opportunity to learn about the processes and knowledge related to technology that are needed to solve problems and extend human capabilities." (p.13, ITEA, 1996) This contemporary mission provides valuable direction for the development of curriculum goals to guide the study of technology.

Curriculum Goals

Technology is a way of learning, knowing, and doing. It represents a powerful form of symbolic communication, like mathematics and languages, and involves thinking and problem solving that engage the individual in multi-sensory activities employing multiple intelligences.

Education about technology should create opportunities for each learner to know and experience the exhilaration of technology in action—the sheer joy of creating effective designs and solutions that work. Technology education promotes the capability of people to be engaged, influential, thinking/doing beings. Consequently, the K-12 curriculum goals for technology education enable learners to:

I. Understand and experience technology's creation, application, and control.

II. Understand and develop ways of thinking about technology that consistently respect the environment, promote human well-being, and benefit society.

Effective technology education curricula embrace these goals and promote student experiences that provide the basis for lifelong learning of technology. Contemporary tech-

"Technology education standards are written statements about what is valued in the study of technology.…they are not intended to be the curriculum which is the structure, organization, balance, and presentation of the content in the classroom."

William E. Dugger, DTE
ITEA Technology for
All Americans Project

nology education curriculum contributes to the following goals in which students can:

- Understand why and how people design, engineer, and innovate to meet human needs and wants.

- Apply ways of thinking and doing essential to designing and problem solving, developing, making, managing, and assessing technological systems in various contexts.

- Safely use, manage, and evaluate technological systems and engineering processes.

- Relate technology with science, mathematics, and other subjects to understand systems in different contexts and to engineer solutions to practical problems.

- Communicate technology content and processes, individually as well as in teams.

- Understand the historical and future significance of engineered designs and impacts of technological solutions.

- Develop an awareness of and appreciation for career paths and opportunities in technology and engineering.

Technology education programs across grades K-12 need to address the knowledge, processes, and contexts associated with meeting these student goals/outcomes.

Technology Education Curriculum Criteria

Quality technology education curricula reflect best educational practices and foster student achievement. Such curricula promote technological literacy through challenging activities that stimulate student thinking and appropriate actions concerning developing, using, and managing technology. A model technology education curriculum exhibits the following criteria:

- *Focuses on students and their learning:* Teaching and learning activities focus on student-generated knowledge, inquiry, reasoning, and design and problem-solving processes to produce logical, effective designs and engineered solutions.

- *Reflects exemplary practices for teaching and learning:* Incorporates best practices to stimulate student interest and confidence in technological studies, develop technological literacy, and enhance student achievement.

- *Emphasizes design and problem-solving activities:* Provides multi-sensory experiences based on technological knowledge, processes, and contexts. Students create design plans, engage in design and problem-solving processes, and systematically evaluate the effectiveness of designs and solutions to practical problems.

- *Contributes to standards attainment:* Provides the framework for planned student experiences for achieving content standards for technology education at respective grade levels.

- *Develops technological literacy:* Promotes technological literacy and student achievement through organized and sequenced experiences.

- *Integrates math, science, and other subjects:* Makes purposeful content connections with other school subjects to broaden students' understanding of technology.

- *Promotes careers in professional and technical fields:* Develops career awareness in technology and engineering fields, with exploration of career paths, analyses of career options, and development of transferable career skills.

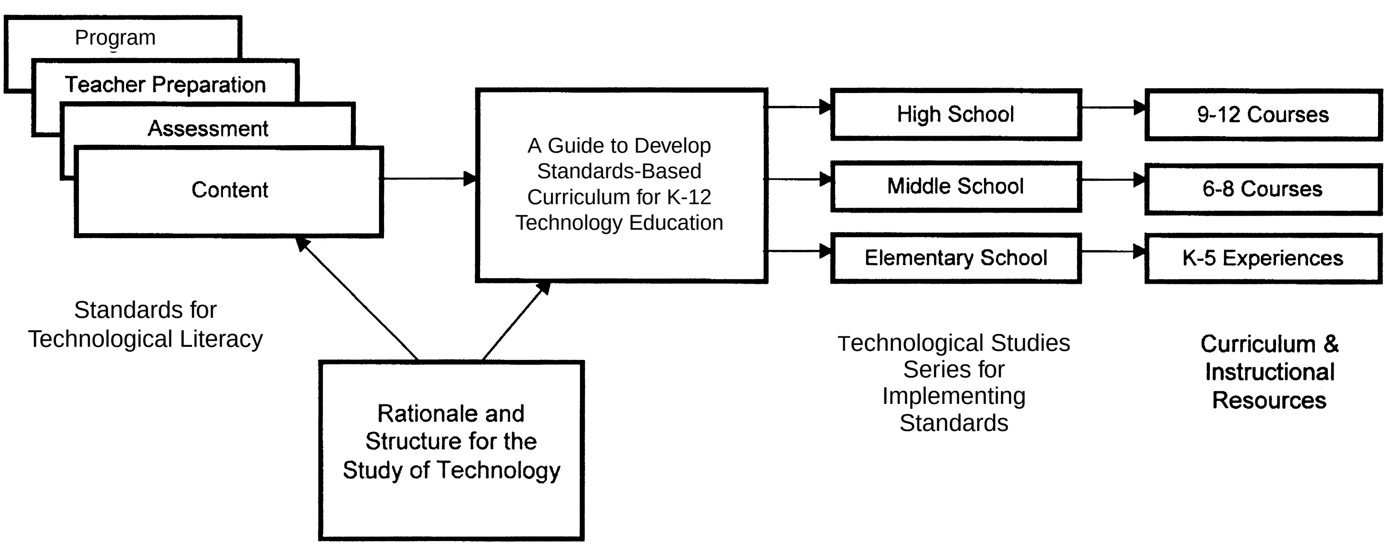
Curriculum Resource Development Plan

Key resources will be needed to develop effective technology education curriculum. See Figure 2. *Rationale and Structure* and *Standards for Technological Literacy* will provide the basis for making decisions concerning content and direction. Companion resources that will guide the state or provincial curriculum are program, assessment, and teacher preparation standards. Technology education program, assessment, and teacher preparation standards will be developed in Phase III of the Technology for All Americans Project (ITEA). The model K-12 curriculum described in this document provides a framework for curriculum development based on the standards; curriculum criteria, thrusts at various grade levels, delivery strategies, and teaching approaches are described. The model curriculum provides the framework for the *Technological Studies Series for Implementing Standards (Technological Studies Series);* this series provides guidance to teachers for translating *Standards for Technological Literacy* into effective instructional activities. The technology education *Rationale and Structure, Standards for Technological Literacy,* this guide, and *Technological Studies Series* provide important input from which to develop curriculum and instructional resources for K-5 experiences and 6-12 courses.

