Invention and Innovation

A Standards-Based Middle School Model Course Guide

Advancing Technological Literacy: ITEA Professional Series

Contemporary Curriculum for Technological Literacy

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Preface

This guide presents a model for a standards-based contemporary technology education course for the middle school. This model course guide features an exploratory curriculum thrust for a cornerstone middle level course. Course content is based on the International Technology Education Association (ITEA) publications, *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 (Standards for Technological Literacy/STL)* (ITEA, 2000/2002), and *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards* (*AETL*) (ITEA, 2003). Also, if your state has standards for technology education, it will be important to correlate those standards with the technological literacy standards.

Technology for All Americans: A Rationale and Structure for the Study of Technology

Technology for All Americans: A Rationale and Structure for the Study of Technology provides a vision for the study of technology. It addresses the power and promise of technology and the need for every student to be technologically literate when he/she graduates from high school. Understanding the nature of technological advances and processes and participating in society's decisions on technological issues is of utmost concern. This publication outlines the knowledge, processes, and contexts for the study of technology.

Standards for Technological Literacy: Content for the Study of Technology

What is *Standards for Technological Literacy*?
ITEA, through its Technology for All Americans Project (TfAAP), published *Standards for Technological Literacy: Content for the Study of Technology (STL)* in April of 2000. *STL* defines, through K-12 content standards, what students should know and be able to do in order to be deemed technologically literate. However, it does not put forth a curriculum to achieve these outcomes. *STL* will help ensure that all students receive an effective education about technology by setting forth a consistent content for the study of technology.

Why is *STL* important?

- Technological literacy enables people to develop knowledge and abilities about human innovation in action.
- *STL* establishes requirements for technological literacy for all students from kindergarten through Grade 12.
- *STL* provides expectations of academic excellence for all students.
- Effective democracy depends on all citizens participating in the decision-making process; many decisions involve technological issues, so citizens need to be technologically literate.
- A technologically literate population can help our nation maintain and sustain economic progress.

Guiding Principles for *STL*
The standards and benchmarks were created with the following guiding principles:

- They offer a common set of expectations for what students should learn about technology.
- They are developmentally appropriate for students.
- They provide a basis for developing meaningful, relevant, and articulated curricula at the local, state, and provincial levels.
- They promote content connections with other fields of study in Grades K-12.
- They encourage active and experiential learning.

Who is a technologically literate person?
A person who understands—with increasing sophistication—what technology is, how it is created, how it shapes society, and in turn, how technology is shaped by society, is technologically literate. A technologically literate person can hear a story about technology on television or read it in the newspaper and evaluate its information intelligently, put that information in context, and form an opinion based on it. A technologically literate person is comfortable with and objective about the use of technology—neither scared of it nor infatuated with it.

Technological literacy is important to all students in order for them to understand why technology and its use is such an important force in our economy. Anyone can benefit by being familiar with it. All people, from corporate executives to teachers to farmers to homemakers, will be able to perform their jobs better if they are technologically literate. Technological literacy benefits students who will choose technological careers—future engineers, aspiring architects, and students from many other fields. Students have a head start on their future with an education in technology.

What is included in *STL*?
There are 20 content standards that specify what every student should know and be able to do in order to be technologically literate. The benchmarks that follow each of the broadly stated standards at each grade level articulate the knowledge and abilities that will enable students to meet the respective standard. A listing of the content standards and benchmarks is presented in Appendix B of this document. Teachers are encouraged to obtain *STL* to review the complete information associated with each standard.

Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards (AETL).

While *Rationale and Structure for the Study of Technology* provides a vision, and *Standards for Technological Literacy: Content for the Study of Technology* provides the content, neither was designed to address other important elements that are critical to a comprehensive program of technological studies. As a result, ITEA's Technology for All Americans Project developed *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards (AETL)* in 2003. This publication will help schools to implement new strategies and evaluate existing practices of assessing students for technological literacy, providing professional development for teachers and other professionals, and improving programs of teaching and learning.

Advancing Technological Literacy: ITEA Professional Series

The Advancing Technological Literacy: ITEA Professional Series is a set of publications developed by the International Technology Education Association (ITEA) based on *Standards for Technological Literacy* and *Advancing Excellence in Technological Literacy*. The publications in this series are designed to assist educators in developing contemporary, standards-based K-12 technology education programs. This exclusive series features:

- Direct alignment with technological literacy standards, benchmarks, and guidelines.
- Connections with other school subjects.
- Contemporary methods and student activities.
- Guidance for developing exemplary programs that foster technological literacy.

Titles in the series include:

Technological Literacy Standards Series

- *Standards for Technological Literacy: Content for the Study of Technology*
- *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards*
- *Technology for All Americans: A Rationale and Structure for the Study of Technology*

Addenda to Technological Literacy Standards Series

- *Realizing Excellence: Structuring Technology Programs*
- *Developing Professionals: Preparing Technology Teachers*
- *Planning Learning: Developing Technology Curricula*
- *Measuring Progress: A Guide to Assessing Students for Technological Literacy*

Engineering by Design: Standards-Based Program Series

Elementary School Resources

- *Technology Starters: A Standards-Based Guide*
- *Models for Introducing Technology: A Standards-Based Guide*

Middle School Resources

- *Teaching Technology: Middle School, Strategies for Standards-Based Instruction*
- *Exploring Technology: A Standards-Based Middle School Model Course Guide*
- *Invention and Innovation: A Standards-Based Middle School Model Course Guide*
- *Technological Systems: A Standards-Based Middle School Model Course Guide*

High School Resources

- *Teaching Technology: High School, Strategies for Standards-Based Instruction*
- *Foundations of Technology: A Standards-Based High School Model Course Guide*
- *Engineering Design: A Standards-Based High School Model Course Guide*
- *Impacts of Technology: A Standards-Based High School Model Course Guide*
- *Technological Issues: A Standards-Based High School Model Course Guide*

Standards-Based Technological Study Units

Elementary School Resources (Grades K-6)

- Kids Inventing Technology Series (KITS)

Elementary/Middle Level Resources (Grades 5-6)

- Invention, Innovation, and Inquiry (I^3) Units
  - ➢ *Invention: The Invention Crusade*
  - ➢ *Innovation: Inches, Feet, and Hands*
  - ➢ *Communication: Communicating School Spirit*
  - ➢ *Manufacturing: The Fudgeville Crisis*
  - ➢ *Transportation: Across the United States*
  - ➢ *Construction: Beaming Support*
  - ➢ *Power and Energy: The Whispers of Willing Wind*
  - ➢ *Design: Toying with Technology*
  - ➢ *Inquiry: The Ultimate School Bag*
  - ➢ *Technological Systems: Creating Mechanical Toys*

Secondary School Resources (Grades 7-12)

- Humans Innovating Technology Series (HITS)

ITEA-CATTS

The **International Technology Education Association – Center to Advance the Teaching of Technology and Science (ITEA-CATTS)** was created in July 1998 to provide curriculum and professional development support for technology teachers and other professionals interested in technological literacy. ITEA-CATTS initiatives are directed toward four important goals:

- Development of standards-based curricula.
- Teacher enhancement.
- Research on teaching and learning.
- Curriculum implementation and diffusion.

The Center addresses these goals to fulfill its mission to serve as a central source for quality professional development support for the teaching and learning of technology and science. Teachers, local, state, or provincial supervisors, and teacher educators are encouraged to become familiar with ITEA-CATTS and how this Center provides additional support as *STL* is implemented.

ITEA-CATTS Consortium was established as part of ITEA-CATTS to form professional alliances in order to enhance teaching and learning about technology and science. Consortium members (see Appendix A) receive quality curriculum products and professional development based on the standards. This publication was conceptualized and developed through the Consortium.

Contents of This Guide

Invention and Innovation: A Standards-Based Model Course Guide provides the teacher with an overview of the concept, suggestions for planning the course, and ideas for developing student-centered instruction. It also introduces the content and impacts of invention and innovation, the core concepts of technology and problem solving: design, troubleshooting, research and development, and experimentation. This guide also provides sample resources for the teacher including Internet activities, worksheets, and suggested topics to further address *Standards for Technological Literacy: Content for the Study of Technology.*

How to Use This Guide

This guide is intended to help teachers and school districts design and offer comprehensive experiences in the study of technology. It is one of three such course guides that address middle level education. The other guides include *Exploring Technology: A Standards-Based Middle School Model Course Guide* (ITEA 2001) and *Technology Systems: A Standards-Based Middle School Model Course Guide* (ITEA, currently being developed).

State curriculum models will vary from state to state. Courses may carry different titles. However, most states are striving to be consistent with *Standards for Technological Literacy* (*STL*) with their standards and suggested course offerings for middle level technology education. Schools may also have different titles for their middle school offerings, and the amount of time dedicated to technology education will vary widely among schools. While *Invention and Innovation* and the other model middle school guides can be implemented as courses, they are intended to support a state, school district, or individual school technology curriculum. Therefore, these guides can be helpful in developing or revising an existing curriculum and in supporting state and local curriculum models that are already in place.

Chapter 1

Course Introduction

Technological Literacy: "The ability to use, manage, understand, and assess technology."

Standards for Technological Literacy

Chapter 1 – Course Introduction

Section 1: Overview and Planning

Course Description

Invention and Innovation is a middle school course based on *Standards for Technological Literacy: Content for the Study of Technology (STL)*. The major purpose of this course is to provide students with opportunities to apply the design process in the invention or innovation of a new product, process, or system. In this course, students will learn all about invention and innovation. They will have opportunities to study the history of inventions and innovations, including their impacts on society. They will learn about the core concepts of technology and about the various approaches to solving problems, including engineering design and experimentation. Students will also be given the opportunity to be creative as they apply themselves in the invention and innovation of new products, processes, or systems. Finally, students will learn about how various inventions and innovations impact their lives.

All people in the world have needs and wants. It is through technology that many of these needs and wants are satisfied. Technology starts with invention and is improved through innovation. An **invention** can be thought of as a new product, system, or process that has never existed before and is created by study and experimentation. **Innovation** refers to an improvement of an existing technological product, system, or method of doing something.

In this course, students will participate in engineering design activities to understand how criteria, constraints, and processes affect designs. Students will be involved in activities and experiences where they learn about brainstorming, visualizing, modeling, constructing, testing, experimenting, and refining designs. Students will also develop skills in researching for information, communicating design information, and reporting results.

Suggested Grade Level: 6-8

Course Length: Variable (12-18 weeks recommended)

Prerequisite: None

Photo courtesy of Ronald D. Yuill.

Major Course Goals

At the completion of this course, students should be able to:

1. Understand the meanings of invention and innovation.
2. Understand the roles that technology and society play in the invention and innovation process.
3. Discuss an historical perspective of various inventors, inventions, and innovations.
4. Recognize the core concepts of technology.
5. Understand design and other problem-solving techniques.
6. Work individually and cooperatively in groups to apply a design process that leads to an invention or innovation.
7. Describe how various inventions and innovations have impacted society.
8. Safely use tools, materials, equipment, and other technology resources.

STL Standards Addressed in the Course

Standard #1:
Students will develop an understanding of the characteristics and scope of technology.

Standard #2:
Students will develop an understanding of the core concepts of technology.

Standard #3:
Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Standard #4:
Students will develop an understanding of the cultural, social, economic, and political effects of technology.

Standard 5:
Students will develop an understanding of the effects of technology on the environment.

Standard #6:
Students will develop an understanding of the role of society in the development and use of technology.

Standard #7:
Students will develop an understanding of the influence of technology on history.

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

Standard #9:
Students will develop an understanding of engineering design.

Standard #10:
Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Standard #11:
Students will develop the abilities to apply the design process.

Standard #12:
Students will develop the abilities to use and maintain technological products and systems.

Standard #13:
Students will develop the abilities to assess the impact of products and systems.

Standard #14:
Students will develop an understanding of and be able to select and use medical technologies.

Standard #15:
Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.

Standard #17:
Students will develop an understanding of and be able to select and use information and communication technologies.

Standard #18:
Students will develop an understanding of and be able to select and use transportation technologies.

Standard 19:
Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard #20:
Students will develop an understanding of and be able to select and use construction technologies.

Facility Design

Ideally, the course Invention and Innovation should be taught in a multipurpose facility (i.e., a classroom and laboratory). Existing technology education/industrial arts laboratories are well suited for this course because of their flexibility and the typical space, tools, materials, and equipment they bring with them. It is also recommended that individual work areas (e.g., prototyping, testing, etc.) be established and identified in the laboratory.

The facility should be equipped with multimedia computers connected to the Internet. Computers should be loaded with software programs that can be used to complement course activities. Examples of appropriate software for the course include those programs related to word processing, presentation, digital editing and image manipulation, and drawing. Other recommended support materials for the course would include a videocassette and DVD player, television/monitor, overhead projector, video projector, color ink jet printer, computer scanner, digital camera, and digital camcorder.

Classroom

The classroom should contain desks and chairs and appropriate multimedia equipment. In addition, the classroom should be flexible so that the seating can be easily arranged to accommodate different instructional strategies (e.g., group problem-solving activities).

Modules

Modules (i.e., self-contained activities that students complete) are not required in the Invention and Innovation course. However, some teachers may find modules helpful in teaching some of the content required in Invention and Innovation.

Laboratory

Traditional power tool equipment (e.g., table saw, drill press, lathe, etc.) is not required in this course but would be beneficial to some of the activities, especially when students need to build models and prototypes. The laboratory itself should be equipped with an assortment of basic hand and power tools, and common materials used in the building of models and prototypes. Additional materials and supplies should be obtained as needed. Suggested tools and equipment would include:

- Hammers
- Wire cutters
- Power drill & bits
- Adhesives
- Nut drivers
- Foam cutter
- Power supplies
- Clamping devices
- Hot glue gun
- Assortment of screwdrivers
- Assortment of pliers
- Rulers and tape measures
- Storage containers
- Soldering set
- Soldering iron
- Safety glasses
- Vise
- Volt-Ohm-Multimeter (VOM)
- Computer repair kit
- Utility and X-acto knives
- Saws (coping, back)
- Wrench assortment
- Files and abrasive papers
- Tap and die set
- Socket set
- Scissors
- Calculators

Course Framework

The course is divided into five major units. These five major units represent the "core" technology

Table 1
Invention and Innovation Weighted Course Units

		Recommended Coverage	
Units	**Weight**	**12 Week Course**	**18 Week Course**
Unit 1	20%	12 days	18 days
Unit 2	15%	9 days	14 days
Unit 3	15%	9 days	14 days
Unit 4	40%	24 days	36 days
Unit 5	10%	6 days	8 days

content for Invention and Innovation. The five major units of this course include:

Unit 1 Introduction to Invention and Innovation
Unit 2 Core Concepts of Technology
Unit 3 Problem-Solving Design, Troubleshooting, Research and Development, and Experimentation
Unit 4 Let's Invent and Innovate!
Unit 5 Impacts of Invention and Innovation

The length of the course may vary from a few weeks to a complete year. The recommended length of the course is one semester. Depending on the length of the course, the teacher will need to adjust the length of time spent on each unit. To help teachers in the planning of the course, the units have been "weighted" to show a recommended coverage. Shown in Table 1 are the course units, weighting of units, and examples of coverage of each unit for 12-week (60 days) and 18-week (90 days) courses.

Unit Framework

Each unit begins with a short introduction of the unit. Following the introduction, a section is provided that lists the *STL* **Standards for Technological Literacy** addressed in the unit and the "**Big Ideas**" associated with the unit. After the standards section, suggested **Student Assessment Criteria** for the unit are presented in the form of a rubric.

Rubrics are assessment tools that teachers can use to evaluate instruction and performance according to predetermined expectations and criteria. When using rubrics, teachers should start and strive to have students at "target" level and then adjust up and down as appropriate. To help teachers in developing their own rubrics, suggested rubrics based upon the major objectives in each unit are provided.

The sample rubrics shown in this guide were developed using Bloom's (1956) taxonomy of educational objectives for the cognitive domain as a guide (see table 2). To learn more about rubrics and other assessment strategies, teachers are encouraged to review *Measuring Progress: A Guide to Assessing Students for Technological Literacy* (ITEA, 2004).

Following the Student Assessment Criteria, a section is presented that lists the major **Student Learning Experiences** covered in the unit, including *STL* Standards-related "benchmarks." Benchmarks provide detailed information concerning what students will need to know and be able to do to attain the standards and provide additional guidance for developing content in each unit. This section is the crux of the entire unit and the foundation by which each unit was designed. This course is based on those standards identified for Grades 6-8. Teachers are encouraged to read the entire section of information on the related standards and benchmarks presented in *Standards for Technological Literacy: Content for the Study of Technology (STL)* (ITEA, 2000/2002).