Curriculum Thrusts

Content thrusts for technology education curricula at various grade levels are aligned with the content standards and the needs, abilities, and interests of students. Each instructional level has a unique thrust for the study of technology as illustrated in Figure 3. Primary students begin to discover technology through hands-on experiences and project-based learning in the classroom. As they progress through the elementary grades, students discover technology's tools, activities, and content through thematic activities. In the middle school years, students explore basic technological systems and the role of technology in their world. Through multisensory activities, students in grades 6-8 are engaged in explorations into the ways in which technology influences their lives. In high school, students apply technological knowledge and content to problems and opportunities associated with technology. Also, students

Figure 2. Technological Literacy Resource Development Plan



establish connections between technology and potential careers. The technology curriculum thrust progresses from discovery of technology to applying technology to a range of issues, problems, and opportunities.

Technological Studies — Grades K-2 — Early Discovery Thrust

The curriculum for primary education draws upon the reality of the technological world to stimulate the learner's curiosity and strengthen knowledge in academic areas, while technological knowledge and processes are introduced. The early elementary grades afford rich opportunities to integrate the study of technology in thematic units and basic studies. Students benefit from experiences that begin to foster an awareness of technology and the artifacts of technology that are an integral part of their daily lives. Students develop an awareness of the created world and experience the design process. They have purposeful and integrative activities using materials to create practical designs. Through discovery, students develop an understanding of how the physical world around them is created, or made, and that people create many different designs to serve various purposes.

Technology education content can be integrated with current instruction. Elementary teachers may incorporate technology content in a unit theme or may develop a technology strand in a social studies unit or language arts activity. For example, students may design and build habitats to address the needs of nomadic peoples or create signs that direct people to various parts of a building. Students at this level should experience technology, that is, engage in activities involving design and the processes associated with making and communicating the results of the processes. Students will learn that technology involves thinking about and making something to serve a particular purpose.

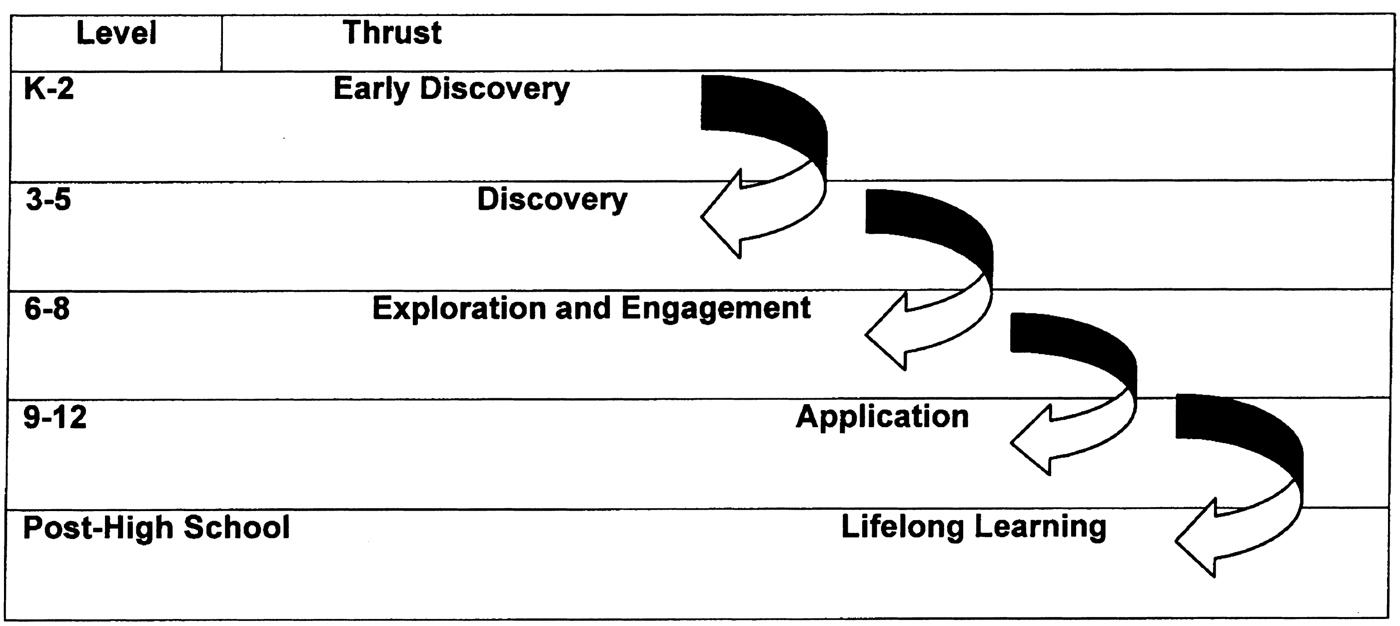
K-2 content standards can be met by providing planned experiences that integrate units of study with developing an understanding of their technological world. Teachers at this level may benefit from specialized inservice training to provide successful experiences in planning and implementing the study of technology to serve various purposes.

Technological Studies — Grades 3-5 — Discovery Thrust

Students in grades 3-5 have the prime opportunity to explore technology in a variety of contexts and through concrete experiences. Through planned and integrated experiences, students will develop a functional understanding of technology, technological systems, and design processes.

Technology activities continue to be integrated in current units of study across school subjects. Students may create innovations or brainstorm solutions to local problems related to various technologies or contexts. Students should be allowed to gather information, propose techniques for developing a

Figure 3. K-12 Technology Education Curriculum Thrust



design, and create designs and solutions through trial and error as well as controlled testing. In a geography unit for example, students may design and develop an efficient transportation system for a given rural or urban site. Students at this level benefit from communicating about their activities and documenting the progress and results of the design process. Through paired learning, group discussions, and the preparation of journal and portfolios, students communicate their reflections about the study of technology and their growing understanding of the world around them.

Technological Studies — Grades 6-8 — Exploration & Engagement Thrust

The middle level curriculum is derived from early adolescent concerns and compelling issues in the larger world. The curriculum should encourage the learner to investigate, examine, try out, and inspect concepts related to technological systems. By exploring and becoming engaged in design, problem solving, and technological systems, the learner is able to further uncover and evolve personal interests and abilities related to a continuum of careers and educational programs.

The middle school years afford greater involvement in the planning and execution of designs for technological systems. Students at this level can engage in decision-making involving critical and creative thinking to construct effective and efficient solutions. In grades 6-8 technology education activities, students create and improve upon designs and make constructive decisions. Through planned experiences, they will solve practical problems in a variety of contexts and be able to evaluate solutions for effectiveness. Technology education courses engage students in a well-planned instructional sequence that builds on K-5 experiences and develops a student's understanding of the scope of technology and the iterative nature of technological design and problem-solving processes. Likewise, students will be able to communicate their ideas verbally and visually, and document the development of their plans through visual representation, journals, and portfolios. Teaming, peer monitoring, and individual actions contribute to student achievements at this level.