Also in this section, **Acceptable Evidence** for the unit is presented. The acceptable evidence section identifies a set of tasks that students should be able to demonstrate as evidence that the standards have been met. It requires that a variety of learning experiences are completed and assessed.

The major information to be covered in the unit by the teacher is presented in the **Overview** section. The overview provides a narrative to "prepare" teachers to teach the unit. In this section, the standards-based content that must be covered in the unit is presented. In addition, the narrative provides examples that

Table 2
Bloom's Taxonomy

1. **Knowledge:** Remembering of previously learned material; recall (facts or whole theories); bringing to mind. *Related terms*: arrange, define, identify, describe, duplicate, label, list, memorize, name, order, recognize, relate, recall, match, and repeat.
2. **Comprehension:** Grasping the meaning of material; interpreting (explaining or summarizing); predicting outcome and effects (estimating future trends). *Related terms*: classify, describe, discuss, explain, express, identify, indicate, locate, recognize, report, restate, review, select, translate, convert, defend, distinguish, estimate, and generalize.
3. **Application:** Ability to use learned material in a new situation; apply rules, laws, methods, theories. *Related terms*: apply, choose, demonstrate, dramatize, employ, illustrate, interpret, operate, practice, schedule, sketch, solve, use, write, change, compute, operate, show, and use.
4. **Analysis:** Breaking down into parts; understanding organization, clarifying, concluding. Identify parts; relationships. Clarify. *Related terms*: diagrams, outlines, relates, breaks down, subdivides, appraises, calculates, categorizes, compares, contrasts, criticizes, differentiates, discriminates, distinguishes, examines, experiments, and questions.
5. **Synthesis:** Ability to put parts together to form a new whole; unique communication; set of abstract relations. *Related terms*: combines, complies, composes, creates, designs, arranges, assembles, collects, constructs, designs, develops, formulates, manages, organizes, plans, prepares, proposes, sets up, and writes.
6. **Evaluation:** Ability to judge value for purpose; based on criteria; support judgment with reason. (No guessing). *Related terms*: appraises, criticizes, compares, supports, concludes, discriminates, contrasts, summarizes, explains, argues, assesses, defends estimate, judges, predicts, rates, selects, values, and evaluates.

teachers can use to help better explain the materials being presented. It is recommended that teachers present all the information in the overview section to students and also supplement it with their own related materials. Teachers may find it helpful to make overhead transparencies or PowerPoint presentations on the information covered in the overview.

The **Content Outline** is based on the Big Ideas presented at the beginning of the unit and provides a suggested sequence for instruction.

Following the Content Outline, the **Suggested Learning Activities** for the unit are presented. Each learning activity begins with a title, a suggested time frame to complete the activity, and a **Teacher Preparation** section, which reviews the activity and presents the teacher with helpful suggestions on how to deliver the activity. Included in many of the activity sections is a listing of helpful **Resources** that the teacher should consider reviewing or obtaining. Also, many of the teacher preparation sections contain suggestions for alternative or optional activities related to the content that is being covered in that unit. At the end of each teacher preparation section, the **Big Ideas** covered in the activity are presented. These ideas represent the "enduring understanding" associated with the activity. They identify what students should be able to know or do after they have completed the activity.

The **Student Activity** follows the teacher preparation section. The activities represent the application of the content covered in the unit. The activities allow students to apply what they have learned in the unit through various experiences, including worksheets, design briefs, and hands-on problem-solving activities. Each student activity presents students with an introduction to the activity, a listing of objectives related to the activity, and a listing of connections to other academic areas. Following the connections section, students may be presented with directions needed to complete the activity or worksheet contained in the activity. In some activities, students are presented with step-by-step procedures that are required to complete the activity. The final stage of the activity requires the teacher to evaluate it using appropriate assessment techniques.

Developing a Quality Technology Education Curriculum

The course Invention and Innovation should reflect current educational practices that foster student achievement. Invention and Innovation was developed as the basis for a "model" technology education curriculum. As teachers prepare and plan to teach Invention and Innovation, they should strive to make it a model program. To help teachers in their quest for developing a model program, they should follow the suggestions identified in *A Guide to Develop Standards-Based Curriculum for K-12 Technology Education* (ITEA, 1999, pp. 8-9). This document identifies the following criteria that are exhibited in a model technology education curriculum:

- Focuses on students and their learning.
- Reflects exemplary practices for teaching and learning.
- Emphasizes design and problem-solving activities.
- Contributes to standards attainment.
- Develops technological literacy.
- Integrates math, science, and other subjects.
- Promotes careers in professional and technical fields.

Exemplary Practices for Teaching and Learning

The course Invention and Innovation should be taught using a variety of instructional methods (e.g., design briefs and cooperative learning), assessment techniques (e.g., rubrics), and learning experiences. Excellent companion publications for this course include ITEA's publications *Teaching Technology: Middle School, Strategies for Standards-Based Instruction* (2000); *Exploring Technology, A Standards-Based Middle School Model Course Guide* (2001); and *Measuring Progress: A Guide to Assessing Students for Technological Literacy* (2004). These publications provide technology education teachers with excellent resource information that can be used when teaching technology in the middle school grades. Teachers are encouraged to obtain and review these publications. Included in these documents is information that details appropriate teaching methods, suggestions for student activities, suggestions on appropriate assessment methods, and a discussion on the nature of middle school learners.

Connections to Other Academic Areas

In the teaching of Invention and Innovation, teachers should try to make purposeful content connections with other school subjects to broaden students' understanding of technology. Presented below are several general examples of content from other academic areas that could be readily integrated into this course. The information given is only a beginning, since additional material will emerge as the course progresses. Teachers are encouraged to obtain current textbooks being used in their schools as references for their classrooms and to interact with the teachers of these subjects.

Mathematics
Mathematics deals with the science of patterns and order and the study of measurement, properties, and the relationships of quantities using numbers and symbols. In this course, mathematic connections may include:

- Collecting and graphing data
- Developing timelines
- Making measurements
- Analyzing formulas

Science
Science deals with the study of the natural world through observation, identification, description, experimental investigation, and theoretical explanations. In this course, science connections may include:

- Describing differences between science and technology
- Describing how principles of science and technology work together
- Identifying scientific principles associated with mechanical, electrical, fluid, thermal, and chemical systems
- Using the scientific method
- Discussing the influences of science on technology and technology on science

Social Science
Social science is a branch of science that deals with the institutions and functioning of human society and with the interpersonal relationships of individuals as members of society. In this course, social science connections may include:

- The history of inventors, inventions, and innovations
- Impacts of research and development
- Impacts of inventions and innovations
- Society's need for inventions and innovations

Language Arts
Language arts deals with the subjects, such as reading, spelling, literature, and composition, that aim at developing a student's comprehension and capacity for use of written and oral language. In

this unit, language arts connections may include:

- Reading
- Developing written and oral presentations
- Taking notes and keeping records
- Participating in class discussions
- Developing a scientific journal
- Developing sketches
- Developing a portfolio or inventor's notebook

Invention and Innovation Competitions

There are many types of sponsored invention and innovation competitions for students that teachers may want to consider incorporating into their programs. Some examples are provided below.

- The ***A World In Motion (AWIM)*** program was developed for elementary and middle school students to pique their interest in math and science. The program offers fun, hands-on activities in an interdisciplinary curriculum. A variety of challenges is offered by AVIM. For more information, visit: www.sae.org/students/awim.htm.

- Unlocking that potential is the mission of the ***Christopher Columbus Awards*** program, a cutting-edge, national competition that combines science and technology with community problem solving in a real-world setting. With the help of an adult coach, sixth-, seventh- and eighth-grade students work in teams of three or four to identify an issue they care about and use science and technology to develop an innovative solution. They work with experts, conduct research, and put their ideas to the test, just like adult scientists. This is science and community involvement at its best, with real rewards. To find out more, visit: www.nsf.gov/od/lpa/events/bayernsf/start.htm.

- ***The Craftsman/NSTA Young Inventors Awards Program*** challenges students to use creativity and imagination along with science, technology, and mechanical ability to invent or modify a tool. The Young Inventors Awards Program is open to all students in Grades 2-8 in the United States and its territories. Students must work independently to conceive and design their tool inventions. The student, with guidance from a teacher-advisor, parent, or significant adult, will design and build a tool. The tool must perform a practical function, including (but not limited to) tools that mend, make life easier or safer in some way, entertain, or solve an everyday problem. For further information, check out: www.nsta.org/programs/craftsman/forteachers.htm.

- The ***FIRST LEGO League (FLL)*** is considered the "little league" of the FIRST Robotics Competition. It is the result of a partnership between FIRST (For Inspiration and Recognition of Science and Technology) and the LEGO Company. FLL extends the FIRST concept of inspiring and celebrating science and technology to children aged 9 through 14, using real-world context and hands-on experimentation. With the help of LEGO MINDSTORMS Robotics Invention System technology, young participants can build a robot and compete in a friendly, FIRST-style robotics event specially designed for their age group. Using LEGO bricks and other elements such as sensors, motors, and gears, teams gain hands-on experience in engineering and computer programming principles as they construct and program their unique robot inventions. For more information visit: www.usfirst.org/jrobtcs/flego.htm.

- The mission of the National Engineers Week ***Future City Competition*** is to provide a fun and exciting educational engineering program for seventh- and eighth-grade students that combines a stimulating engineering challenge with a "hands-on" application to present their vision of a city of the future. For more information visit: www.futurecity.org.

- ***INVENT AMERICA*** is a nonprofit K-8 education program, launched in 1987, that helps children develop creative thinking and problem-solving skills through a fun, unique, and proven learning tool—inventing! In this activity, teachers become members of the INVENT AMERICA program, and students get an opportunity to enter their inventions in their National INVENT AMERICA Contest. Further information can be found at: www.inventamerica.com/default.cfm.

- The ***Technology Student Association (TSA)*** is a national non-profit organization devoted exclusively to the needs of elementary, middle, and high school students with a dedicated interest in technology. They have developed middle school technology education activities in which students can compete at both the local and national levels. Many of these activities, especially those that deal with problem solving, can be incorporated into the invention and innovation course. For more information, visit: www.tsawww.org.

- The ***Young Inventors Program (YIP)***, established in 1986, is a statewide program coordinated by the Academy of Applied Science and a volunteer consortium of New Hampshire educators developed to spark creativity in students in Grades K through 8. YIP combines teacher training with the integration of invention into the classroom curriculum, and hosts an annual celebration for student inventors. A helpful publication available to teachers is *The Young Inventors' Program Meant To Invent! Teacher Guide*. For more information about this program, visit: www.aas-world.org.

Photo courtesy of Ronald D. Yuill.

The Internet

The Internet is a powerful tool that should be utilized in this course. Throughout this course, Internet sites are listed that can be used to help teachers find more information related to the topic or activity being discussed. Helpful Internet sites related to this course are contained in the appendix. Teachers are also encouraged to use the Innovation Curriculum Online Network ICON (http://icontechlit.org) that was developed through a partnership between the International Technology Education Association (ITEA) and the Eisenhower National Clearinghouse (ENC).

Remember, the Internet is a very dynamic and fluid entity. Web sites and information listed at the sites can change daily. The Internet sites listed in this document were current at time of publication. Teachers will want to continually update and add relevant Web sites as needed and consider brainstorming search topics with students as an instructional strategy to identify these sites.

Lesson Plans

Lesson plans can be developed for use by teachers and students. Lesson plans developed for teachers are invaluable guides that help them plan and deliver effective instruction. Those in technology education should strive to develop lessons based on *Standards for Technological Literacy*. Standards-based lesson plans can help to ensure that students achieve technological literacy.

There are many different lesson plan formats for teachers. Effective teacher lesson plans can be developed using the "Four-Step" method of Instruction. The stages of the Four-Step method of instruction include (1) Preparation, (2) Presentation, (3) Application, and (4) Evaluation. In the first step, teachers identify the standards or objectives of the lesson and gather and prepare the resources needed in the lesson. Also, in this step, they should prepare students by arousing their curiosity about the upcoming lesson (e.g., they may ask students a question such as: *How would life be without the invention of the internal combustion engine?)*. In step two, teachers present their lesson based on an outline of information they want to cover. In step three, students are given the opportunity to apply or "try out" what they have learned. In this step, teachers should develop experiences and activities (e.g., design briefs or projects) that challenge students to apply what they have learned in the lesson. In the final stage of the Four-Step method of instruction, students are evaluated on their level of understanding related to the lesson.

Lesson plans developed for students help guide them in learning the course materials. Student lesson plans guide students in their actions and should be written with enough details to accomplish this. Typical components of a student lesson plan may include the objectives of the lesson, the materials and other resources needed in the lesson, an activity, assignment, design brief, or experience needed to meet the objectives of the lesson, procedures that need to be followed to complete the lesson, and an evaluation component related to the lesson.

Design Briefs

A well-written curriculum document will include activities for students to complete. One method of presenting activities is in the form of a design brief. A design brief is typically a written plan that identifies a problem to be solved, its criteria, and its constraints.

Design briefs are typically developed by teachers and given to students. However, students may become involved in the writing of their own design briefs. In this situation, students are presented with a problem that needs to be further investigated and solved. After a thorough investigation and understanding of the problem, students write a design brief that outlines the problem to be solved. As they write their design briefs, students are required to narrow down the problem to manageable terms so that they can solve it. A student-developed design brief will typically document the "design process" and may include aspects related to investigating the problem, developing possible solutions to the problem, developing specifications for the design, choosing and developing the best solution, and testing and evaluating the solution. Student- developed design briefs are best presented in a portfolio.

Teacher-developed design briefs come in many variations. Components associated with a design brief may include:

- Context or Situation
- Challenge or Problem
- Objectives
- Requirements/Criteria/Constraints
- Resources
- Evaluation

Recommended Teacher Resources

There are many excellent resources available to teachers that can be used to enhance the Invention and Innovation course (see Chapter 3). However, there are a few noteworthy resources that teachers should use in the teaching of Invention and Innovation. One of the best Internet sites that deals with invention and innovation is *The Jerome and Dorothy Lemelson Center for the Study of Invention and Innovation* that was founded in 1995 at the Smithsonian Institution's National Museum of American History (http://invention.smithsonian.org). This site provides excellent free print and multimedia resources to help teachers teach about the history and impacts of inventions and innovations. Another noteworthy site is How Stuff Works (www.howstuffworks.com). Other strongly recommended resources that can be used to compliment Invention and Innovation include:

- ABC News Video: *The Deep Dive* (www.abcnewsstore.com)
- Bridgman, R. (2002). *1000 Inventions and Discoveries*. New York, NY: DK Publishing. ISBN 0-7894-8826-4.
- Ebert, C & Ebert II, E. (1998). *The Inventive Mind in Science: Creative Thinking Activities.* Englewood CO: Teachers Ideas Press. ISBN 1-56308-387-6.
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Section 2: Teaching Invention and Innovation

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Department of Technology Education, Valley City State University, Valley City, ND

There are very few concepts that capture the essence of technology more succinctly than those of invention and innovation. The human species itself has been defined by the tools it makes—*Homo Faber*—Man the Tool Maker. The process of creating those tools, that is, invention and innovation, is really the story of the human race. From the stone tools of prehistory, to the early tools of civilization, and now the tools of the information age, humans continue to define themselves, express themselves, and evolve through the tools they make.

So what about teaching invention and innovation? Can it be taught? Many feel it can be, though it is less certain that creativity, the underpinning of invention and innovation, can be taught successfully. There is also a converse argument that says, "we are born curious and creative, and that it is the mass-production style education system adopted during the industrial era that discourages creativity in favor of memorization of facts and conformity to rules."

Many leaders are convinced that the economic success of a nation depends upon technological creativity, innovation, and invention. Not surprisingly, this belief is most apparent among nations that feel outclassed and economically threatened by the technological achievements of the U.S. Some nations have acted to ensure competitiveness of their workforce by mandating technology be studied from the early primary years through secondary schools. These nations include: Australia, Canada, Czech Republic, Finland, France, Republic of South Africa, Sweden, Taiwan, and the United Kingdom (Newberry, 1999).

Can technology education teachers simply study technology and hope that students learn to innovate and invent? Probably not. But remember, educators are, for the most part, operating in new territory since they have been teaching facts, memorization, and conformity with few exceptions for the past 200 years. So what can technology education teachers do? In the simplest terms, they must present students with opportunities to design solutions to technological problems, over and over again, and in many contexts. And they must hold them accountable for the innovation and invention that is necessary to create new solutions. How can teachers do this?