Suggested Course Titles and Descriptions:

- *Exploring Technology*
  Students develop an understanding of the progression and scope of technology through exploratory experiences. In group and individual activities, students experience ways in which technological knowledge and processes contribute to effective designs and solutions to technological problems. This course may be six weeks or nine weeks in duration.

- *Innovation and Engineering Design*
  Innovations, or commercially produced inventions, affect us personally, socially, and economically. Students participate in engineering design activities to understand how criteria, constraints, and processes affect designs. Brainstorming, visualizing, modeling, constructing, testing, and refining designs provide first-hand opportunities for students to understand the uses and impacts of innovations. Students develop skills in communicating design information and reporting results. This course is suited for 18 weeks.

"I involve my students in several whole and small class activities to activate knowledge for them to build on in later studies. Technology activities engage students in simple research and writing, as well as math and science applications. Once a foundation is laid, the students' technological literacy develops through hands-on, inquiry-based activities."

Kristen Callender
Second Grade Teacher, CO

- *Technological Systems*
  Students become acquainted with content and processes associated with basic technological systems. The design, development, and relationships of different systems are explored. Students apply systems concepts to design and problem-solving activities related to transportation, information, energy, power, biotechnology, and other technological systems. Laboratory activities engage students in constructing, using, and assessing technological systems. This course may be 18 weeks or 36 weeks in duration.

Technological Studies — Grades 9-12 — Application Thrust

The thrust of the high school curriculum should develop each student's capacity to make responsible judgments about technology's development, control, and use. Critiquing appropriate technology and sustainable development are important. The curriculum should bring explicit discussions of technological values so that students can reflect and develop their own ethical standards. Students should be actively involved in the organized and integrated application of technological resources, engineering concepts, and scientific procedures.

Through high school technology education experiences, students address the complexities of technology and issues that stem from designing, developing, using, and assessing technological systems. In developing a functional understanding of technology, students will comprehend how human conditions, current affairs, and personal preferences drive technological design and problem solving. Actively engaged in making and developing, using, and managing technological systems, students will better understand the role of systems in meeting specific purposes. For example, students may be engaged in designing and developing information systems that monitor temperature, moisture, and fluid flow to communicate environmental conditions. Or, students may address the problem of aging bridge structures by examining new bridge materials and construction techniques, developing efficient bridge designs, and testing bridge design effectiveness. Students should be able to analyze and understand the behavior and operation of basic technological systems in different contexts. Also, students should be able to extend their knowledge of systems to new and emerging applications by the time they graduate from high school.

Suggested Course Titles and Descriptions:

- *Foundations of Technology*
  This beginning high school course prepares students to understand and apply cornerstone technological concepts and processes. Group and individual activities engage students in creating ideas, developing innovations, and engineering practical solutions.

  Technology content, resources, and laboratory activities encourage student applications of science, mathematics, and other school subjects. This course may be 18 weeks or 36 weeks in duration.

- *Technology Assessment*
  Technology has positive and negative impacts, and intended and unintended results. In this course, students learn ways to evaluate the appropriateness and effectiveness of various technologies. Students engage in technology activities to determine and assess the effectiveness of new ideas, innovations, and technological systems. Analytical thinking, decision making, and continuous design improvements are emphasized. This course may be 18 weeks or 36 weeks in duration.

Advanced Studies * *

- *Issues in Technology*
  Students investigate critical historical and emerging issues affecting the creation, development, use, and control of technology. Case studies, simulations, portfolio developments, and group seminars are ways that students address complex issues and propose alternative solutions to technological developments. Global governmental, social, and economic policies concerning technology also are studied. This course may be 18 weeks or 36 weeks in duration.

- *Engineering Design Fundamentals*
  Engineering scope, content, and professional practices are presented through practical applications. Students in engineering teams apply technology, science, and mathematics concepts and skills to solve engineering design problems and innovate designs. Students research, develop, test, and analyze engineering designs using criteria such as design effectiveness, public safety, human factors, and ethics. This course may be 18 or 36 weeks in duration.

*** *** *These offerings could be developed as "advanced placement" courses, subject to accreditation requirements.*

Implementing the Curriculum

Curriculum Delivery

Delivering technology education curriculum involves making decisions about appropriate delivery strategies, teaching approaches, facilities, and assessment in order to enhance the development of technological literacy. Curriculum must be purposefully connected with each consideration for successful and meaningful implementation.

A *delivery system* is, "the actual method the technology education teacher uses to present content" (Kemp & Schwaller, 1988, p.19). Selection of appropriate delivery systems reflects the needs and abilities of learners and instructional goals. Using a variety of delivery systems addresses the broad spectrum of student needs and interests. Linking appropriate delivery systems with technology education content and activities enhances the teaching-learning process. Students benefit from delivery systems tailored to their needs, interests, and abilities.

Project-based learning is a technology delivery strategy in the elementary grades that engages students in manipulative activities to learn about various school subjects. Technology provides the theme for project-based learning about reading, arithmetic, social studies, and other subjects. For example, in a unit on the early colonization of America, students may recreate forms of transportation available at that time, housing designs, tools that were used for making farm implements or household items, or the ways in which people communicated information. Likewise, students may explore habitats in space, making design decisions about the space station environment and how to sustain life's activities in space. In studying such themes, students discover activities, tools, and basic knowledge related to the study of technology.

Group learning is a strategy appropriate at all levels of instruction. This strategy involves purposeful grouping, or teaming, of students and assigning responsibilities to each student to achieve a common goal. This strategy is based on principles of cooperative learning or group learning that is characterized by positive interdependence, personal interaction, and individual accountability. (Johnson, 1984) Technology education students experience the benefits of working in a group to achieve a technological goal, solve a problem, or develop an innovation.

Modular instruction is a strategy predominant at the 6-8 grade levels, but may be present in high school programs. Modules consist of self-contained workstations with resources and activities reflecting a particular technology unit or theme. Modules are not designed to replace curriculum nor is module content intended to drive curriculum decisions. Instead, modules can be used to introduce students to a technology unit/theme, provide for self-paced instruction, and expose students to a range of topics. Modules may or may not incorporate hands-on activities for application and reinforcement.

Engineering design and development is a delivery strategy to address the impacts, consequences, and benefits of technology. Students work individually or in teams to identify a problem and develop one or more solutions related to products, systems, or services. The design process begins with determining the nature of the problem and conducting research to understand the nature and scope of the problem. Possible solutions are explored. Students select the optimal solution for development. They model and test solutions for efficiency, make adjustments, and communicate the solutions to others. Along the way, students learn about trade-offs and ethical considerations. This strategy is a long-term delivery strategy made up of many sub-activities, to include visual representation, testing, modeling, and prototyping, and simulation. This strategy lends itself to high school application, although middle school programs may use simplified, streamlined versions.

Simulation involves students as active participants in simulating activities, situations involving complex issues, or environments. Simulated activities may be closely related to real-world applications or may be hypothetical. Students develop skills in problem solving, decision making, and expressing viewpoints concerning technological issues. Role playing and computer simulations are examples of simulation activities (Edmison, 1990). Students in K-12 technology education may engage in simulation to experience a career role, develop responsible attitudes toward technology, or engage in decision making concerning impacts and consequences of technology.

Design portfolios are a delivery system for documenting progress and student reflections about technology content and activities. Students compile chronologies of their activities, drawings, plans, reflections, and assessments into a single document. The portfolio represents not only the developments in their technology activities, but also in their thinking. Portfolios may represent the work developed by a group or an individual and may document short- or long-term experiences.

“…there is no perfect design. The task is to arrive at a design that reasonably balances the many tradeoffs with the understanding that no single design is ever simultaneously the safest, most reliable, most efficient, most inexpensive, and so on.”

A Project 2061 Report on Literacy Goals in Science, Mathematics, and Technology, AAAS, 1989

Teaching Approaches

Teaching approaches are broad styles of teaching related to the curriculum goals (Kemp & Schwaller, 1988). Teachers use multiple teaching approaches to reach students of varied abilities and with different learning styles. Contemporary teaching approaches in technology education encourage student involvement, interaction, and reflection.

Technology education activities at all levels incorporate *problem-solving and designing approaches.* Numerous models have been developed for problem solving and designing, with similar steps or processes. Problem solving involves using logical procedures or a plan to determine and examine a problem, consider viable alternative solutions, develop one or more solutions, and analyze solutions for effectiveness. Students may be provided with a specific problem to solve or may determine the problem when given issues or scenarios. Problem solving often incorporates collaborative learning and reporting. In describing the role of the teacher, educator Walter Waetjen stated,

“Teachers play an active part while students are solving problems. The single most important role of the teacher is that of directing student learning while helping with problem understanding, asking questions that extend cognition, suggesting alternatives, inviting discussion, structuring learning groups, and focusing students’ attention. By all means, the teacher of technology does not assign a problem, and remove himself or herself from further student contact.” (p. 10)

Problem-solving activities may include research and development, the scientific process, project management, troubleshooting and debugging, and the design process. (DeLuca, 1992)

A *design brief* is an approach appropriate for all grade levels in which students begin with a general problem or need, frame the problem so that is “manageable,” and proceed to develop a design to meet the identified need or defined problem. Students may go through a number of design iterations based on how the final design is developed and whether it effectively addresses the need.

An *interdisciplinary approach* is a way of organizing instruction to show interrelationships between disciplines and subject matter. At the elementary level, this approach is used to make content connections related to the theme of technology.

For example, students may be studying the development of communities, towns, and cities. Students may design and build housing appropriate to a given geographic location, simulate the building of cities on computer, and develop appropriate forms of communication and transportation for a community. As students progress through this activity, they learn about history and geography—how and why communities develop in particular places; language arts—reading, writing, and reporting on what students discover; science—climate, biomes, and natural resources in a given location; and mathematics—measuring, collecting data, and graphing information. Technology provides valuable opportunities in the elementary grades for interdisciplinary content connections.

At the secondary level, school subjects such as mathematics and science may be integrated with technology education content. For example, a technology education unit dealing with alternative energy systems may integrate science content addressing fundamental energy concepts and energy transformation, mathematics content involving quantification of energy loss or gain, and social studies concepts involving economic impacts and governmental policies. Technology teachers may collaborate with teachers of other subjects to identify pertinent content connections for purposeful integration.

Facilities

Facilities should reflect the vision and mission of technology education. Contemporary technology education facilities are designed to meet several instructional criteria. Consideration should be given to the following:

- State, provincial, and local goals
- Recommended instructional approaches and delivery strategies
- Flexibility for teaching and learning activities
- Location within the school buildings
- Necessary tools and equipment needs
- Budget

Facilities must enable a wide range of activities from designing, building, using, modeling, analyzing, and testing, to reporting. Laboratory requirements need to be connected to teaching and learning activities and goals. Facilities should allow for individual and group activities. Safety considerations continue to be important in technology education facilities, where multisensory activities engage students in using a wide range of tools, equipment, and materials. Facilities should be conducive to integrative activities. Location of facilities should take into consideration the program's positioning with respect to other programs.

Elementary technology education activities may be conducted in an existing classroom, a technology area within the classroom, or in a room devoted solely to technology activities. Tools and materials may be housed in mobile units or in designated areas within classrooms. Facilities need to accommodate groups of students as they engage in planning, designing, making, testing, and presenting activities. Storage and display areas will be needed. Middle school technology education curriculum is usually implemented in specialized yet flexible laboratories. Classroom areas are designated for various technological activities such as research and designing, fabrication, testing, and presentation. Electronic information access will be needed for research and planning activities. Delivery strategies such as collaborative learning and modular instruction impact facility decisions at the middle school level.

The high school technology education facility allows for general and specialized technological studies with capabilities for research, design, development, testing, and presentation. Facilities should be flexible to accommodate a wide range of technology activities. Technology education labs in contemporary school designs may be located in the same area as the mathematics classrooms or science labs. Labs should be electronically

“The laboratory must be appropriately equipped to accommodate student learning through active, hands-on, multisensory interaction with significant technology systems. It must include design tools, fabrication tools, a variety of materials, testing apparatus, and the computers that monitor and control modern technology systems.”

Maryland State Department of Education, 1994

connected to other parts of the school and have electronic information access outside the school. Storage of long-term activities is a consideration in high school facilities design.

Role of Assessment

Assessments exert tremendous influence on curriculum development and implementation. Assessments provide accountability measures for school systems and local programs. Educational policies and priorities are guided by assessment priorities, measures, and results. Assessments convey expectations about what is to be learned and what is deemed important to learn, and provide data concerning student progress and achievement. According to Kleinsasser and Horsch (1992), meaningful assessment “is based on clearly-articulated consensus of what the learner must know or be able to do; demands the learner construct meaning as well as respond to questions; probes the process used to answer the question; assigns tasks that are both meaningful to the learner and accurate measures of the instructional program; allows for more than one acceptable answer; probes understanding of the big picture; allows for alternative ways of demonstrating achievement; includes the use of appropriate tools; allows for individual and group performance; includes self and peer evaluation and student-teacher collaboration in designing the assessment process; is an ongoing process which measures growth; and is a celebration of success rather than proof of failure.” (p. 52)

Assessments are an important facet of curriculum development and implementation, yet technology education programs in most states, provinces, and localities do not have a comprehensive, well-articulated plan for assessing students, teachers, and programs. Technology education curriculum decision making should include determining key content and experiences to evaluate, effective ways to assess in the curriculum, use of assessment data to enhance student experiences, and ways to drive continuous curriculum improvements.