One suggestion is changing from reliance on traditional testing and grading in favor of performance assessment. So, what is performance assessment? The most visible sign that you may be aware of is the portfolio. The portfolio contains evidence of a student's ability to complete the assigned tasks. It should show evidence of the quality of work, and also evidence of a student's understanding of the work, including a self-assessment. Appearance of the portfolio is important, but teachers must look beyond the appearance; they must look at what is expected of students—what do students need to understand? The key word is *understanding*. Teachers must hold students accountable for understanding whatever problem or solution is at hand.

In their book *Understanding by Design*, Wiggins and McTighe (1998) discuss that there are many different ways of understanding and present six facets of understanding. When a person understands, he or she:

- Can *explain*: provide thorough, supported, and justifiable accounts of phenomena, facts, and data.
- Can *interpret*: tell meaningful stories, offer apt translations, provide a revealing historical or personal dimension to ideas and events, make it personal or accessible through images, anecdotes, analogies, and models.
- Can *apply*: effectively use and adapt what we know in diverse contexts. Have perspective: see and hear points of view through critical eyes and ears, see the big picture.
- Can *empathize*: find value in what others might find odd, alien, or implausible, perceive

sensitively on the basis of prior direct experience.
- Have *self-knowledge*: perceive the personal style, prejudices, projections, and habits of mind that both shape and impede our own understanding; we are aware of what we do not understand and why understanding is so hard (p. 44).

To summarize, the teaching of innovation, invention, and creativity is something new in the experience of many technology educators. To be successful, teachers must give students many opportunities to become technologically literate, including opportunities to innovate and invent... They must be able to communicate their expectations, hold students accountable for developing innovative solutions, and bring them to an understanding of the many facets or contexts in which the solution they develop will fit or interact in society.

Definitions

It may be useful to discuss a few of the many related terms that will certainly come up in any discussion regarding invention and innovation.

- ***Science***
  Science is the pursuit of new knowledge about nature. Its primary goal is knowledge, not solutions to problems. The reward for the acquisition of new knowledge is recognition and honor. The pinnacle of all scientific pursuit is the Nobel Prize. Scientists revere great thinkers like Einstein, and before him, Newton. Throughout prehistory and most recorded history, even up to the beginning of the twentieth century, technology in the form of inventions usually preceded science. For example, compasses were invented hundreds of years before science understood (discovered) how they work. Due to the rapid accumulation of knowledge today, often the reverse is true.

Photo courtesy of Ronald D. Yuill.

- ***Discovery***
  One must be aware of the many ways that science and technology interact. Discovery is the primary process used in science to uncover new knowledge. This is not to say that scientists cannot innovate or invent, or that engineers and technologists cannot make a discovery. For example, Thomas Edison, an inventor with over 1,000 patents to his credit, actually made only one scientific discovery in his life. It was later named after him—the Edison Effect. Conversely, great scientists are not out to invent. This distinction is important but also obvious—we (technologists) cannot invent or create something that already exists in nature; it is up to scientists to discover it. On the other hand, discoveries often lead to inventions. For example, the recent discovery of the Bucky Ball, a rare form of the carbon atom, (which resembles a soccer ball, as well as Buckminister Fuller's Geodesic dome) will no doubt lead to many inventions in the future.

- ***Invention***
  An invention can be thought of as a new human-made device or process. In lay language, the laser is thought of as an invention, while the tiny light-emitting diode laser could be thought of as an improvement on the basic laser. On the other hand, the operation of the LED laser may be so different it is really an invention in its own right rather than a mere

improvement or innovation. Some clear-cut examples: a running shoe might be considered an invention, whereas the gel-cushioned running shoe might be considered an innovation. Another example might be the invention of the Velcro fastener, where putting Velcro on a shoe or jacket might be considered an innovation.

- ***Innovation***
  Innovation can be thought of as simply a better way of doing things. Another concept of innovation is simply an improvement. The concept is equally applicable to processes or devices. For example, we can just as easily improve service as well as products. Norman (1993) provides a useful concept of innovation in that it currently lags seriously behind both discovery and invention. For example, both discoveries and inventions are the raw materials for innovation. Computers have been invented, chips have been invented, wonderful flat displays have been invented, but there is always room for improvement. In the same vein, hardware (computers) will probably always outpace the software development—a more time-consuming activity. Another perspective is that discoveries and inventions are sort of like the letters of the alphabet. Will we ever exhaust the ways that we can put these 26 characters together? And of course, discoveries and inventions are vastly more numerous than the letters of the alphabet. Food for thought!

- ***Creativity***
  Creativity is a most elusive concept, though there is little disagreement that creativity is the major ingredient of innovation and invention. It is hard to define since it can take so many forms. One approach says that creativity, at least in the technological sense, is the ability to see a problem in several dimensions. If one has this ability, the most elegant solution may become obvious. Another aspect of creativity that was referred to in the introduction is the ability to truly understand the problem at hand. Again, the elegant solution may follow. Another approach to understanding creativity is to discuss it in a number of forms. A researcher who provides a great deal of insight is Harvard professor Howard Gardner in his book *Frames of Mind: A Theory of Multiple Intelligences* (1983).

  In essence, Gardner says that intelligence is much too complex to be measured by a simple cognitive test. In his first book, referenced above, he described intelligence as taking at least seven forms: spatial, linguistic, logical/mathematical, bodily/kinesthetic, interpersonal, and intra-personal. For this discussion however, a paraphrase of his broad definition of intelligence is most revealing: "the capacity to solve problems or to fashion products that are valued in one or more cultural settings" (Gardner, 1983). Incredible as it may seem, here we have one of the most widely read and respected researchers of modern times defining intelligence as the ability to solve problems and create products (invent and innovate)—exactly what we are trying to do in technology education.

- ***Engineering***
  The Engineers Council on Professional Development defines engineering as: "The profession in which the knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize economically the materials and the forces of nature for the benefit of mankind." Engineering, in the simplest sense, is the deliberate, orderly process through which technology is created.

- ***Technology***
  Technology is human innovation in action.

- ***Design***
  As with technology, there are many definitions of design. For example there is graphic design, interior design, architectural design, set design, landscape design, industrial design, and many more. Of greatest interest in this course is none of the above, but the broadest concept of design. That is, the process of designing solutions to technological problems—innovating and inventing.

Invention, Innovation, and History

Throughout history, inventions and innovations have always sparked change, although the process was not formalized until modern times.

In fact, history itself was an invention. Yes, humans have existed on earth for a length of time that, for now, is unknowable. However, some geneticists are beginning to suggest with increasing certainty that modern man can be traced back to a single female who lived about 200,000 years ago. All this is based on known rates of genetic change or mutation, and the date is established by sort of triangulating back to a point of convergence. But for most of this time, man has existed in what we call pre-history. History began, really, when we became capable of recording it through the invention of handwriting. Handwriting was invented out of the need to record surplus; for example, what is in the large clay pot, how much, and who owns it? Of course, pottery and storage became necessary only when food gathering became annualized and settlements became permanent—in other words, when agriculture became a way of life. Agriculture was possible only with the invention of the plow. And so a pattern begins to emerge, a new invention, new possibilities. Early civilizations were based on just a few inventions. The plow, handwriting, metallurgy, pottery, brick making, stone cutting, spinning, weaving, surveying instruments, and a few more.

James Burke, perhaps the most prolific writer on the history and effects of technology, with over a half-dozen video series on the subject, states that there are but a handful of stimuli, forces, or mechanisms that influence invention and innovation (Burke, 289-291). One of the most readily recognized mechanisms is deliberate search, very common today, and very uncommon in the past. A good example of deliberate search and a successful invention that came out if it was the story of Thomas Edison and the light bulb. He set out to invent the light bulb, and he did, after 6,000 tries.

A second mechanism is the deliberate search for one thing that leads to something else. An example of this mechanism is that of young William Perkin, a chemistry student in the mid 1800s in England. Because of the scarcity of Quinine needed to fight malaria in the British colonies, he was given the task of trying to synthesize Quinine from a favorite waste material, coal tar. He failed, but ended up with aniline dye, the source of virtually all the color in our world today.

A third mechanism is at work when totally unrelated developments have a profound affect on the main event. One example is that of a Cambridge University physics student named C.T.R. Wilson. When serving as an unpaid observer at a mountaintop observatory he noticed a "glory," which is a dispersion of light on clouds and appears a bit like a rainbow, but the colors are reversed or backwards. He decided to go back and build a cloud chamber so he could understand why the colors were backwards in the glory. This research, which resulted in the invention of the cloud chamber, was of little value to the meteorological community. However, it was a device that allowed nuclear scientists to see what they were doing when splitting the atom, thereby accelerating the development of the atomic bomb by years or decades.

A fourth mechanism is one in which military needs or military inventions give rise to intense development efforts, and equally significant social change. For example, the stirrup, a very simple invention which permitted fighting from horseback, gave such an advantage to the combatants that a whole new social order was ushered in. The age of the knight in shining armor lasted for several hundred years, and ended only after another military invention, the Swiss Pike, proved devastating to the mounted horseman. The pike, later shortened to become the bayonet, was to be assisted by yet another weapon, the musket, in changing the social order once and for all. Much of our modern life is influenced by the intense military stimulus of WWII, and more recently, the Cold War.

A fifth mechanism that is still at work is the result of religion. For example, in the early Islamic world, the need to pray at various times of the day and night stimulated the development of the "astrolabe" and other astronomical innovations. In the Christian world, a similar need resulted in the crude alarm clock, and later other clocks with incredible social impact. Today the clash between Western technology (along with the attached cultural hegemony) and Islamic values is resulting in a war of terrorism, no doubt with lasting impact.

A sixth mechanism that is always at work is the weather along with other natural forces. One of the most spectacular examples of what can happen when the weather mixes with invention is the coming of the mini-ice age in Europe in the 12th century. As the weather became colder, some nameless inventor got the idea of bringing a fire into the house to stay warm. But not in the usual way—using a hole in the roof. He borrowed the chimney idea from a smithy, and the world has never been the same. Thanks to the year-round productivity cycle permitted by the indoor warmth, Northern Europe became an economic beehive, moving the center of civilization northward at a rapid pace. First came Holland, next came England, then France, Germany, the U.S., and Russia. Each northern nation has had its day in the sun, while displacing the nations of the Mediterranean rim, such as Italy, Spain, and Portugal. Today these nations are popular tourist destinations, but not economic powers. This change is even more powerful than it seems at first. Prior to the chimney, all great civilizations were born in temperate regions, some venturing northward a bit later on. Examples are Egypt, Rome, Mesopotamia, Greece, Central America, and southern China.

A seventh and most interesting mechanism stimulating change and invention is pure accident. For example, a leak in a kiln (that was designed to produce coal tar to paint on ship bottoms) resulted in an explosion, along with the invention of equipment to produce domestic gas for street lighting.

Discovery, Invention, and Innovation Today

Many factors that influence invention and innovation today result from legislation and the huge bank of previous inventions and discoveries, not the least of which is the tremendous increase in efficiency of communication technology. This section will examine a few of the most influential factors, which are of a different origin than the mechanisms mentioned above.

Communication Technology

A very strong positive influence on invention and innovation is the tremendous increase in our ability to communicate rapidly (Burke, 1978). An organized mail service, the telegraph, telephone, radio, and television all assist in the spread of knowledge. What this means is that we can stand on each other's shoulders and reach higher because we don't have to invent or discover everything ourselves. If Thomas Edison lived a million years, as creative as he was, he could not match the inventive productivity of just a few people who are free to communicate effectively. The faster we can communicate, the faster we can infect others with new inspiration and new inventions, discoveries, and innovations to build on. The Internet is the most powerful of all communication tools in this regard because it permits us to find information we need more efficiently, thanks to search engines, and we can collaborate with the person who has the expertise we may need even if that person is on the other side of the planet.

Specialization of Knowledge and Teamwork

Thomas Edison was an entrepreneur and promoter who promoted the notion that he, the lonely genius, created things out of thin air. It was a good marketing strategy, but hardly true even then. He had many highly skilled and highly specialized people working for him (in other words, an interdisciplinary team). This concept was reinforced by the needs of wartime development.

The Rise of Organized Science

Another factor in the explosion of invention and innovation is the rise of organized science (Burke, 1978). As mentioned previously, in the past, discoveries often followed the practical application. In other words, technology preceded science. Compasses were in practical use for hundreds of years before science understood (discovered) magnetism. Airplanes were built long before science understood turbulence. Today, however, it is rare that technology precedes science. Science produces so much knowledge, and thanks to the Internet, it is so easy to get to, an inventor merely has to "go shopping," so to speak, to find the necessary knowledge to complete a

project. If the knowledge is not readily available, again thanks to the Internet, someone can be found who has the expertise to find it. The process also feeds in the other direction. As inventors create better tools, science can use these tools to discover more new knowledge. The Hubble telescope is a bit of technology that has pushed the frontiers of science ahead by decades in a matter of months.

The Influence of Government
The need for rapid wartime development of technology tends to push the envelope of efficiency. Perhaps the first project of massive size was the Manhattan project, which produced an atomic bomb in a very short time. One secret of success of the project was the unprecedented teamwork of technicians, engineers, and scientists. Today this kind of teamwork is common thanks to the Internet, and no one has to be in a given location. Another effect of government on the rapid pace of innovation and invention is the funding of research, which is often available for the asking. Government can also influence invention and innovation by legislation, that is, creating the rules that others must play by. Several legislative concepts are discussed below.

- *Intellectual Property*
  The concept of intellectual property goes back at least to the time of the founding of our government. It was recognized even then that to promote rapid growth of technology, there had to be something in it for both users and producers, and if the correct balance could be found, it would be good for the country.

- *Trademarks*
  Trademarks are a type of intellectual property that is relatively simple, at least in concept. A trademark gives an individual or corporation a right to identify a product with a graphic symbol that customers can readily recognize for the quality and service they have earned. Generally a trademark has no time limit. For example, a Coca Cola logo registered over a century ago is still the property of the company. Even if a company goes out of business, the trademark may still have value and is owned by someone. A name and trademark such as the Duesenburg auto could be resurrected under new leadership. Thanks to the popularity of Harley-Davidson motorcycles, long dead competitors such as Indian and Excellsior-Henderson have been recreated.

- *Copyrights*
  A copyright is related to written material, graphic material, or music, and is markedly different than either a trademark or a patent. Copyrights provide the creators of written materials the right to profit from the sale of their works for a definite period of time. At the expiration of this period, the work became public domain and anyone could use it freely. A single copyright law was in effect from 1906 until the mid 1970s and provided authors or designers with 28 years of rights. If the author was still alive, and applied for an extension in the 28th year of publication, it could be extended for another 28 years. Working backwards 56 years from the mid 1970s one can see that anything produced prior to the early 1920s is in the public domain. Another feature of the old law was that the author had to register the work and include the copyright symbol for the copyright to be valid.

  The revision of the law in the mid 1970s swung in favor of the author in several ways. First, one no longer must register a work for a copyright to be valid. The date simply must be established when the work was penned or transferred to a medium such as paper. A copyright symbol need not be displayed. Secondly, the rights of the author were extended to 50 years after death. In 1998, Congress passed the Digital Millennium Copyright act. In general, the act favored authors with even more rights, and extended the law to include many electronic works and a host of issues brought about by new information technology. Since legal precedents are established over decades, it is quite early to say just what the impact of the law will be. There is one interesting exception to copyright law that has been in existence since the beginning. A typestyle or typeface cannot be copyrighted. The nation's founders felt the new printing technology was so critical for freedom of expression, that they should not allow Americans to be held hostage to type designers and foundries. Today most typefaces on computers are digital and the appearance cannot be copyrighted, but the computer code underneath can be. Early in the digital age, digital type pioneer Adobe charged ad agencies nearly $200,000 for a complete PostScript type collection so they could reproduce the work of customers. Today, thanks to Apple and Microsoft's TruType font technology, as well as cheap scanners and type authoring software, this monopoly has been broken.

- *Patents*
  Patents provide inventors with exclusive rights to manufacture a device for a period that has been fixed at 17 years. The concept behind the patent was essentially this: If an inventor would share the details of the device through the patent application process, then the public would benefit by knowing how the device works. This would permit other inventors to "innovate" by applying the concept to other applications. So, in the end, the public and the nation would benefit by feeding a host of other inventions or innovations, while the inventor would benefit by exclusive rights to profit from the device for a period of time. Patents can sometimes be extended by application. A few of the many issues surrounding patents include the issue of breadth. If the Patent office grants a patent that is too broad, it renders the public benefit as minimal, since no one else can design around it, and hence it does not stimulate innovation. If too narrow, the inventor has shared knowledge in exchange for nothing because others can too easily design similar devices.

  Another concept is that of "patent pending" (a notice that the inventor has applied for a patent, but has not yet received it). This allows manufacturing to begin and a market test to be done. If the product fails in the marketplace, there is no point in continuing through the patent process, which gets more expensive as it progresses, often costing a minimum of $5,000. In the meantime, potential competitors are placed on notice, but no secrets get shared until a patent is awarded. Another point about patents is that they are assigned to individuals, not corporations. Therefore, inventors who work for corporations must sign a contract to turn over all rights to the company before work begins.

  Another important point about patents is the documentation that an inventor must keep, in the form of dated logs, in order to prove who invented something first. There are two famous cases to illustrate this point. Alexander Graham Bell was awarded a patent on the telephone because he got to the patent office first—by a few hours. Had his competitor, Elisha Gray, maintained meticulous notes in a log, he may have been able to win the legal battle as to who invented the telephone first (PBS Vignette).

  More recently, another famous case has emerged with a different result. In 1958, Charles Townes along with Arthur Schawlow were jointly awarded a patent on the laser. For the past 40 years history books have told the story about the invention. But as a result of a 20-year legal battle, that award was overturned by evidence to the contrary. In 1977, Gordon Gould proved that he had invented the laser first (MIT Vignette.) Even today, the prestigious Bell Labs claim that their workers (Townes and Schawlow) invented the laser (Bell Labs Vignette). It may be many years or decades before the history books get rewritten.

- *Design Patents*
  It may also be worth making a distinction between a patent and a design patent. For example, it is not possible to get a patent on a windshield wiper blade; it has already been in the public domain for decades. But one could patent a particular style of blade. One might think of a design patent as protection for an innovation as opposed to an invention.

Great Inventors

Perhaps there is nothing that can inspire young inventors in the classroom more than hearing and seeing the success stories of great inventors as told in multimedia format. There is a huge collection of exciting material on the Web, not only about great inventions and great inventors, but about classroom activities that support invention, innovation, and discovery. Prospective teachers are invited to take a look. In addition, the major networks, and especially the cable channels such as the History Channel, the Discovery Channel, the Learning Channel, and Public Television, have created some fantastic material that is available on the Web as supplements to their video productions. These are useful as is, and even more useful when some of the video material is purchased for classroom use.

Can We Teach Invention and Innovation?

As educators, we are handicapped by our own education and the habits we have formed. All teachers alive today were born during the industrial era, and if born on the fringe of the information age, were still victims of a mass-produced, assembly-line education. This system mimicked the factory of Henry Ford and was indeed "Cheaper by the Dozen." This factory-style education was uncannily like the factory. The factory whistle blew and the school bell rang. As workers slaved to keep up with the moving assembly line, students rushed to be on the same page, on the same line, at the same time, in the same book, of course. Students could have any kind of education they wanted as long as it was the same—as Henry Ford bragged "you can have any color Model T you want as long as it's black." To be fair, the schools of the industrial age really had no precedent; only the rich could afford tutoring prior to the industrial era. These schools were the best that industrial-era productivity would allow. Now that the information age is upon us, and a whole new generation of productivity-enhancing tools are at our disposal, we must begin to try to use them to make education better. Education today, many experts agree, must value individual differences and prize creativity and problem solving.

It is perhaps too soon to say if creativity and the inventions and innovations that flow forth can be taught, but we can, at the very least, pose challenges and reward novel and unusual solutions. If one types keywords such as "theory of multiple intelligences" or "creativity" or "problem solving" or "invention" or "innovation" into a browser and does a search, the thousands, indeed tens of thousands, of hits one encounters are a pretty good indication that educators are willing to give it a try.

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Section 3: Why Invent?

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Much has been written about the present condition of American education. It is difficult to pick up a newspaper or magazine that doesn't have an article by someone concerned with the quality of public schools. Parents are concerned that their children are not keeping up with students in other countries, and businesses are afraid of "losing the competitive edge." Studies show that today's youth may lack the basic skills needed to function effectively in the workforce.

In too many instances, corporations must spend capital on upgrading the education of their new recruits so they can handle the increased sophistication of their jobs. In an article published in *Educational Leadership* (1992), John O'Neil reported that "Unless U.S. students are better equipped to enter a changing workplace, the financial future for graduates—and likely the economy as a whole—is likely to remain bleak even after the present recession breaks." A decade has passed since the O'Neil article, and businesses still are concerned with the lack of skills of the entering workforce. Still worse, the National Science Board reports in its latest *Science Indicators* (2000) that American student performance in international math and science competitions remains dismal.

Teaching students to be creative thinkers and problem solvers will address many of the problems of public education and will help prepare students for an uncertain future. Instead of the traditional rote memorization of facts from lectures and textbooks, students must be encouraged to think through problems, analyze, ask questions, and support decisions. In schools as well as in the workplace, individuals are confronted daily with problems demanding solutions. How they solve those problems is often determined by how well they have developed critical-thinking and problem-solving skills.

Learning the process of inventing develops students' problem-solving abilities and creativity in the broadest sense. Inventing provides a unique opportunity for learners of all ages to synthesize and apply knowledge and skills in an interdisciplinary, real-life manner. The process places a strong emphasis on defining an actual problem, formulating an original solution, developing a product, and sharing the results or products with appropriate audiences. A unit on invention, included herein, challenges students to become actively engaged in the learning process. They quickly discover that it's also fun.

The invention process provides an opportunity for all students to participate and be successful. All children can identify problems in their homes or neighborhoods. Almost every day they will face at least one problem. An unmade bed, a dog that eats the cat's food, a mother with a broken leg that must be elevated when she sits, a grandfather who cannot grasp a bar of soap because of severe arthritis—all are examples of real-life problems identified and solved by students participating in this program. When students identify a problem to be solved, they become actively engaged in the learning process. Once the problem has been identified, teacher and parent have but to stand aside and watch them go.

A unit on inventive thinking, which includes the production of an original invention, is limited only by the imagination of the teachers and students. The teacher might ask, "With everything else I have to teach, why take the time for inventing?"

Research has shown that inventing will:

- Stimulate and foster creativity.
- Enhance self-image.
- Develop the essential skills of logical thinking, creative problem solving, intellectual risk-taking, and communication.
- Relate the scientific method to real life.
- Spark the inventive spirit in our culture.

Students will also:

- Develop higher-level thinking skills.
- Use creative and critical-thinking skills.
- Solve actual problems.
- Use library and other research skills.
- Learn to document the inventive-thinking process.
- Experience success and increased self-esteem.
- Produce an original invention and receive recognition for participating in the invention process.

These are all solid reasons for studying inventors, inventions, and the inventive process. For teachers who understand learners and learning, there are three primary reasons for incorporating these ideas into classrooms and the curriculum. These ideas are relevant, they allow for choice, and they connect.

Connections

Not only does the study of invention connect disciplines, it connects school to life. It's "science with a purpose," as one student aptly put it. An invention is the concrete application of the scientific process. Whether studying inventions from the past or creating their own, students can make connections. The study of invention is the study of humanity's past and its impact on the natural world in recorded history and beyond. It touches all aspects of life. Our economic and sociological history can be examined by the impact of inventions from the earliest days of America's agricultural-based economy and through the industrial and information revolutions. Have the VCR, automobile, telephone, television, and Internet changed the way we live and do business? What is the relationship of invention to geography and the environment? Why were certain things invented in certain places and in certain times? Is "necessity the mother of invention"? What are the ethical issues connected with recent medical and genetic inventions? Has our definition of *artist* changed with the technical advances made in the visual and performing arts?

Global civilization can be studied through invention. Science fiction stories even predict the impact of humanity's inventiveness on the future. Invention can be a tremendous organizing theme for a unit, a course, or a year-long, school-wide program. The study of invention will help our students connect the past to the present and to the future.

Relevance

If we want to keep smiling, be effective in today's classroom, and prepare our youth to cope with the incredible challenges that have arrived with the twenty-first century, our lessons must be relevant. What can be more relevant than studying inventions? Everything students see and use was invented by *someone*—why not by them?

Who is an inventor, anyway? Is an inventor just a frazzled old man in a white coat with glasses and big hair? Inventors are simply people—male or female, young or old—any race or creed—everyday people who solve problems. When someone brings a new solution to a problem, he or she is an inventor. Some solutions are simple. Some are complex. But all inventors have common traits:

- Inventors are curious.
- Inventors like to tinker with their ideas.
- Inventors are persistent.
- Inventors share their inventions.
- Inventors are constantly inventing.

In 1899, (then) U.S. Patent Office Commissioner Charles Duell allegedly reported to President McKinley and the Congress that, "I recommend closing the Patent Office, since everything that can be invented has been invented."

Archivists disavow this quote, pointing to many of Duell's verified statements to the contrary. Inventors were operating in high gear at the time, and the Patent Office in 1899 could hardly keep abreast of American innovation. This country was, after all, in the very midst of the *industrial revolution*. Nonetheless, this misquote made the rounds for decades, appearing in advertisements and repeated by lecturers. Too bad for poor Mr. Duell, but still, his *non-statement* does serve a very useful purpose. It keeps reminding us that, just when we thought we've seen everything, more amazing inventions are rolled out. Inventors are constantly inventing.

This has been particularly true of the more recent *information revolution*. We can only dream of the miracles that will flow from the fertile minds of inventors in the days to come. But, educators and curriculum developers can do more than dream when it comes to preparing our students to be ready to become proactive problem solvers—perhaps even to prepare them for roles as tomorrow's inventors.

Through biographies and journals, students can learn about the process of inventing, as well as about individual inventors. They can learn that even though Thomas Edison was reportedly learning disabled—he was still our most prolific inventor. For students who are having difficulties in school, this can be enlightening; it can be an opportunity to identify with determined and successful people.

Another relevant point about the study of inventions for teachers, parents, and administrators is that newly published national goals and state academic standards all speak to making connections and to studying unifying themes. In mathematics, science, social studies, and language arts, numerous goals and proficiency standards can be easily and clearly addressed through the study of invention, inventors, and inventing.

Choice

What better way to address the work done by Howard Gardner on multiple intelligences than to allow students to follow their strengths and interests through inventing? This is a chance for each student to be the expert, to become empowered, and to exhibit his or her individuality. Whether following a special interest in a research project, conducting a traditional science project, or trying their hands at inventing, the element of choice can be highly motivating for students.

All types of learners can find success when multiple product possibilities are acceptable. Whether the strengths are written, verbal, musical, or body/kinesthetic, inter- or intrapersonal, logical/mathematical, or visual/spatial—all have a place in the invention theme.

In the era of "too much to teach and not enough time," the perfect solution is to use an interdisciplinary approach.

The Academy of Applied Science, incorporated in 1963, is a private, nonprofit, tax-exempt organization, chartered for the purpose of promoting creativity, invention, and scientific achievement. It is recognized nationally as an educational resource center offering enrichment programs for students, and professional development for teachers and educational administrators. The Academy honors learners of all ages, striving to encourage inventive thinking, productive research, and talent development in the disciplines of math, science, and the humanities. The Academy's youth science activities annually reach over 12,000 elementary and high school students nationwide and are sponsors of the Young Inventors' Program. More information about AAS can be found at www.aas-world.org.

Section 4: Developing Student-Centered Instruction

Those technology teachers involved in the teaching of Invention and Innovation should consider using a "student-centered" (learner-centered) approach to instruction in their classrooms. This section will compare traditional learning to student-centered learning and provide suggestions for developing student-centered instruction.

What is student-centered instruction? In the student-centered approach to instruction, the learner (student) becomes the central focus in the learning process. In the student-centered classroom, learners learn primarily because of what they bring, in terms of their perceived needs, motivations, past experiences, background knowledge, interest, and creative skills to their classroom experience. Teachers, on the other hand, are seen as "facilitators, helpers, coaches, and resources," and their roles become de-centralized (Campbell & Kryszewska, 1992).

Advocates of the student-centered teaching methodologies and curriculum argue that involving learners through student-centered techniques enhances motivation, which in turn heightens achievement. Coombe and Kinney (1998) identify the following benefits of using student-centered instructional approaches in the classroom:

- Constant assessment of student needs.
- Less teacher preparation time.
- Increased group cohesiveness.
- Teacher's role becomes more decentralized.
- Increased understanding of student concerns and problems.
- More mature and responsible students.

Traditional Learning Versus Student-Centered Learning

What is learning? Learning is a change in behavior. We say that students "have learned" when they can demonstrate new knowledge and skills presented to them by the teacher. In traditional approaches to teaching and learning, teachers are typically in charge of developing and delivering most of the instruction to students. The teacher's main goal is "getting the information across to the students," and his/her primary responsibilities are lecturing, designing assignments and tests, and grading. Students have "very little say" in the entire teaching and learning process.

When developing traditional teaching and learning environments (classrooms) or student-centered classrooms, there are many important variables for teachers to consider, including:

- The required course content (typically stated in the goals and objectives of the course).
- How to develop the student's cognitive abilities (such as problem-solving or critical thinking).
- How to develop positive attitudes in students toward teaching and learning.
- How to evaluate students.
- How to help students succeed.

The following offers a comparison of how traditional learning and student-centered learning differ in philosophy and objectives of instruction, roles of the teacher and student, and purpose of assessment (*Developing Your Instructor Skills*, 1999).

Philosophy and Objectives of Instruction

- *Traditional Learning*
  - ➢ There's so much our students need to know, how will they ever learn everything? Repetition is necessary!
  - ➢ In the course, teachers must try to cover all the information required in the class and "adhere" to the lesson plan. They need to be "recognized" as the experts who know everything!
- *Student-Centered Learning*
  - ➢ We learn, not by being told, but by experiencing the consequences of our own actions. Learning is an experiential process—we learn by doing!
  - ➢ In the course, the purpose of the class is to change

behavior so that it improves the knowledge and skills of the learner. The focus is to meet the needs of the students—not to show them how smart the teacher is!

Roles of the Teacher

- *Traditional Learning*
  - ➢ Teachers are the providers of almost all information, and they lecture a lot. They talk and "show and tell" most of the time—students rarely have an opportunity to say anything. Teachers may ask: "Do you have any questions?" or "Do you understand?" (Teachers talk 95% of the time.)
- *Student-Centered Learning*
  - ➢ Teachers become facilitators and coaches who arrange meaningful learning experiences and activities for students. Teachers often ask students questions that require them to think. Teachers may ask: "Why do we do it this way? or "What would you do if...?" (Teachers talk no more than 50% of the time.)

Roles of the Students

- *Traditional Learning*
  - ➢ Students are passive "sponges" who are expected to absorb all the information that the teacher is providing and are expected to "repeat" back what the teacher has said.
- *Student-Centered Learning*
  - ➢ Students are "active" learners who learn by doing. Students are given tasks or situations in which they must practice and apply their newly acquired knowledge, skills, and attitudes. Students correct their own behavior because they are experiencing the result of their own actions.

Purpose of Assessment

- *Traditional Learning*
  - ➢ To see if the students understand the information. To test the student's retention of the information. To see if the information should be repeated. Reward and punishment (good and bad grades—sanctions and embarrassment).
- *Student-Centered Learning*
  - ➢ To see if students can apply what was just learned. To see if students need more time to practice. To see if the teacher needs to provide additional (remedial) instruction. To provide students with both positive and negative reinforcement (praise and constructive criticism).

Suggestions for Developing Student-Centered Instruction

There are many popular non-traditional approaches to instruction that support student-centered learning. Some of these popular approaches include cooperative learning, constructivism, and "hands-on" learning.

In cooperative learning, students work together in small, structured groups (i.e., three to four students) to achieve a shared goal. However, it involves much more than simply placing students in a group and instructing them to complete the activity. To be effective, cooperative learning must be properly structured and implemented, where students know their responsibilities and understand the consequences of their actions.

Photo courtesy of Ronald D. Yuill.

In constructivism, teachers and students actively learn together and share knowledge. Learning is dependent on such things as prior experience, and the learner's ability to construct his/her own meaning. Its principles include discovery learning and "real-world" classroom tasks, where the teacher serves as a facilitator and resource person (Kaplan, 1999).

In hands-on learning, the curriculum centers on experiments, group activities, and real-life applications. A "hands-on" classroom may appear more "noisy" and more "active" than a traditional classroom. In this type of instruction, students are presented with "real-life" applications of subject matter that focus on why they need to learn the materials (Hayes, n.d.). In developing student-centered approaches to learning, the focus is on students.

Felder and Brent (n.d.) discuss other student-centered techniques of instruction. In these techniques, teachers should consider:

- Substituting active learning experiences for lectures.
- Holding students responsible for materials that have not been covered in depth in the classroom.
- Assigning open-ended problems and problems that require critical or creative thinking that cannot be followed by text examples.
- Involving students in simulations and role-playing.
- Using self-paced learning methods.