Assessments in other school disciplines may influence decisions concerning what is taught and learned in technology education. Curriculum development decisions may need to address “crosswalks” i.e., content connections with other subjects that must be demonstrated in the technology education curriculum. As a core subject, technology education curriculum contributes to overall student achievement and performance measures. The power and pervasiveness of technology can be demonstrated through effective curriculum that integrates other school subjects such as science and mathematics, and taps wide-ranging student abilities and capabilities.

Section 4

Technology Education Programs in Action

Elementary School Examples:
Robin Wright
Fourth Grade Teacher, Missouri

It is 8:00 a.m. and my fourth grade students want an immediate answer to their question, "Are we going to do a technology activity today?" The answer will undoubtedly set the pace for the entire day. My response is, "Yes," which sends waves of excitement buzzing throughout the room. As a teacher, I can't think of a better way for all of us to start our day. What are we making? We are making a town, incorporating technology education into a social studies unit. Technology education has proven to be a valuable tool for motivating my students and increasing their attention span and time on task, all of which are known to be critical elements in student learning. Also, my students are gaining valuable knowledge and skills about technology and the technological world.

My goals focus on preparing my students for the world in which they will live and work in the 21st century—citizenship, career, and life-long learning. Specifically, as a result of studying technology, instructional goals for my students include:

- Learning to understand the technological world around them.

- Developing positive attitudes toward technology and technological careers, especially for girls.

- Learning to be good problem-solvers.

- Learning to be creative in their use of tools and materials.

My class is organized so that there is a combination of individual and group activity. Sometimes the projects are individual in nature and other times students work in teams to complete a larger project. In either case, I do not direct the students to a single correct answer. Students work through the problems themselves, although I will help or prompt them slightly if they seem to be "stuck" for an extended period. Examples of individual projects include the construction of small houses that are part of a larger community. Each student is expected to accept responsibility for his or her design, and safely use tools and materials to construct the design.

For larger projects each student is encouraged to explore and design on his or her own. Then, as a class, we may select one design or solution that students will work on together. I will divide the students into groups to work on various aspects of the larger project. Each group contributes to the project, and each student has a role in its success.

There is never a "wrong" answer, although sometimes there are "better" answers in terms of efficiency, materials, or structure. I spend a lot of time at the beginning of the year building "community" in my room so that all students feel safe in exploring and generating ideas without fear or failure or ridicule from their classmates.

We spend a lot of time making connections between the "outside" or real world and the technology activities that we do in the classroom. For example, when we did a unit on bridge and structure design last year, I was quite pleased when the students volunteered information about the various bridges over the many rivers and creeks in the area. One of the best examples was by a student who built a bridge that was completely flat, with no support structure. He had the only bridge in the class of this type, and it didn't resemble any of the diagrams we had discussed in class. When asked about his design, the student responded that it was made like the bridge he goes over in order to get to his grandpa's farm!

Girls and boys are interested in the technology activities we do. Individual students may have preferences for one type of process or material over another, but I can honestly say that our technology studies are not "gender-biased." For example, we just completed a "Popcorn Party" activity. This activity was based on our social studies unit on Native Americans and how corn was an important food source. We calculated how much popped corn was yielded from a certain amount of kernels.

After deciding how much was an appropriate serving size, each student designed an individual serving container to hold the popped corn. As a class, we discussed the pros and cons of each container design, then selected one "best" design to mass produce. Also, we chose a logo to be included on the containers. A fifth grade class was invited to join us for a presentation of our activity… naturally they ate the popcorn served in the new containers! Through these types of activities, all students are equally interested and involved.

A variety of assessments are used in my technology activities. Every activity or unit involves a writing assignment where the students write about what they did, what they learned, connections to the "real" world, and reflections about how they would modify or improve on their design/project the next time (what kinds of things would have made it better). In this way I am able to assess more of the process rather than just the final product. I also work closely with the students throughout the activity, and make notes about their thinking, discovery, and creative solutions. I have not actually used a pencil-and-paper type of objective test over facts, except as is normally done for our other subject areas such as science and math. This is because so far in our technology studies we have focused more on process than product or content. In the future I hope to be able to have an increased focus on technological content as well.

All of my technology activities have four broad concepts that run through the unit. Different activities tend to emphasize one over another at various times, but all include the following concepts and principles:

- *Design*
  Design is one of the fundamental components of many technological endeavors. It involves creating solutions to real problems, ability to visualize, ability to represent three-dimensional objects on two-dimensional material, understanding of constraints, and the ability to communicate ideas effectively to others. We discuss engineers, architects, commercial graphic artists, and web designers as workers who regularly use design principles.

- *Using tools and materials safely*
  We use a variety of tools and materials in the classroom that are appropriate for the age and developmental levels of the children. Learning about the properties of materials and their limitations is closely related to our science units. We stress safe and correct use of all tools, whether it is a pencil, pair of scissors, or a hand saw.

- *Assessing the impacts of technology*
  I teach the students that technological processes are neither good nor bad in themselves. Rather, it is how people choose and apply the processes that may be good or bad, used to help people and the environment, or damage them. One of the things we talk about in class is what it means to be a responsible citizen and how the students will eventually be making decisions which will affect our country. The best decision maker is ultimately one who has some knowledge of technology's impact on the environment. Peoples' actions have consequences, and through the study of technology, I teach my students to understand their role in making responsible decisions about technology.

- *Cooperative group work*
  An important life skill for students to learn is how to work cooperatively and productively in a group; to be a "team player." All of my technology activities involve some cooperative learning strategies.

Children learn better when they are actively engaged in meaningful learning, in activities they perceive as important, that involve different ways to learn (multiple intelligences), and that use multiple senses. The technological studies units incorporate these principles and thereby guarantee success for all my students.

One classroom example was the Marvelous Marble Transfer Unit. This project is based on a reward system used in the classroom. Each time the class demonstrated a positive behavior, a marble or two was put in a container. When the container was full, the class received a reward party. I gave the class a challenge to design and build a unit using the simple machines (studied in our science unit) which would hold marbles and release one marble at a time into another container. The materials used in this project were "scrounged" materials (cardboard tubes, craft sticks, ketchup bottles, pencils, coat hangers, and cardboard). The students worked in small groups on various simple machines and came together to assemble the entire machine. They were really engaged in problem solving at that point! Each child was totally committed to this activity because it was something they were going to use in the classroom.

I like technology education in the classroom because it gives the students a chance to ask "What if?" kinds of questions. It appeals to ALL of my students. All students are motivated to succeed. The more they participate in technological activities, the more skilled they become at asking good questions and seeking answers. Technology education enhances the elementary curriculum: it has taken my students to a higher level of learning!