Integrating student-centered instructional techniques into the traditional classroom is not a difficult task. However, to be effective, teachers must believe in the philosophies associated with student-centered learning and be willing to "try" to implement these approaches in the classroom. The following provides some good suggestions for technology education teachers to use when developing student-centered instruction (Ollikkala, 2000).

Suggestion #1:
Tell Students Why!

- Tell students why (i.e., the reasons) you are using a new approach or activity (e.g., change in seating arrangements, assessment techniques, etc.)—it helps students recognize and cope with their own learning styles.
- Students who know "why" may be able to apply the "learning method" to improve their own ways in which they acquire knowledge or solve problems.

Suggestion #2:
Change the Learning Environment!

- Rearrange the classroom, get rid of the traditional rows of chairs facing the teacher—it helps to change passive learners into active learners.
- Make students more accessible to the teacher, each other, and course resources.

Suggestion #3:
Teach to all Learning Styles!

- Try to accommodate all students by varying the ways in which you present information to the class. Remember, students have preferred learning styles that may fall into several categories: visual, auditory, and tactile (touchy/feely).
- Don't be afraid to ask students how they like to learn best and give them opportunities to decide what is to be learned, through which activities, and at what pace.

Suggestion #4:
Help Students Develop a Student-Centered Attitude About "Learning"

- In traditional education, students have learned or "think" that:
  - ➢ They must always work only alone or in pairs.
  - ➢ They need to get all the answers right—or they will be penalized.
  - ➢ There is only one right answer.
  - ➢ They have to hurry, and if they don't finish, they will be penalized.
  - ➢ They can't share their answers (that's cheating).
  - ➢ They must get it right the first time.
  - ➢ They must be able to exactly repeat what they just memorized.
- In student-centered learning, teachers will need to change the "attitudes" of students about their perceptions of instruction and learning. Students will need to learn that:
  - ➢ They can choose the resources that best suit their needs.
  - ➢ The goal for every student in the class is to agree on acceptable answers before any new materials are covered.
  - ➢ Some questions are "open-ended" with many answers.
  - ➢ It is all right to "think outside the box" (be creative).
  - ➢ They can work at their own pace—not everyone does

    everything the same way at the same speed.
  - They can network with others to find out more information.
  - They are not penalized for mistakes—it is a learning experience.
  - People do better when they are relaxed.

Suggestion #5:
Help Students Develop a "Student-Centered Attitude" About Completing Course Assignments and Activities

- In traditional education, students have learned that when completing activities or assignments:
  - They are doing this assignment for the teacher.
  - No one cares about their work as long as they get good marks.
  - Their work has no meaning outside the classroom.
- Teachers need to develop a student-centered attitude in students about completing assignments and activities and one in which they learn that:
  - They are encouraged and supported by the teacher and also by other students.
  - A little bit of competition in the classroom is healthy.
  - Each student's work is important, and they all possess unlimited potential.
  - Their work in the classroom is important, and it can be placed into a professional portfolio for others to review.
  - They must be open to comments, feedback, and other constructive criticism so that they can learn from their own mistakes and improve themselves.

Suggestion #6:
Teach Students to Reflect

- Students must be given opportunities to "reflect" on their own progress or progress of the group and must be encouraged to give "honest" and "open" answers.
- Student reflections can help teachers assess student progress and learning levels.

Suggestion #7:
Teach Students How to do Research and Problem Solving

- Most students have poor research skills and become frustrated when trying to find information or solve a problem.
- Teachers must teach students the basics of research methodology and problem solving (e.g., the process of understanding a problem, devising a plan to solve the problem, carrying out the plan, and evaluating the plan).

Suggestion #8:
Teach Students to Brainstorm and Encourage Creativity

- Brainstorming provides students an opportunity to express many ideas on a topic and is frequently used when trying to generate a solution to a topic. Make sure to give students time and support to enhance or refine what they have previously learned.
- All students are creative and need to understand creative thinking (i.e., the ability or power used to produce original thoughts and ideas based upon reasoning and judgments). However, students need to realize that creativity is not something you teach—it occurs in people at different times and in different ways.

Suggestion #9:
Use Today's Instructional Technology

- Students and teachers can communicate through e-mail or online chatting.
- Teachers should have their own Web Sites for students to access.
- Teachers should strive to teach using a variety of instructional technologies (e.g., computers, video projectors, the Internet etc.) and sound instructional design principles.

When developing student-centered instruction, teachers must continually provide students with guidance and support as students learn to accept "responsibility" for their own learning. Teachers must always consider students' learning styles and be aware that, when trying to develop student-centered learning, they may encounter "resistance" and negativity from students. For example, students may say to the teacher, "I can't believe we have to do homework in groups" or think, "I am not going to play the teacher's dumb games." However, in the end, students may actually change their minds and begin enjoying student-centered instructional approaches to learning.

Conclusion

Technology education teachers should consider adopting a student-centered approach to instruction. In a student-centered classroom, students take more responsibility in the teaching and learning process, which may increase student motivation and achievement.

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Chapter 2

Course Framework and Units of Study

"My advice is to do something which interests you or which you enjoy...and do it to the absolute best of your ability. If it interests you, however mundane it might seem on the surface, still explore it because something unexpected often turns up just when you least expect it. With this recipe, whatever your limitations, you will still do better than anyone else. Having chosen something worth doing, never give up and try not to let anyone down."

Nobel Laureate Sir Harold Kroto, 2001

Chapter 2, Unit 1

Introduction to Invention and Innovation

Nils Bohlin (1920-2002) recently died at the age 82 in Sweden. Most people have never heard of him. However, the technology he invented has saved millions of lives worldwide. Who was he? He was the inventor of the car lap-and-shoulder belt that was introduced by carmaker Volvo in 1959. Today, the seatbelt is required by law in many countries. The main goal of this unit is to introduce students to the key concepts associated with technology, invention, and innovation, and to have them "invent something." Students must learn the basics associated with technology and how inventions and innovations lead to new technology and how technology influences innovations and inventions. Students must also develop an understanding to the problem-solving process and learn that invention and innovation are a type of problem-solving approach.

Standards for Technological Literacy Standards Addressed in Unit 1

Unit 1 addresses *STL* standards as follows:

- **Standard 1** Students will develop an understanding of the characteristics and scope of technology.
- **Standard 3** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.
- **Standard 6** Students will develop an understanding of the role of society in the development and use of technology.
- **Standard 7** Students will develop an understanding of the influence of technology on history.
- **Standard 8** Students will develop an understanding of the attributes of design.
- **Standard 9** Students will develop an understanding of engineering design.
- **Standard 10** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.
- **Standard 17** Students will develop an understanding of and be able to select and use information and communication technologies.

Big Idea

Concepts associated with invention and innovation.

Student Assessment Criteria – Introduction to Invention and Innovation

Achievement Level / Sub-concept	Above Target 3	At Target 2	Below Target 1
Concepts and Terms	Can define and describe all terms and concepts related to Invention and Innovation.	Can define and describe most terms and concepts related to Invention and Innovation.	Can define and describe a few concepts and terms related to Invention and Innovation.
Technology and Society	Can describe, explain, and evaluate the role that technology and society play in the invention and innovation process.	Can describe and explain the role that technology and society play in the invention and innovation process.	With assistance, can describe the role that technology and society play in the invention and innovation process.
History of Invention and Innovation	Can identify, explain, and discuss the history of various inventions and innovations.	Can identify and explain various historical inventions and innovations.	With assistance, can identify and explain various historical inventions and innovations.
The Design Process	Can explain, analyze, and apply the design process in the development of a simple invention.	Can explain and apply the design process in the development of a simple invention.	With assistance, can use and apply the design process in the development of a simple invention.

Student Learning Experiences

Our First Invention

The Most Important Invention or Innovation of All Time

Introduction to Invention and Innovation

As a set of learning experiences, the following *STL* content standards and corresponding benchmarks are addressed: **Standard 1**, Benchmarks F, G, H, and I; **Standard 3**, Benchmark F; **Standard 6**, Benchmarks D, E, F, and G; **Standard 7**, Benchmarks C, D, E, and F; **Standard 8**, Benchmarks E, F, and G; **Standard 9**, Benchmarks F, G, and H; **Standard 10**, Benchmark G; and **Standard 17**, Benchmark H. However, if you choose to use only a specific activity, please refer to Appendix B to determine exactly which standards and benchmarks are being addressed by that learning experience. See **Appendix B** for a complete listing of the *STL* content standards.

Acceptable Evidence of Student Understanding

The items listed below reflect a set of tasks that students should be able to demonstrate as evidence that the standards have been met. This will require that a variety of learning experiences are completed and assessment is conducted throughout the unit.

1. Define the following: technology, science, engineering, invention, innovation, and creativity.
2. Discuss the roles that technology and society play in the invention and innovation process.
3. Identify an important invention or innovation from the past and give a presentation on it.
4. Research one artifact related to information and communication technology that is at least 20 years old and report on its origins and impacts.
5. Design and make a simple invention.
6. Explain the basic steps of the engineering design process.

Special note: Please keep in mind that criteria must be developed to measure the evidence that students provide in demonstrating their levels of understanding—what are we looking for and how will we know it when we see it? For example, if students are asked to build a model, how will we know if it's a good one?

When considering achievement levels and helping students to understand how they might improve, it will be necessary to know what we mean by terms such as effectively, efficiently, adequately, creatively, thoughtfully, mostly, clearly, minimally, marginally, correctly, safely, systematically, randomly, logically, thoroughly, introspectively, insightfully, and meaningfully. (See **Appendix D, Acceptable Evidence Glossary**, for definitions.)

Unit 1 Overview

Begin this unit by having students complete an activity where they "invent something." This activity should be used in the first few days of the class to help get students interested in the class, to show them that anyone can invent, that invention requires imagination and creativity, and that inventing can be fun.

Discuss the meaning of the terms invention, innovation, technology, science, and engineering. Explain that these terms are not always easy to define and interpret. Using various sources (e.g., dictionaries, encyclopedias, and literature from professional organizations) present various definitions, meanings, and examples related to these terms. Challenge students to share their own ideas related to theses terms. Shown below are some basic concepts related to theses terms.

1. **Technology** – Human innovation in action. It involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities.
2. **Science** – The study of the natural world through observation, identification, description, experimental investigation, and theoretical explanations.
3. **Engineering** – The profession or work performed by an engineer. Engineering involves the knowledge of the mathematical and natural sciences (biological and physical) gained by study, experience, and practice that are applied with judgement and creativity to develop ways to utilize the

materials and forces of nature for the benefit of humankind.
4. **Invention** – A new product or system, or process that has never existed before, created by study and experimentation.
5. **Innovation** – An improvement of an existing technological product, system, or method of doing something.

Discuss the term "technology" in depth. Explain that most people think of technology as only "computers" or the Internet. However, technology is so much more. Technology has existed since the beginning of humankind. For example, a long time ago, people lived in caves and hunted animals for food. To meet their basic needs, they "invented" a technology for hunting—a long wooden pole with a sharp end—a spear. Later on, they innovated the spear by adding a sharp stone as the point.

Provide students with an opportunity to learn about the history of technology. Studying the history of a technology provides students with the opportunity to see how people learn from their successes and failures. It can also teach them that inventions and innovations typically take time and involve lots of patience. It can show them that a "technology of the time" influences the way in which people live and work. For example, why is vinyl record technology no longer the primary way in which people buy and listen to music? Students must learn that technology is continually changing and that a society's acceptance of a technology is very important. Without support, a new technology will fade away. What happened to vinyl records?

It is important in this unit to introduce students to the concept of design. Design is regarded by many as the core problem-solving process of technological development. Students must learn that design is a creative planning process that leads to useful products and systems. They should learn that there is no perfect design, and that the design of a product or system is typically governed by a variety of criteria and constraints.

In this unit, students must learn that one very popular approach that engineers use in developing a technology is called the engineering design process. The basic steps associated with the engineering design process include the following:

1. Identify the problem or need.
2. Brainstorm a solution.
3. Determine an appropriate solution.
4. Select a solution to solve the problem or meet the need.
5. Implement the solution (e.g., build a model or prototype).
6. Test and evaluate the solution.

Engineering design is one type of problem solving, but not all technological problems are design problems. Technology includes many other types of problems and different approaches to solving them, including troubleshooting, research and development, invention and innovation, and experimentation.

Review the concepts associated with invention and innovation. Invention and innovation are open-ended and creative problem-solving approaches that can give society new products or improvements on old products. Invention is the process of coming up with something new, and innovation is aimed at improving existing products, systems, or methods of doing something. Discuss that most inventions and innovations are done to benefit society; however, they can have negative impacts.

Very important to invention and innovation is creativity. Creativity is an important ingredient to new inventions and innovations. Creativity is the ability to imagine or invent something new. It is the ability to generate new ideas by combining, changing, or reapplying existing ideas. Some creative ideas are astonishing and brilliant, while others are just simple, good, practical ideas that no one seems to have thought of yet.

In this unit, students should study the history of inventions and innovations. They should study different inventions and innovations that have occurred over the years. They should also learn about the history of famous inventors and the impacts of their inventions. Sample inventors and their inventions are listed below. It is recommended that, because of students' familiarity with information and communication technologies (e.g., television, radio, telephones, etc.), they complete an in-depth study of an invention of innovation in this area.

1. Leonardo da Vinci – made the first real studies of flight (1480s)
2. Alexander Graham Bell – telephone (1870s)
3. Levi Strauss – blue jeans (1873)
4. Thomas Edison – lightbulb (1879)
5. Gottlieb Daimler – invented a gas engine (1885)
6. George Eastman – photographic film (1888)
7. Marie Curie – together with her husband, she discovered two new elements—radium and polonium (1890s)
8. Ole Evinrude – outboard boat motor (1907)
9. George Washington Carver – industrial applications for agricultural products (1910s)
10. Henry Ford – assembly line (1913)
11. Garrett Morgan – traffic light (1923)
12. Philo T. Farnsworth – electronic television (1927)
13. Buckminister Fuller – geodesic dome (1950)
14. Nolan Bushell – video game (1971)
15. Steve Wozniak – personal computer (1976)

Unit 1 Content Outline

I. Definitions

A. Technology – Human innovation in action that involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities. The innovation, change, or modification of the natural environment to satisfy perceived human needs and wants.

B. Science – The study of the natural world through observation, identification, description, experimental investigation, and theoretical explanations.

C. Engineering – The profession or work performed by an engineer. Engineering involves the knowledge of the mathematical and natural sciences (biological and physical) gained by study, experience, and practice that are applied with judgement and creativity to develop ways to utilize the materials and forces of nature for the benefit of humankind.

D. Invention – A new product or system or process that has never existed before, created by study and experimentation.

E. Innovation – An improvement of an existing technological product, system, or method of doing something.

F. Serendipity – An accidental discovery.

G. Artifact – A human-made object.

H. Creative Thinking – The ability or power used to produce original thoughts or ideas based upon reasoning and judgement.

II. Scope of Technology

A. Technology provides new products and systems.

B. Humans have needs and wants—they invent or innovate a new technology to satisfy their needs and wants.

C. Creativity is an important ingredient to technology.

D. Advertising helps create demand for new or improved technology.

III. Society Influences Technology and Technology Influences Society

A. People have invented and innovated since the beginning of humankind.

B. Technology is continually changing.

C. Technology influences the needs and wants of people.

D. People and culture influence technology.

E. Societies' acceptance of technology is important.

F. Inventions and innovations can have both positive and negative impacts.

IV. History of Technology

A. Studying the history of technology provides people a way to learn from the successes and failures of their predecessors.

B. Invention and innovation typically take time and involve patience.

C. Specialized functions of a product or system can lead to technological improvements.

D. Technology of the times influences the way in which people live and work.

E. Early inventions and innovations were not developed with the knowledge of science.

V. Design

A. It is the creative planning process that leads to useful products and systems.

B. There is no perfect design.

C. Design has criteria and constraints.

VI. Engineering Design

A. Engineering design consists of basic steps.

1. Identify the problem or need.
2. Brainstorm a solution.
3. Determine an appropriate solution.
4. Select a solution to solve the problem or meet the need.
5. Implement the solution (e.g., build a model or prototype).
6. Test and evaluate the solution.

VII. Famous Inventors and Their Inventions

A. Leonardo da Vinci – made the first real studies of flight (1480s)

B. Alexander Graham Bell – telephone (1870s)

C. Levi Strauss – blue jeans (1873)

D. Thomas Edison – lightbulb (1879)

E. Gottlieb Daimler – invented a gas engine (1885)

F. George Eastman – photographic film (1888)

G. Marie Curie – together with her husband, she discovered two new elements—radium and polonium (1890s)

H. Ole Evinrude – outboard boat motor (1907)

I. George Washington Carver – industrial applications for agricultural products (1910s)

J. Henry Ford – assembly line (1913)

K. Garrett Morgan – traffic light (1923)

L. Philo T. Farnsworth – electronic television (1927)

M. Buckminster Fuller – geodesic dome (1950)

N. Nolan Bushell – video game (1971)

O. Steve Wozniak – personal computer (1976)

Suggested Learning Activities

Our First Invention!