Kim Weaver
First Grade Teacher, Maryland

The purpose of an elementary technology program is to develop students' awareness of technology and the process of technological development. My technology program is not a stand-alone curriculum, but rather is integrated into other subjects in our school system's first grade curriculum. The program reinforces basic learning through hands-on technology-related activities.

To begin each unit, I read a variety of books about the technology subject to the students. Using plywood, I build a large replica of the technology project so that students have a place to read and role-play about the technology unit. In one area of my classroom, I set up a store. This store became the focal point for acquiring all necessary materials to build their solutions to the engineering problems. The contents of the store change as a new activity is introduced. This "store" enables students to very quickly learn to count and use money to obtain needed materials. I laminate paper coins and dollars so students can begin to learn their numbers and perform basic addition and subtraction operations in mathematics. I make every effort to connect all activities with experiences from their daily adventures.

Engineering portfolios are a key feature during all the technology units. Each student is responsible for completing an information worksheet about their team, collecting test results and recording them, graphing the materials they purchase, and completing several worksheets about their final project. These worksheets require students to measure and record the size of their final structure, draw pictures, and explain how they built it.

In addition to the portfolio, students must keep a daily journal while they are building. To help students develop cooperative work habits, students work in engineering teams of two or three. They must collaboratively make decisions about their project. Students understand they must listen to each others' ideas and try each idea to see which one works the best. Students spend a lot of time testing and revising their technology project. They learn very quickly to determine what makes good test results and where adjustments need to take place. At this age level, comparing numbers is a learning process in itself.

I developed workbooks for the following technology topics: sailboats, bridges, dams, wind turbines, mag lev trains, and car bumpers. Each workbook has worksheets and activities that correlate with the required objectives. The following sections are incorporated: an introduction which has philosophy statements about technology education, a technology education activity overview and design requirements, and reading/
language arts, math, science, social studies, health, careers, store, engineering portfolio,
and bulletin board/center ideas.

Each unit is designed to last approximately two to three weeks. At the end of each unit, I invite parents, administrators, and colleagues to come to a grand finale. This is a time when students can show off their work. All students are rewarded for their efforts. It is a very exciting day. With each technology unit, it is my goal that every child develops a better sense of their technological world.

Middle School Example:

Mark Wallace
Technology Teacher, Grades 5-8, New Jersey

The technology program emphasizes the systems design approach to achieve technological literacy in all students. My school system adopted a curriculum which models *A Framework for the Study of Technology in New Jersey, Technology Content Standards*, AAAS Project 2061, and the state's Core Curriculum content standards. The 40-week program, divided among middle school grades 5-8, consists of technology programs which:

- Focus on the application of knowledge unique to technology.
- Utilize a variety of learner-centered instructional strategies emphasizing design and problem solving.
- Integrate the core curriculum and provide opportunities for students to transfer and apply knowledge and skills from other subject areas.
- Provide opportunities for all students in grades 5-8 to develop technological literacy and capabilities.
- Are taught in safe, flexible, and multi-purpose facilities conducive to technology learning.
- Are taught by qualified teachers who have been trained in both content and methodologies of the technology curriculum.

The curriculum focuses on key areas that develop students' skills and knowledge base as they proceed through the four grade levels. As their abilities develop, students face increasingly challenging opportunities. The units are mutually dependent on one another and cannot be realistically separated. They are applied holistically in all four re-quired programs. The key areas are:

- Understanding the nature, role, and history of technology and relationship to people, society, and the environment.

- Developing problem-solving and design abilities to solve a range of real world problems.

- Developing technical abilities to select and safely use materials, tools, and processes to fabricate products.

- Developing the ability to effectively communicate information and ideas through a variety of media.

- Developing the ability to select and use technological products and services effectively and safely.

- Strengthening knowledge of and relationship between school subjects.

- Developing generic career skills.

- Developing an understanding of the characteristics, behaviors, and applications of technological systems.

The program uses four systems—mechanical, fluid, electronic, and structural—to guide the research and development of a technological innovation or invention. Fifth graders develop mechanically-controlled systems. Teams of three students design mechanical amusement fair rides based on four conversions in motion: rotary vertical to rotary horizontal, rotary to oscillating, rotary to reciprocating, and rotary to linear.

Sixth graders develop fluid-controlled systems. Students design solutions to a problem involving the development of a pneumatically controlled robotic arm. Each team of three solves a problem that, when combined with the other teams' solutions, mimics a robotic controlled factory.

Seventh graders develop electronic controlled systems. Teams of students design electronically- controlled educational games. Students research what is taught in a lower grade level and develop quiz games, sports games, or "operation" type games that, when used by the younger students, will teach the context of a particular subject area.

Eighth graders develop structural systems. The objective is to give them knowledge of structural systems while at the same time reinforcing what they have learned in the three previous technology programs. For example, teams of students may design mechanical and/or pneumatic drawbridges with an electrical warning system.

The delivery strategies are similar in all four programs. First, teachers give students the "opportunity, situation, problem" that they will be dealing with for the duration of the marking period. Students then develop questions that need to be answered in order to solve the problem. Also they develop a logo, company name, slogan, and documentation booklet on the computer. The teacher presents the class with nine to fourteen investigation activities. This portion of the program reflects the research and development part of a company. Learning activities include research, experimentation, and analysis. These investigation activities are designed to give the students enough of the most valuable resource—knowledge—so that they will meet with success when solving the problem. After gaining the knowledge, teams must develop ideas. Several idea-generation tactics are used: synectics, brainstorming, analogies, and lateral thinking. Students at this level are taught sketching and drawing techniques so that they can communicate their ideas to team members. Teacher-designed testing stations have been built so that real-world testing, that can be graphed, takes place. Students then learn to evaluate and critically analyze their solutions. They must close the design loop by checking to see if all their design brief criteria has been met. Teams develop presentations to teachers, students administration, parents, board members, and local business representatives.

Students are assessed in a variety of ways. Both authentic and paper-and-pencil methods help to round out the program. A generic grading rubric has been developed. This rubric grades the teams on documentation of the design process, team presentation of the designed system, the effectiveness of the system, and teamwork. Written tests are given on problem solving, systems, and the knowledge that goes along with the activity theme.

The entire curriculum has been matrixed with the New Jersey State Core Curriculum, Project 2061, and the State Technology Association's *Framework for the Study of Technology in New Jersey*. This assists the teacher when presenting justification for program funding and support. Public relations is now a major job of the technology teachers. Technology teachers continually look for ways to recognize other teachers, their administrators, business representatives, and themselves.

The public must continually see articles about the program on the district web page and in the papers. This "education of the community" stimulates people to get involved and share what they know with the students. Technology education is a win-win situation for the students, school, town, state, and nation. Without design and problem solving, students would simply be learning facts about devices and systems.

High School Example

Michael Mino
High School Technology Teacher, Connecticut

The vision of the Technology for All Americans Project (TfAAP) is that technology education will be a subject in the core curriculum for all students in the United States. Typically, technology education may be a special weekly class in elementary school, a semester requirement or elective in middle school, and a semester or full year elective in high school. The most difficult of these programs to envision becoming a core subject for all students is the high school level. Yet, since September 1997, technology education has been a required core subject for all ninth grade students at my high school.

The school is a 550 student, 9-12 comprehensive public high school in rural Connecticut. For 24 years, an industrial arts program offered students elective courses in mechanical drawing, general shop, wood technology, and metal technology.

The principal supported the technology teachers in an effort to transform the industrial arts department into a state-of-the-art technology education program. In one year, the technology teachers completely renovated the program and the facilities. Students played a key role in the renovation of the facilities during the school year. Local and state funds provided the necessary computers and equipment. Drawing on local, state, and national resources, a new program was introduced, offering semester courses which focused on emerging technology.

The new program offered two foundation courses for high school freshmen, titled "Survey of Design and Drawing" and "Introduction to Technology." These courses provided hands-on experiences in design, technical drawing, computer assisted drafting, and the use of academic knowledge and resources to solve technological problems. The use of design briefs and design activity portfolios provided students with a structure and format for all activities, and would be used in all technology education electives. During the first year of operation, a diverse group of over 225 students from grades 9-12 chose technology education elective courses.

After the first successful year of operation, all remaining industrial arts courses were phased out and more electives were added to the program. Also, serious consideration was given to an interdisciplinary course in science and technology education. Since science teachers were consulted throughout the program development phase, a logical discussion developed between the science and technology teachers. Because of connections in the content and focus of Physical Science 9 and "Introduction to Technology," we developed a pilot course for freshman students that would focus on the physical sciences and their application in the world of technology.

In the first year, the pilot course was team-taught by a science teacher and a technology teacher in two adjacent technology education labs with a randomly selected group of 35 freshman students. The content of the course focused on the physical sciences such as motion, forces, electricity, principles of flight, and light and sound. Activities were developed and selected based on the science applications to real-world technology. The science teacher delivered the science content to half the class while the technology teacher introduced the design activity to the other half. Students were exposed to video presentations, demonstrations, and occasional lectures to clarify and present the science and technology content. The teachers applied for and received a grant for instructional materials and supplies for the science and technology course. At the end of the first year, the pilot was evaluated and revisions were made in the course structure to allow more time for teachers to address the science content and for students to complete the technology design activities.

In the second year, another group of 35 students was randomly selected and was scheduled for a seven-period-a-week course in Science and Technology.

The students earned both science and technology education credits for the course. Design activities, the design brief, and design portfolio are the core components of the science and technology course. The design activities focus on the application of the science content to real-world applications in communications, production, or transportation technology. The design brief sets the parameters of the activity and the portfolio focuses and documents the students' work on the activity. Each design brief includes five parts: the *scenario* which sets the context and rationale for the activity, the *problem statement* which clarifies the problem, the *resources* which are the materials, tools, machines, software, and computers available to assist in the development of the solution, the *constraints* or the limitations of time or resources imposed upon the students, and the *evaluation* which lists the criteria for grading the students' solutions. The design portfolio is used to focus the students on the problem-solving process and document their work throughout the activity. The first page of the portfolio takes the students through the problem-solving process by having them state the problem, their goal, their research, and the evaluation of possible solutions. The second page provides a place for students to list and describe the resources used and the processes completed in the course of the activity. The third page requires students to show any math calculations or data collected during the activity along with the science concepts applied or observed during the activity. The final page of the portfolio requires students to analyze their solution to the problem, propose changes or modifications, and describe an application of their solution to the real world. Students are also expected to keep any sketches, drawings, or other relevant papers in the design portfolio. A recent innovation in the portfolio is to have the students transfer the paper document into a web page template which can then be viewed on the school or classroom web page by other students. The use of the portfolio in the science and technology course provides a foundation on which all additional technology education courses build. Each of the technology education courses utilizes the design brief and the design portfolio system for students' activities. The structure and consistency of this format has proved to be an effective method for guiding and documenting hands-on learning.

Based on the success and popularity of the pilot program, the principal, with support of the school board, requested that the science and technology course be implemented for all freshmen students. The next year, 150 freshman students were enrolled. Expanding this program required the support of the administration, the school board, the guidance department, parents, the business community, and the students. An additional technology education teacher was hired, the department budget was increased, scheduling hurdles were overcome, and public concerns were addressed.

The freshman year introduction to technology and science is helping students understand the challenges and opportunities presented by our technological society. Students are building on this experience and are electing to participate in extracurricular technology education activities. A new chapter of the Technology Student Association (TSA) successfully competed at state and national conferences. The success and popularity of the technology education program has resonated throughout the school community. The technology education department has assumed a leadership role in curriculum development and technology utilization throughout the school. The vision of the Technology for All Americans Project is being realized as these students are developing technological literacy and are making a positive contribution to their school and local community.

Articulated Program: A Vision

Chip Miller
High School Technology Teacher, Oregon

We arrive at the North side of the high school at 8:00 a.m.; already two yellow school buses have arrived with elementary and middle school students from the district's schools. The students are anxious to get to work in one of the most unique educational facilities in the Pacific Northwest. We enter directly into a large room and are immediately facing the front end of a full-scale replica of a space shuttle flight orbiter simulator.

The elementary students are quickly split into two groups. High school student mentors takes the elementary students into the amphitheater for a multimedia presentation of the technology activities they will do over the next two hours. The presentation is rich in technology and features an "animatronic" talking face. We pass again into the large room housing the donated space shuttle simulator. Several students wearing bright red and bright blue vests are busy at a bank of video monitors near the simulator and in the cavernous lab area. I ask a student the reason for the colored vests and quickly learn that there are 60 students in the lab and the vests help lab facilitators (teachers) identify where students should be engaged in their activities. Five college students from the local university wear special vests that identify them as student teachers. I learn later that the vests have special sensors sewn into them. The students are tracked by a number of video cameras in the lab. The video from these cameras will give the student teachers valuable feedback on their teaching at the end of the day.

An alarm sounds, strobe lights flash, and the shuttle simulator begins to move behind the bright orange safety rail. Two students sit at video monitors observing the activities of the shuttle crew facilitating the "piping" of the current simulation out to students at a school in Idaho. There students act as mission control on the current simulation, with students from Japan acting as a tracking station for the orbital flight of the simulator. The simulator gracefully moves atop a bed of hydraulic cylinders and stepper motor drives. The simulator and related educational program were developed in cooperation with work force mentors from several technology companies.

Nearby, high school students assist elementary students in testing the motorized submarine they just built. Looking in the water tank, one submarine in particular draws my attention. I hold a long waterproof tube in my hand as the elementary students tell me about the force transducers they taped to the hull to measure water pressure. They go on to tell about the test they plan to simulate to show how thermoclines can be mapped out in lakes and oceans.