Time: 4-6 days

Teacher Preparation

This activity should be used in the first few days of the class to help get students interested in the class and to show them that anyone can invent, that invention requires imagination and creativity, and that inventing can be fun.

Begin the activity by reviewing important terms and concepts related to invention and innovation. To get students motivated and interested in the various terms and concepts associated with invention and innovation, develop a crossword puzzle activity for students to use. Free crossword software is available for downloading at www.eclipsecrossword.com.

This is a small group (i.e., three to four students) activity. Develop for each group an *"Inventor's Pack"* (e.g., straws, balsa wood, balloon, tape, paper clips, cups, etc.) and obtain some jelly beans that can be used to invent a new jelly bean dispenser. Review the engineering design process with the class and have each group build the jelly bean dispenser and present their invention to the class. In their short presentation, they must tell what the invention is, how it works, and describe some of the thought processes they went through as they designed their invention. Commercially available "invention" materials (e.g., *Invention Explore-A-Pak* or *Inventor's Workshop Kit)* are available from Pitsco (www.pitsco.com).

Helpful Resources

Ebert, C. & Ebert, E. S., II. (1998). *The Inventive Mind in Science: Creative Thinking Activities.* Teachers Ideas Press. ISBN: 1-56308-387-6. www.teacherideaspress.com.

Flack, J. D. (1989). *Inventing, Inventions and Inventors: A Teaching Resource Book*. Teachers Ideas Press. ISBN: 0-87287-747-7. www.teacherideaspress.com.

Egan, L. H. (1997). *Inventors and Inventions.* Scholastic Professional Books. ISBN: 0-590-10388-1.

For fun, have students go to the interactive Web site "Invention at Play" (www.inventionatplay.org) where they can explore and complete various activities related to invention.

Big Ideas Covered in this Activity

- Anyone can invent!
- People invent or innovate to satisfy a need or want.
- Invention requires patience and creativity.
- The engineering design process.

Name: ___________________________________
Date: ____________________________________
Hour/Period: ______________________________

Invention and Innovation

Chapter 2, Unit 1: Introduction to Invention and Innovation

Student Activity #1

Our First Invention!

Introduction

This is a small group activity where your group will have the opportunity to invent a new *Jelly Bean Dispenser* using an *Inventor's Pack*.

Objectives

Upon successful completion of this activity, you should be able to:

- Invent a new "Jelly Bean Dispenser."
- Work together in a group setting.
- Explain the basic steps in the problem-solving process.

Connections

During this activity, you will be applying knowledge from the following areas:

- Mathematics: measurement, geometry, numbers and operations
- Science: motions and forces
- Language Arts: reading, communication skills
- Social Sciences: entrepreneurship

Directions

In this activity, you will complete the following *design brief.* A *design brief* is a written plan that identifies the problem to be solved, and identifies criteria and constraints related to the problem.

Design Brief

Situation
Your aunt Laura, the "candy connoisseur" and "part-time scientist" has innovated a new way to make jelly beans that have different flavors. For example, she has discovered a way to make jelly beans that taste like chocolate ice cream, hot dogs with ketchup, and peanut butter and jelly. She would like to share her new type of jelly beans with the public by offering free samples in stores. She hopes that by offering free samples, people will like them so much that they will go out and buy them by the jars and make her rich and famous. However, she needs someone to "invent" a jelly bean dispenser for her.

Challenge
In this small-group activity, your team is given the challenge to design and develop (invent) a prototype (working model) of a small jelly bean dispenser.

Criteria and Constraints:
- Your jelly bean dispenser must be made with at least ten different items from the *Inventor's Pack*. You may use all the materials if you wish.
- You must "brainstorm" a name for your jelly bean dispenser.
- The jelly bean dispenser must be able to hold at least four ounces of jelly beans and be able to dispense a small "free sample" of approximately 4-10 jelly beans.
- The only other tools and materials you may use for the prototype are located on the *Inventor's Workbench.*

Tools, Materials, and Equipment Needed
- *Inventor's Pack*
- An assortment of craft tools (e.g., glue gun, scissors, x-acto knife, etc.)

Procedures
1. Break into small groups (4-5 students). Assign a group leader.
2. Obtain and review the items in the *Inventor's Pack.*
3. With your team, complete the following "problem-solving" process:
    - Discuss the problem (take notes).
    - Discuss ideas for solving the problem (make sketches).
    - Choose the "best idea" and build a prototype (working model).
    - Evaluate and test your prototype, refine as needed.
4. After your prototype is finished, name it—be creative.
5. Present the completed "Jelly Bean Dispenser" to the class.

Time: 4-6 days

Teacher Preparation

This can be a "buzz group" activity. In a buzz group activity, a leader is chosen and the class is broken into small groups (i.e., three to four students) and given a relevant topic (i.e., The Most Important Invention or Innovation of All Time) to discuss for about 10 to 20 minutes. In the buzz group, the leader is responsible for directing the discussions and reporting back to the class. In each buzz group, the group must reach a consensus on the topic being discussed.

This activity can be expanded to include a research aspect where students use the Internet to help them in determining the most important invention or innovation of all time. Individually or in groups, students will be required to search the Internet to find out what others feel were the top inventions or innovations of all time. To help students get started, they can visit the following Internet sites:

- Greatest Engineering Achievements of the 20th Century: www.greatachievements.org
- Major Technological Inventions: www.swishweb.com/Science_and_Technology/Major_Technological_Inventions

To help students in their understanding of the "most important inventions or innovations of all time" and when they occurred, develop and post a classroom "timeline" showing important dates of inventions or innovations. Helpful resources include:

- Timeline of Toys and Games: www.historychannel.com/exhibits/toys/timeline.html
- Historical Timeline: www.historicaltimeline.com

This activity could be modified to focus on "Famous Inventors and Their Inventions." In this activity, each student will select an inventor and report on what he or she invented. The report should include information about when and where the invention occurred and how it impacted society. The teacher could also ask the students

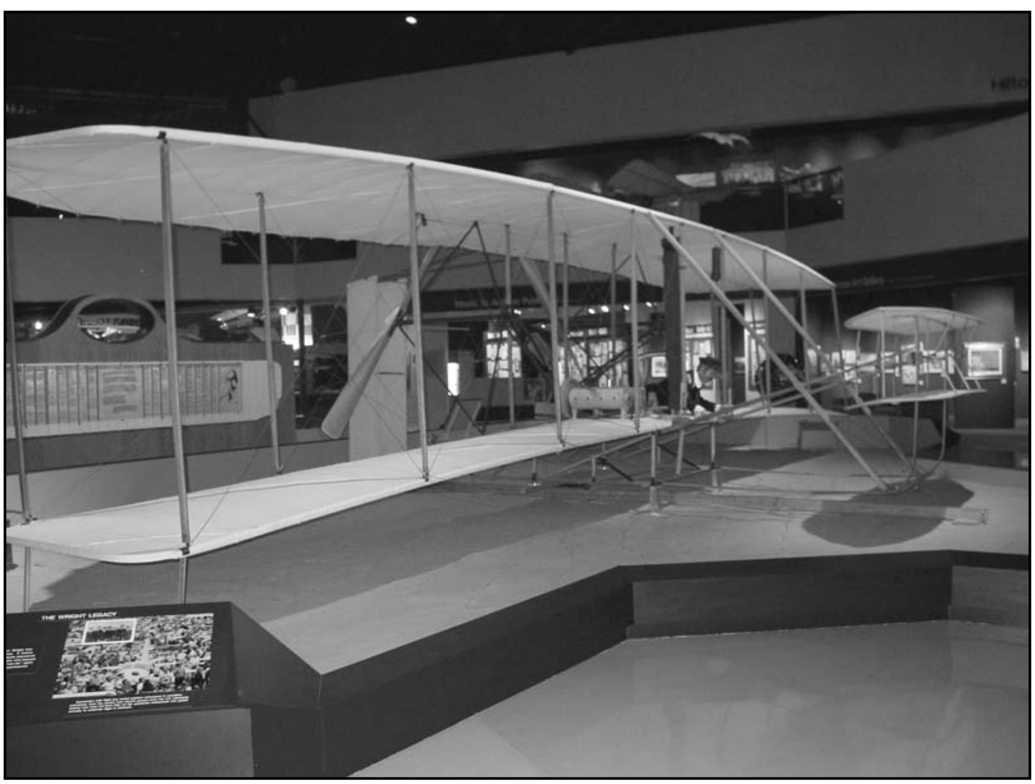


Photo courtesy of Alan G. Gomez.

A replica of the Wright brothers plane.

to highlight different groups of inventors, for example famous African American inventors or women inventors. Excellent information about inventors and their work can be found on the Internet at:

- http://inventors.about.com/library/bl/bl12.htm
- www.bkfk.com
- www.inventorsmuseum.com
- www.smith.edu/hsc/museum/ancient_inventions/home.htm
- www.african-american-inventors.com
- www.si.edu/resource/faq/nmah/afinvent.htm
- www.princeton.edu/~mcbrown/display/women_inventors.html
- http://members.aol.com/TeacherNet/Invention.html

Other good resources include *Technology's Past: America's Industrial Revolution and the People Who Delivered the Goods, Technology's Past: More Heroes of Invention and Innovation,* and *History of Technology Series* by Dennis Karwatka and available from *Tech Directions* at www.techdirections.com, and Roger Ridgman's (2002) *1000 Inventions and Discoveries* book.

This activity could be modified so that it focuses on "one" important invention or innovation. For example, in 1903 the Wright Brothers invented the airplane. The one-hundredth anniversary of their historic flight occurred in 2003 and received much publicity. In this activity, the class would have the opportunity to learn more about the Wright Brothers. The teacher would need to obtain a variety of resources and activities and present them to the class. Following the presentations, the class could be broken into small groups (i.e., three to four students) where students would be given the opportunity to discuss the first flight using questions such as: "Why did they fly their first flight in North Carolina?" or "What type of testing did they do as they built the first airplane?" Also, the teacher may want to have students invent and test their own flying machines (e.g., paper airplanes, rubber-band-powered airplanes, etc.). Excellent resources for this activity include:

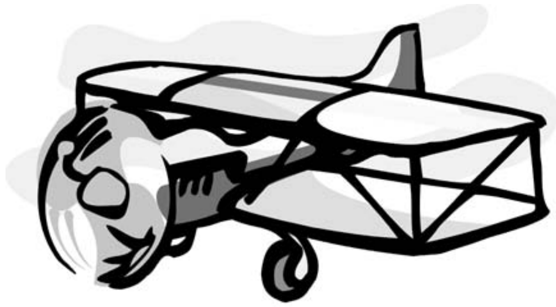
- Kitty Hawk Video: www.david.garrigus.com/pages/kittyhawk.html
- National Memorial: www.nps.gov/wrbr
- The Wright Brothers: www.first-to-fly.com
- Henry Ford Museum, The Wright Brothers: www.hfmgv.org/exhibits/wright
- Early Pictures: www.outerbanks.com/wrightbrothers/wrightlc.htm
- Wright Brothers Invention Process: http://wright.nasa.gov/tested.htm
- NASA – *Re-Living The Wright Way*: www.grc.nasa.gov/WWW/Wright/index.htm
- First Flight: www.fi.edu/flight/first/intro.html
- Video: The Wright Challenge (available from the History Channel, http://store.aetv.com/html/home/index.jhtml).

This activity could be modified to reflect inventors' inventions and innovations from around the world. Many inventions and innovations have occurred outside the United States. For example, a famous Italian inventor from the fifteenth century was Leonardo da Vinci. Anton Van Leeuwenhoek, a Dutch clockmaker, invented one of the earliest microscopes at the end of the seventeenth century when he skillfully ground glass into a magnifying lens. In 1895 Italian inventor Guglielmo Marconi built the equipment and transmitted electrical signals through the air from one end of his house to the other, and then from the house to the garden. In this activity, each student should be challenged to find an inventor, invention, or innovation from outside the United States. Teachers could make a bulletin board that showcased inventions or innovations from around the world, or students could make an information sheet highlighting the inventor, invention, or innovation. For example, information about Chinese inventions can be found at: http://inventors.about.com/od/chineseinventors.

For fun and motivation, obtain decks of the inexpensive Inventor's Card Game and have students play the game in small groups (4-6 students). In this game, students learn about famous inventors and their inventions. The achievements of 13 famous inventors are highlighted, and the game features color portraits of the inventors and notes some of their important inventions. The Inventor's Card Game is published by U.S. Games Systems, Inc. (www.usgamesinc.com) and is available from many sources (e.g., Pitsco).

Big Ideas Covered in this Activity

- Inventors, inventions, and innovations that changed our lives.
- The history of important inventors, inventions, and innovations.



Name: ______________________________
Date: ______________________________
Hour: ______________________________

Invention and Innovation

Chapter 2, Unit 1: Introduction to Invention and Innovation

Student Activity #2

The Most Important Invention or Innovation of All Time

Introduction
What is the most important invention or innovation of all time? Could it be electricity? How about television? Or maybe the Internet is the most important invention of all time. In this activity, you are going to work in small groups to identify what your group feels are the most important inventions or innovations of all time.

Objectives
Upon successful completion of this activity, you should be able to:
- Discuss a variety of inventions and innovations that impacted our lives.
- Identify the names of some famous inventors and their inventions.
- Explain the basic steps in the problem-solving process.

Connections
During this activity, you will be applying knowledge from the following areas:
- Science: scientific inquiry
- Language Arts: communication skills, communication strategies, understanding of the human experience, multicultural understanding
- Social Sciences: history of America, profit, and the entrepreneur

Directions
In this activity, you will work in small groups to complete the following worksheet that will help you decide upon the most important inventions or innovations of all time.

Invention and Innovation

Chapter 2, Unit 1: Introduction to Invention and Innovation

Student Activity #2 - Worksheet

The Most Important Invention or Innovation of All Time

Introduction

What is the most important invention or innovation of all time? Could it be electricity? How about television? Or maybe the Internet is the most important invention of all time. In this activity, you are going to work in small "buzz" groups to identify what your group feels are the most important inventions or innovations of all time.

Procedures

1. Break into small groups.
2. Choose a group leader. The group leader will be responsible for directing the discussion of the group and reporting back to the class.
3. Discuss the following question: *What do you feel were the most important inventions or innovations of all time?* List below what the group feels were the top 10 inventions or innovations of all times. Discuss one or more "impacts" related to the invention or innovation. How did the invention of innovation change people's lives?

   For example: *Invention:* Telephone *Impact:* People could communicate over long distances.

Top Inventions or Innovations	Impacts
1.____________________________	____
2.____________________________	____
3.____________________________	____
4.____________________________	____
5.____________________________	____
6.____________________________	____
7.____________________________	____
8.____________________________	____
9.____________________________	____
10.___________________________	____

4. Class discussion: Each group must present its findings to the class. The class must come to a consensus of the top inventions or innovations of all time.

Exploring the History of Information and Communication Technology Objects, Processes, and Systems

Time: 4-6 days

Teacher Preparation

In this activity, students will complete a worksheet and develop an Information Sheet about an historical object, process, or system related to information and communication technology. In this activity, students will use the Internet to research one object, process, or system related to information and communication technology that is at least 20 years old and report on its origins and impacts.

Photo courtesy of Lorraine Leo.

Big Ideas Covered in this Activity

- The history of important inventors, inventions, and innovations related to communication and information.
- The impacts of inventions and innovations related to communication and information.

Name: ___________________________
Date: ___________________________
Hour: ___________________________

Invention and Innovation

Chapter 2, Unit 1: Introduction to Invention and Innovation

Student Activity #3

Exploring the History of Information and Communication Technology Objects, Processes, and Systems

Introduction

People create information and communication technology systems to share information. Information is shared in many forms, including numbers, words, symbols, sounds, and images. In the area of information and communication technology, many *objects, processes,* and *systems* have been invented or innovated to satisfy people's need to communicate. For example, the telegraph, telephone, and mobile phone are examples of inventions that changed the ways in which people send and receive information. Today, the cellular phone is an innovation of the mobile phone that makes it easy for everyone to communicate.

How much do you know about things that have been invented or innovated in the area of information and communication technology? The purpose of this activity is to research one *object* (e.g., a 35mm camera), *process* (e.g., developing film), or *system* (e.g., a minilab photo developer and printer system) related to information and communication technology **that is at least 20 years old** and to develop a **one-page** information sheet on it that discusses its origins and impacts.