Elsewhere in the lab, middle and high school students are working on activities ranging from wind tunnel testing to the creation, manipulation, and control of a simulated, fully automated factory floor. I watch brightly-colored cubes travel down a conveyor and then be sorted according to size and color. Students are working with computer-controlled machining tools, turning out parts of plastics, brass, and aluminum.

In another room off the gallery, modular instruction is taking place. Middle school students are working on activities in which they explore computer control and programming, simulate city planning and management, hydroponic plant growth, and multimedia presentations. The elementary students are seated on a carpeted floor, building and testing constructed models related to similar technology themes.

I walk over to the west wall of the simulator gallery and peer through large glass windows. In the next lab, the high school students are huddled around the frame of an electric car they are assembling for a contest. They have welded aluminum parts together, developed hybrid composite car parts, wired motor and controller circuits, and vacuum molded car body parts. I learn that the car is the culmination of months of research, computer-aided design, and extensive prototype testing. Elementary students are helping to name the car and design computer-generated graphics to decorate the finished car.

Arrayed on the expansive wall of the gallery area are neon signs demonstrating the community and regional commitment to this technology education program. High technology companies, manufacturing concerns, higher education, and committed parent groups support this facility. I learn from the teachers that the facility was made possible by a number of grants and donations of equipment, employee time, and guiding vision. A trust fund was created to help maintain the labs.

At the end of the school day, the buses come for the elementary students, and two instructors arrive to teach evening adult classes. Community members and individuals from technology companies will soon arrive for coursework in automated manufacturing systems and desktop publishing. A local community college is using the rich program resources for adult education. Technology education is a central part of the educational program in this community.

Section 5

Strategies for Change

This document is intended to provide guidance to curriculum developers, decision makers, and teachers in developing a contemporary technology education curriculum framework that promotes technological literacy for all students. The information contained herein provides a beginning for reforming technology education for grades K-12. Systemic reforms in technology education depend on state and provincial leadership, local curriculum adoption efforts, staff development, support and advocacy, and teacher preparation and enhancement.

State and Provincial Leadership

The state or provincial curriculum framework reflects the vision for technology education, its program goals, and student expectations. Leadership is necessary to develop a clear vision and framework based on contemporary technology education content and practices, and content standards. State and provincial leaders can assist local school districts by:

- Developing a curriculum framework.
- Disseminating and interpreting the framework.
- Supporting local curriculum development and adoption.
- Collecting data on student achievement and program effectiveness.

Resources and staff development will be needed to support local efforts to develop contemporary technology education curriculum. Local school systems will benefit from state guidance in interpreting the framework and supporting local developments. Collecting data concerning technology education's role in career decisions, school successes, and student achievements would provide a database to inform state initiatives and local programs.

Local Adoption

For successful implementation, the curriculum framework needs to be understood and accepted by local school boards, principals, guidance counselors, school faculty, technology teachers, students, and parents. These stakeholders need to know the role of technology education in the total school program and its many benefits for students. Local programs need to emphasize the role of technology education in a child's educational development and in educational reforms across the school curriculum. Articulated K-12 technology education programs are needed; technological literacy development begins with students' play and learning experiences in elementary grades, continues in middle school explorations, and culminates in wide-ranging applications in the high school. Teachers need to implement quality programs that are tailored to the educational needs, abilities, and interests of their students. Successful local adoption depends on:

- Proving the value of technology education.
- Setting high program and student expectations.
- Providing quality classroom experiences.
- Promoting student achievements.
- Engaging in continuous curriculum and program improvements.

Local curriculum adoption requires a vested interest on the part of teachers, administrators, and other stakeholders in maintaining high program and student expectations. Dedicating resources and personnel to effectively deliver technology content and experiences in articulated programs is essential in developing technological literacy.

Professional Development

Implementing a new technology education curriculum requires teacher in-service training. Teachers need to understand the nature and role of the *Standards for Technological Literacy* and how they can be implemented in the technology education program. Teacher training helps keep teachers current in research on teaching and learning, contemporary delivery strategies, effective teaching approaches, and assessment. Also, teachers need to interact with their peers concerning curriculum considerations, program transitions, and long-term improvements. Professional development plays a critical role in successful curriculum implementation. Teachers and supervisors can support staff development initiatives by:

- Conveying training needs to administrators, supervisors, and teacher educators.
- Developing an action plan for professional development.
- Attending local, regional, and national conferences.
- Keeping current in content and pedagogy.
- Engaging in continuous professional improvement.

Teachers benefit from well-designed teacher workshops and networking opportunities. Professional development is needed along a continuum of teacher experience and expertise. Master teachers can be identified and trained to model effective teaching behaviors and to coach other teachers. Beginning teachers can be mentored and supported through teacher networks.

Support and Advocacy

Successful curriculum implementation involves support systems that stimulate innovation and risk-taking at the local level. Advocates at all educational levels are needed to provide guidance and support to teachers implementing new curriculum. Teachers can develop support and advocacy by:

- Establishing and meeting regularly with a technology education advisory committee.
- Working with teachers in other disciplines to integrate content.
- Establishing education-business-community linkages.
- Promoting the technology education program at every opportunity.
- Gathering data concerning student achievements and program successes.
- Networking with teachers in other schools and school districts.

Advocates such as parents, business leaders, community representatives, political leaders, and school administrators can help teachers deliver effective technology education experiences for students. Obstacles such as funding, facilities, scheduling, resources, and personnel become opportunities when excellent support is available through advocates.

Teacher Preparation and Enhancement

Teacher educators and their programs have a responsibility and commitment to prepare effective teachers; to provide experiences that reflect contemporary research on teaching and learning, technology education foundations, content, and practices; and provideguidance to new and experienced teachers. Teacher preparation programs can provide leadership for:

- Collaborating with state departments and local districts to provide teacher training.
- Developing effective curriculum resources.
- Creating outstanding teachers.
- Promoting technology education to state and local stakeholders.
- Sponsoring teacher in-service workshops and student competitions.
- Preparing teachers to effectively implement contemporary curriculum.

Teacher educators need to take part in the development and implementation of a state or provincial curriculum framework. Further, teacher educators can provide input to local adoption, and conduct professional development activities. Teacher preparation and enhancement is an important link to systemic reforms for technology education.

Call to Action

A standards-based, contemporary technology education curriculum is based on a clear vision, commitment to teaching and learning excellence, and quality educational experiences. The information presented in this document provides direction and content for change in technology education. This guide is a springboard from which states, provinces, and local school systems can develop a comprehensive and articulated K-12 technology education curriculum. Systemic reforms for technology education can be achieved when teachers, their advocates, and supporters work together to develop and implement curriculum that develops technological literacy in all students.

Section 6

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