Objectives

Upon successful completion of this activity, you should be able to:

- Discuss the origins of a selected information communication technology object, process, or system.
- Identify who invented or innovated the selected object, process, or system.
- Discuss how the object, process, or system influenced and/or impacted society.

Connections

During this activity, you will be applying knowledge from the following areas:

- Science: scientific inquiry, science, and technology
- Language Arts: reading for perspective, evaluation strategies, communication skills, and research skills
- Social Sciences: history of America, goods and services, and incentives.

Directions

In this activity, you will complete the following *worksheet* that will help you to learn about an object, process, or system related to the History of Information and Communication Technology.

Invention and Innovation
Chapter 2, Unit 1: Introduction to Invention and Innovation

Student Activity #3 - Worksheet

Exploring the History of Information and Communication Technology Objects, Processes, and Systems

Procedures

1. Choose an old object, process, or system (at least 20 years old) related to information and communication technology.

   Possible Topics
   - Photography and Cameras (35mm, Instamatic, Polaroid, etc.)
   - Early Drawings (e.g., Hieroglyphics)
   - Television (systems, standards, stations, etc.)
   - Video Game Systems (Nintendo, Atari, Pong, etc.)
   - Records and Record Players (vinyl, cylinder, etc.)
   - Audio Tape and Tape Players (reel-to-reel, 8-track, cassette, etc.)
   - Videotape and Video Recorders and Players (VHS, Beta, U-Matic, etc.)
   - Printing Processes (offset, screen process printing, lithographic, etc.)
   - Telephones
   - Motion Picture (film types, projectors, etc.)
   - Telegraphs
   - Tubes, Transistors, etc.
   - Radio Waves (AM, FM, Shortwave, etc.) and Radio Stations
   - Satellites
   - Computer-Aided Drafting
   - Fiber Optics
   - Communication Cables
   - Signal Codes and Flags
   - Typewriter
   - Two-way Radios

   List Your Chosen Topic:____

2. Using the Internet and other resources, research your topic and complete the following questions. Two references are needed in this activity. To help get you started, check out the following helpful Internet sites:

   - http://inventors.about.com
   - www.enchantedlearning.com/ininventors
   - http://antiqueradio.org
   - www.tvhistory.tv
   - http://dir.yahoo.com/Reference/Encyclopedia
   - www.libraryspot.com/encyclopedias.htm

Questions Related to Your Topic. Answer the following questions related to your topic. If the information cannot be found, leave the line blank.

A. Name of the object, process, or system: ____

B. Who invented it? ____

C. In what year was it invented? ____

D. Why was it invented?____
____
____

E. Where was it invented? ____

F. Who was it developed for? Was it developed for business and industry, or consumers?
____
____

G. How did it improve life when it was invented?
____
____
____

H. When was it discontinued or when did it decline in popularity?
____
____

I. If discontinued, describe the next innovation related to the object, process, or system. For example, the reel-to-reel tape recorder was discontinued in the early 1970s because of the growing popularity of the cassette tape.
____
____
____

J. If discontinued, were there any negative consequences associated with the object, process, or system when it was in use? (For example, were people spending too much time on it, did it pose health concerns, etc.)
____
____
____

K. How does it work? Briefly describe the operation or other important facts related to your object, process, or system.
____
____
____
____
____
____

L. Two references are required in this activity. List them below:

1. ____
   ____
2. ____
   ____

M. If possible, find one or more advertisements related to your topic and print it.

3. After your research is completed, prepare a well-designed, one-page **Information Sheet**—a sheet that could be given to others so that they could learn about your topic. Your one-page information sheet must be typed and contain the following information about your object, process, or system:

   - A picture or drawing of the object, process, or system. If it is a process or system, you may show how it works.
   - When it was invented.
   - Who invented it.
   - Why it was invented.
   - How it impacted society.
   - Optional:
     - ❋ Interesting or "fun" facts related to the object, process, or system.
     - ❋ Advertising associated with the object, process, or system.

4. Share your Information Sheet with the class in a short (one to two minute) presentation to the class.

Chapter 2, Unit 2

Core Concepts of Technology

All inventions and innovations are influenced by the core concepts of technology. To understand many of the inventions and innovations found in the designed world, it is helpful to have a good understanding of the core concepts of technology. In this unit, students will be introduced to the core concepts of technology that include systems, resources, requirements, optimization and trade-offs, processes, and controls. Students will learn about common systems found in technology, and have an opportunity to explore systems and subsystems related to transportation and construction technologies.

Standards for Technological Literacy Standards Addressed in Unit 2

Unit 2 addresses *STL* standards as follows:

- **Standard 2** Students will develop an understanding of the core concepts of technology.
- **Standard 3** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.
- **Standard 14** Students will develop an understanding of and be able to select and use medical technologies.
- **Standard 15** Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.
- **Standard 16** Students will develop an understanding of and be able to select and use energy and power technologies.
- **Standard 17** Students will develop an understanding of and be able to select and use information and communication technologies.
- **Standard 18** Students will develop an understanding of and be able to select and use transportation technologies.
- **Standard 19** Students will develop an understanding of and be able to select and use manufacturing technologies.
- **Standard 20** Students will develop an understanding of and be able to select and use construction technologies.

Big Ideas

Core concepts of technology, including systems, resources, requirements, optimization and trade-offs, processes, and controls

Student Assessment Criteria – Core Concepts of Technology

Achievement Level / Sub-concept	Above Target 3	At Target 2	Below Target 1
Core Concepts of Technology	Can identify, explain, and distinguish between all the core concepts of technology.	Can identify and explain the core concepts of technology.	With assistance, can identify and explain the core concepts of technology.
Common Systems Found in Technology	Can identify, explain, and evaluate the common systems found in technology.	Can identify and explain the common systems found in technology.	With assistance, can identify and explain the common systems found in technology.
The Designed World	Can identify, explain, and discuss the technologies found in the designed world.	Can identify and explain the technologies found in the designed world.	With assistance, can identify and explain technologies found in the designed world.
Systems and Subsystems	Can identify, explain, and analyze the systems and subsystems in a selected technology.	Can identify and explain the systems and subsystems in a selected technology.	With assistance, can identify and explain the systems and subsystems in a selected technology.

Student Learning Experiences

Inventions and Innovations in the Designed World
Product Disassembly
Ding Dong!

As a set of learning experiences, the following *STL* content standards and corresponding benchmarks are addressed: **Standard 2**, Benchmarks M, N, O, P, Q, R, S, T, U, and V; **Standard 3**, Benchmarks D and E; **Standard 14**, Benchmark G; **Standard 15**, Benchmarks F and H; **Standard 16**, Benchmark F; **Standard 17**, Benchmark H; **Standard 18**, Benchmarks F and G; **Standard 19**, Benchmarks F and G; and **Standard 20**, Benchmarks G and I. However, if you choose to use only a specific activity, please refer to Appendix B to determine exactly which standards and benchmarks are being addressed by that learning experience. See **Appendix B** for a complete listing of the *STL* content standards.

Acceptable Evidence of Student Understanding

The items listed below reflect a set of tasks that students should be able to demonstrate as evidence that the standards have been met. This will require that a variety of learning experiences are completed and assessment is conducted throughout the unit.

1. For each category of the designed world, identify one or two major innovations and inventions.
2. Build a simple mechanical device. Describe its relation to the systems model and identify its common technological systems.
3. Disassemble a consumer product and discuss how its various components and systems relate to the core concepts of technology.
4. Identify the various systems found in a transportation vehicle or constructed building.

Special note: Please keep in mind that criteria must be developed to measure the evidence that students provide in demonstrating their levels of understanding—what are we looking for and how will we know it when we see it? For example, if students are asked to build a model, how will we know if it's a good one?

When considering achievement levels and helping students to understand how they might improve, it will be necessary to know what we mean by terms such as effectively, efficiently, adequately, creatively, thoughtfully, mostly, clearly, minimally, marginally, correctly, safely, systematically, randomly, logically, thoroughly, introspectively, insightfully, and meaningfully. (See **Appendix D, Acceptable Evidence Glossary**, for definitions.)

Unit 2 Overview

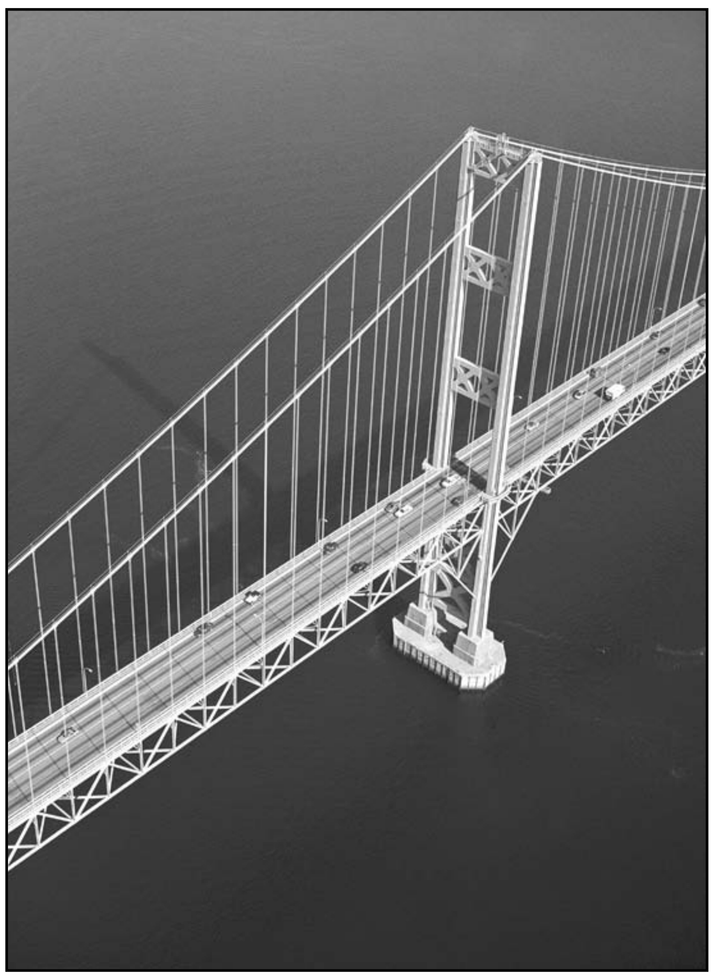
Begin this unit by explaining what is meant by the term "designed world." Humans live in three worlds, the natural world, the social world, and the designed world. The designed world consists of all the modifications that humans have made to the natural world to satisfy their own needs and wants. To help study the designed world, it is useful to break it up into "technology related categories." *Standards for Technological Literacy* (ITEA, 2000/2002) has divided the designed world into seven major categories that include medical technologies, agricultural and related biotechnologies, energy and power technologies, information and communication technologies, transportation technologies, manufacturing technologies, and construction technologies. Review each of these categories with students and have them identify inventions or innovations that occurred in that category. For example, an invention related to energy and power technology is "air conditioning" that helps keep people cool in the summer. The telephone is AN innovation related to information and communication technology that lets people walk around as they talk.

Discuss the impacts of various inventions and innovations that have occurred in the designed world. For example, without the invention of electricity (an energy and power technology), think how different life would be—it is hard to imagine. Explain that the invention of electricity involved considerations to the "core concepts" of technology. The core concepts of technology are those "essential ideas" that help bring the study and understanding of technology together. Review with students each of the core concepts of technology that include systems, resources, requirements, optimization and trade-off, processes, and controls.

A system is a group of interrelated components designed collectively to achieve a desired goal. Technological systems include input, process, output, and at times feedback. In a house's electrical wiring system, electricity is the input. In a simple incandescent lighting wiring circuit, the process of changing electricity to light occurs in the heating of the lightbulb's filament. The output of the system is light. If the light is "switched on" and there is no light, feedback is being provided that the lightbulb may be burned out or that there is no power.

Furthermore, there are typically many types of systems required in a technology. These systems often work together to make the technology work. Common systems found in a technology include mechanical, fluid, electrical, thermal, and chemical systems. For example, in an airplane, one would find all theses systems.

Students must learn to understand that systems are made up of related subsystems, and that technological systems often interact with one another. For example, a commercial building may contain many



subsystems, including waste disposal, water, electrical, structural, climate control, and communication. Very often these systems must interact. For example, the electrical system may provide electricity for the heating system, hot water system, and waste disposal system.

This unit should also introduce students to the concepts related to open-loop and closed-loop systems. An open-loop system has no feedback and requires human intervention. A closed-loop system uses feedback. For example, a home stereo system is an open-loop system—when it is playing too loud, a person will need to turn it down. An electrical timer connected to a house light is an example of a closed-loop system. The timer provides feedback to tell the light when to turn on and off.

All technological activities require resources, which are the "things" needed to get the job done. Basic technological resources include tools and machines, materials, information, energy, capital, time, and people. In this unit, it is appropriate to review with students basic power and hand tools as well as common materials. For example, the teacher could discuss and demonstrate with students the resources needed to install an electrical light in a house.

Most systems and products have requirements placed on them. These are the parameters often referred to as criteria and constraints. For example, safety is a requirement in most home electrical wiring systems around the world. A criteria of an American home electrical system is that most of it is wired to use consumer products that operate on 110-120 volts. A constraint placed on an American home electrical system is the type of electrical outlet that must be used. Discuss why different countries use different voltages and types of electrical outlets.

Optimization and trade-off must be considered in the design or development of any new product, process, or system. Optimization deals with making a product, process, or system as functional as possible. For example, a house wiring circuit should be made up of the optimal number of outlets. A trade-off involves a choice of exchange for one quality over another. In our house wiring example, there is a trade-off for wire gauge size versus number of outlets to install on the circuit. Discuss basic concepts associated with wire size and amperage.

Different technologies involve different sets of processes. A process is a systematic sequence of actions used to combine resources to produce an output. For example, students should learn that designing is the process of applying creative skills in the development of an invention or innovation. Other processes include maintenance, management, and assessment. When a system fails, troubleshooting is used. Discuss with students the requirements of maintaining a home or apartment and introduce students to the concepts of troubleshooting and experimentation. The final core concept of technology deals with controls. Controls are the mechanisms or activities that use information to cause a system to change. A light switch is an example of a control used in a simple home wiring circuit.

To help students learn about core concepts of technology and systems, students should study popular technologies with which they are familiar. For example, transportation and construction technologies can provide students with the opportunity to explore the systems and subsystems found in transportation vehicles (e.g., trucks, cars, trains, airplane, and motorcycles) and constructed buildings (e.g., home or commercial).

Unit 2 Content Outline

I. Designed World
- A. Medical technologies
- B. Agricultural and related biotechnologies
- C. Energy and power technologies
- D. Information and communication technologies
- E. Transportation technologies
- F. Manufacturing technologies
- G. Construction technologies

II. Core Concepts of Technology
- A. Systems
  1. Systems model: input, process, output, and feedback
  2. Open- and closed-loop systems
  3. Systems can be connected to other systems
  4. Different systems require different technologies
  5. System malfunctions
  6. System maintenance
- B. Resources
  1. Tools and machines
  2. Materials
  3. Information
  4. Energy
  5. Capital
  6. Time
  7. People
- C. Requirements
- D. Optimization and Trade-Offs
- E. Processes
- F. Controls

III. Common Systems Found in a Technology
- A. Mechanical
- B. Electrical
- C. Fluid
- D. Thermal
- E. Chemical

IV. Systems and Subsystems of the Transportation and Construction Technologies
- A. Transportation Vehicle Systems
  1. Structural
  2. Propulsion
  3. Suspension
  4. Guidance
  5. Control
  6. Support
- B. Construction Systems - Buildings
  1. Waste disposal
  2. Water
  3. Electrical
  4. Structural
  5. Climate Control
  6. Communication

Suggested Learning Activities

Inventions and Innovations in the Designed World

Time: 2-3 days

Teacher Preparation

In this activity, students will identify inventions and innovations that occur in the designed world. Before giving out this activity, review the major categories of the designed world and provide examples related to each category. After students complete the activity sheet, have a class discussion to review why students answered the way they did. Answers for this activity are as follows: (1) F, (2) C, (3) A, (4) G, (5) E, (6) D, (7) D, (8) C, (9) G, (10) F, (11) B, (12) C, (13) C, (14) F, (15) F, (16) A, (17) E, (18) B, (19) A, (20) B

Good resources for this activity include Roger Ridgman's (2002) *1000 Inventions and Discovers* book and the following Internet sites:

- www.infoplease.com/ipa/A0004637.html
- www.factmonster.com/ipka/A0004637.html
- www.loc.gov/exhibits/british/brit-5.html

Big Ideas Covered in this Activity

- Major categories of the designed world.
- Inventions and innovations and their relationships to the designed world.

Name: ______________________________
Date: ______________________________
Hour/Period: __________________________

Invention and Innovation

Chapter 2, Unit 2: Core Concepts of Technology

Student Activity #1

Inventions and Innovations in the Designed World

Introduction

Humans live in three worlds, the natural world, the social world, and the designed world. The designed world consists of all the modifications that humans have made to the natural world to satisfy their own needs and wants. To help you study the designed world, it is useful to break it up into "technology related categories." The major categories of the designed world, including examples of related products, processes, or systems, are as follows:

1. Medical technologies – vaccines, artificial limbs, wheelchairs, X-Ray machines, and genetic engineering.
2. Agricultural and related biotechnologies – artificial ecosystems, automatic milking machines, improved pesticides, and improved food storage processes.
3. Energy and power technologies – electricity, the internal combustion engine, portable generator, and energy conservation.
4. Information and communication technologies – television, radio, digital cameras, printing, the Internet, and magnetic waves.
5. Transportation technologies – planes, automobiles, guidance systems, and conveyor systems.
6. Manufacturing technologies – cutting, sawing, gluing, welding, durable goods, and mining.
7. Construction technologies – building codes, foundations, building materials such as bricks, glass, and wood, and subsystems in a building such as the water, electrical, and climate control systems.

Objectives

Upon successful completion of this activity, you should be able to:

- Name the major categories of the designed world.
- Identify selected inventions and innovations and their relationships to the designed world.

Connections

During this activity, you will be applying knowledge from the following areas:

- Science: science and technology, science as a human endeavor
- Language Arts: reading, evaluation, communication skills
- Social Sciences: history, economic institutions

Directions

There are many important inventions and innovations that have occurred in the designed world. For example, without the invention of electricity (an energy and power technology), think how different life would be—it's hard to imagine. Listed below are various inventions and innovations that have occurred in relation to the designed world. Match the invention or innovation listed to the designed world category that you feel it "best belongs in" and be able to defend your answer. Place the letter of the designed world category on the line next to the invention or innovation shown.

Designed World Categories

A. Medical technologies
B. Energy and power technologies
C. Transportation technologies
D. Construction technologies.
E. Agricultural and related biotechnologies
F. Information and communication technologies
G. Manufacturing technologies

Inventions and Innovations

_____ 1. Internet

_____ 2. Space shuttle

_____ 3. X-ray machine

_____ 4. Plastic soft drink bottle

_____ 5. Genetically modified food

_____ 6. Space station

_____ 7. Concrete

_____ 8. Escalator

_____ 9. Kevlar

_____ 10. MP3 Player

_____ 11. Jet engine

_____ 12. Jet airplane

_____ 13. Suspension bridge

_____ 14. Television

_____ 15. Cell phone

_____ 16. Test-tube baby

_____ 17. Cloned sheep

_____ 18. Wind generator

_____ 19. Artificial leg

_____ 20. Nuclear power station

Time: 4-6 days

Teacher Preparation

In this activity, students will learn about the systems found in a consumer product and how they relate to the core concepts of technology. Each student (or group of students) will be required to take apart a consumer product and analyze its systems and subsystems. In this activity, students will learn about systems and subsystems. They will learn that systems have inputs, processes, outputs, and at times feedback. They also will learn the difference between closed-loop and open-loop systems. For this activity, obtain a collection of products (e.g., power tools, home appliances, children's toys, telephones, VCRs, etc.) that can be easily and safely disassembled. Furthermore, try to obtain products that consist of more than one "technological" system (e.g., the product contains mechanical and electrical systems inside). A good disassembly activity (Unit 2 - Dissecting a Telephone - Design) can be found in *The Life Cycle of Everyday Stuff* published by the National Science Teachers Association (www.nsta.org).

To "pique" students' interests about systems, have them visit or show them the Smarthome Internet site (www.smarthome.com) and take the "guided tour" (www.smarthome.com/gtour/guidedtour.html) that showcases many of their "high tech" home automation systems (e.g., a laser-guided parking system). Home automation systems can be as simple as remote control of a few lights or as advanced as a voice recognition system. Typical home automation systems can be controlled by a variety of devices, including the telephone, hand-held remote controls, wall mounted controllers, timed events, and temperature.

Optional Activity: Systems in a Building

Constructed buildings contain a variety of systems and subsystems. In this activity, students will have the opportunity to learn about the various systems contained in a building. Develop a check sheet where students have to explore a building (e.g., a school building) or home and identify all the systems in the home. Typical home and building systems include: waste disposal, water, electrical, structural, climate control, and communication.

Big Ideas Covered in this Activity

- Most products contain one or more systems.
- Technological systems have some type of input, process, output, and feedback associated with them.
- There are "different types" of systems (e.g., mechanical, electrical, etc.), each having their own unique properties, and often they interact with one another.
- Open-loop and closed-loop systems.

Name: ______________________________
Date: ______________________________
Hour/Period: __________________________

Invention and Innovation

Chapter 2, Unit 2: Core Concepts of Technology

Student Activity #2

Product Disassembly

Introduction

Did you ever wonder "what's inside something?" What's inside your stereo, telephone, old VCR, or even lawnmower engine? In this activity, you will work in small groups to "take apart" a consumer product to learn about what's inside.

Inside most products, there are systems and subsystems (smaller systems that are part of a larger system) that work together. A "system" is a group of interrelated components designed collectively to achieve a desired goal. For example, the automobile is a type of "transportation system" that takes us places. The automobile is made up of dozens of "technological" subsystems, such as the fuel system, cooling system, brake system, exhaust system, and sound system that lets you listen to your favorite tunes.

Most technological systems have some type of input, process, output, and feedback associated to it. For example, in your automobile's sound system, the "input" could be your favorite CD, the "process" would involve the car's compact disc player playing the music, the "output" would be heard on the speakers, and possible "feedback" could come from your mom telling you to turn the stereo's sound down.

Furthermore, there are "different types" of systems, each having its own unique properties, and often interacting with one another. Common technological systems and subsystems may be based on mechanical, pneumatic (air), hydraulic, electrical, thermal, and chemical properties. For example, an electrical system found in a house may provide electricity for the heating system, hot water system, and waste disposal system.

Finally, systems can be either "open-loop" or "closed-loop." An open-loop system has no feedback and requires human intervention. A closed-loop system uses feedback. For example, a home stereo system is an open-loop system—when it is playing too loud, a person will need to turn it down. An electrical timer connected to a house light is an example of closed-loop system. The timer provides feedback to tell the light when to turn on and off.

Objectives

Upon successful completion of this activity, you should be able to:

- Disassemble a common product and identify the common systems and subsystems found inside.
- Discuss a system and its input, process, output, and feedback.
- Identify common types of "systems" (e.g., mechanical, electrical, etc.) found in technological products.
- Explain the difference between an open-loop and closed-loop system.

Connections

During this activity, you will be applying knowledge from the following areas:

- Science: properties, motions and forces, transfer of energy
- Language Arts: communication skills, developing research skills

Procedures

1. Break into small groups (3-4 students) and obtain a product to "take apart."

   List the name of your product: ____

2. Obtain the "tools and equipment" needed to take apart your product. List below the tools and equipment that will be needed to take apart your product.

   ____
   ____

3. Take apart your product. Check to see if your product contains any of the following systems. Place a "check" next to the systems found in your product.

   _____ Mechanical _____ Hydraulic _____ Pneumatic (air)

   _____ Electrical _____ Chemical _____ Thermal

4. As you disassemble the product, use the "Product Disassembly Worksheet" to try and identify the various systems (name them as best as you can), describe the purpose of the system, and name the materials used in the system. For example, if you took apart a VCR, you might find: "tape system" that "pulls the videotape in" and is made using "plastic gears and metal."

5. As you take apart the product, try to name the inputs, processes, outputs, and feedback loops associated with the various systems.

6. After your product has been taken completely apart and analyzed, share what you found with the class in a short presentation.

Product Disassembly Worksheet

System	Purpose of System	Material Used in the System

Time: 3-5 days

Teacher Preparation

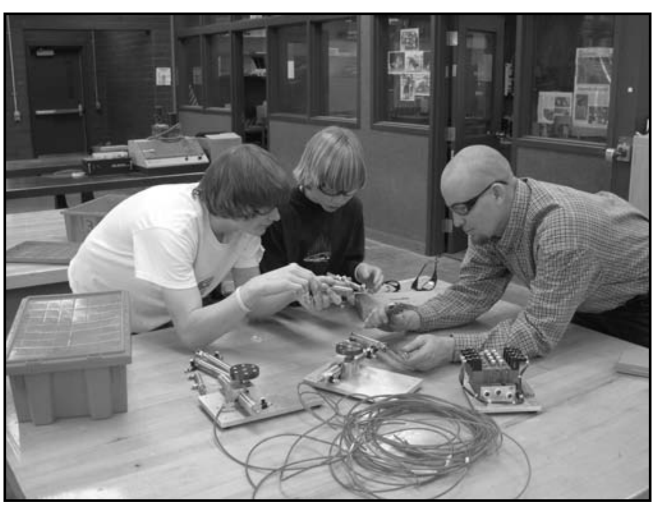
In this activity, small groups of students (2-3 students) will build a simple "low voltage" doorbell circuit—a subsystem commonly found in homes. After completion of the activity, a discussion should follow on the relationship of the system to each of the core concepts of technology. Resources required in this activity include: a doorbell, a doorbell button or switch, a transformer, wiring (18 AWG), and appropriate tools and equipment that may include a screwdriver, wire-stripper, wire nuts, and voltage checker. For this activity, teachers are encouraged to download the free lesson plan "Two Button Doorbell Circuit" that is available at www.ieee.org/organizations/eab/precollege. Free lesson plans can be found in the "Teacher In-Service Program" section.

Other helpful Internet sites related to installing a doorbell include:

- http://electrical.aubuchon hardware.com/do_it_yourself _projects/how_to_install_a_ doorbell_buzzer_or_ chime.asp
- http://doityourself.com/ electric/installdoorbell.htm
- www.electrical-online.com/ howtoarticles/doorbells.htm

The *Ding Dong – A Doorbell System* activity involves electricity, a very important resource used in many systems. To have students learn about electricity, use the Internet as a resource. To ensure that students review the material on the Internet, develop an evaluation sheet they must complete as they review the site. There are many excellent sites on the Internet that cover the basics of electricity. For example, excellent information can be found at *How Stuff Works* (www.howstuffworks.com), Teachers (http:// teacher.scholastic.com), and Tech Topics (www.thetech.org/exhibits/ online/topics).

An alternative to the *Ding Dong – A Doorbell System* activity is to have students "Build a Simple System" from a kit of components. In this activity, small groups of students should have the opportunity to learn about all the types of systems found in technology (i.e., mechanical, electrical, fluid, thermal, chemical, and electrical). In this activity, the teacher should develop or purchase "system kits" that can be given to a group of students to complete. After completion of their systems, each group will report on the system they built. The "kits" should require students work with two or more technological systems. Many types of "system kits are available from such companies as Kelvin (www.kelvin.com), and Pitsco (http://pitsco.com). To learn more about systems, students can explore the Internet site *How Stuff Works* (www.howstuffworks.com) that explains many types of common systems. As students explore an Internet site, they should be required to complete a worksheet that evaluates their comprehension of the material being presented.



Another alternative to the *Ding Dong – A Doorbell System* activity, it to have students assemble an electronic kit. Information about this and other activities can be found in the *Human Innovating Technology Series* (HITS) that is available from the International Technology Education Association (www.iteawww.org).

Big Ideas Covered in this Activity

- The core concepts of technology include systems, resources, requirements, optimization and trade-off, processes, and controls.
- A system is a group of interrelated components designed to collectively achieve a desired result.

Name: ______________________________
Date: ______________________________
Hour/Period: ________________________

Invention and Innovation
Chapter 2, Unit 2: Core Concepts of Technology

Student Activity #3

Ding Dong - A Doorbell System!

Introduction
The core concepts of technology are those "essential ideas" that help bring the study and understanding of technology together. The core concepts of technology include *systems, resources, requirements, optimization and trade-off, processes,* and *controls.*

A "system" is a group of interrelated components designed to collectively achieve a desired result. The "doorbell" is a simple type of system found in most homes and apartments to alert the occupants that someone is at the door. In this activity, you will work in small groups to build a single or double doorbell system. The "doorbell system" can more accurately be described as a "doorbell circuit" because electrical current is being used in the system. A system that is made up of electrical elements where an electrical current flows in a complete path is called a *circuit.*

There are many types of doorbell systems. For example, there are circuits with single doorbell systems for one door, or two button systems for two different doors. There are also "wireless doorbell systems" that require no wiring or cables. A typical wireless system will consist of a ringer button and remote chime unit. When the button is pressed, "radio waves" will be sent to make the bell ring.

The doorbell is a "technology" that alerts people that someone is at the door. The doorbell circuit completed in this activity relates to these core concepts of technology. The circuit is a *system* of components. It requires the *resource* of electrical energy to make it work. It has *requirements.* For example, it requires "low voltage" to operate correctly. It could involve a *trade-off*—instead of a low voltage doorbell circuit, a wireless doorbell system may be better suited to the job. It also has a set of *processes* that need to be followed in order for it to operate correctly. Finally it has *controls*; for example, the "switches" that make it operate.

Objectives
Upon successful completion of this activity, you should be able to:
- Define the term system.
- Build a simple doorbell circuit.
- Give examples of the core concepts of technology.

Connections

During this activity, you will be applying knowledge from the following areas:

- Mathematics: measurement
- Science: motions and forces, transfer of energy
- Language Arts: reading, communication skills

Procedures

1. In this activity, you will work in small groups (2-3 students) to build a doorbell system. A simple doorbell system has three main parts:
   - Doorbell: This is the sound device. There are many types of sound devices, from simple "ringer" bells to devices that have multiple chimes.
   - Button (or switch): When pressed, the button activates or energizes the system to make the bell ring.
   - Transformer: In a house, the voltage that powers the lights and most small appliances is between 110-120 volts. Doorbells systems typically operate on lower voltages (6-24 volts). To convert higher voltages to lower voltages, a transformer is used.

2. Obtain all the tools and materials needed in this activity. Materials and tools required for this activity may include the doorbell, transformer, switches, wire, screwdriver, and wire cutter.

3. Your teacher will assign you a type doorbell system (e.g., a single or double switch) to make. Before making your doorbell systems, draw a schematic (drawing) of how all the parts go together. Label all the components and show your completed drawing to the teacher before assembling your circuit.

4. Assemble your doorbell system and show it to the teacher. DO NOT PLUG THE TRANSFORMER IN UNTIL YOUR SYSTEM HAS BEEN APPROVED BY THE TEACHER. After the teacher has "approved" your circuit, test the system.

5. Identify the following in your doorbell system:
   A. Input: ______________________________
   B. Processes: ____________________________
   C. Output: ______________________________

6. Is your doorbell circuit an "open-loop" or "closed-loop" system? Explain your answer.

7. After your doorbell system has been approved by the teacher, plug in the transformer and test the circuit.

Chapter 2, Unit 3

Problem Solving: Design, Troubleshooting, Research and Development, and Experimentation

Design is regarded by many as the most significant problem-solving process of technological development. It is very important in the development of any new product or system. Design is one type of problem-solving process. However, not all technological problems are design problems. Technology includes many other types of problems and different approaches to solve them, including troubleshooting, research and development, invention and innovation, and experimentation. In units one and four, students learn about invention and innovation. In this unit, students will have the opportunity to learn about design, troubleshooting, research and development, and experimentation.

Standards for Technological Literacy Standards Addressed in Unit 3

Unit 3 addresses *STL* standards as follows:

- **Standard 8** Students will develop an understanding of the attributes of design.
- **Standard 9** Students will develop an understanding of engineering design.
- **Standard 10** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.
- **Standard 12** Students will develop the abilities to use and maintain technological products and systems.

Big Ideas

Problem Solving: Design, Troubleshooting, Research and Development, and Experimentation

Student Assessment Criteria – Design, Troubleshooting, Research and Development, and Experimentation

Achievement Level / Sub-concept	Above Target 3	At Target 2	Below Target 1
Engineering Design Process	Can identify, explain, and evaluate the use of the engineering design process.	Can identify and explain the use of the engineering design process.	With assistance, can identify and explain the use of the engineering design process.
Trouble-shooting Process	Can explain, apply, and evaluate the troubleshooting process in new situations.	Can explain and apply the troubleshooting process.	With assistance, can explain and apply the troubleshooting process.
Research and Development Process	Can identify, explain, and evaluate the use of the research and development process.	Can identify and explain the use of the research and development process.	With assistance, can identify and explain the use of the research and development process.
Experimental Design Process	Can explain, apply, and evaluate the experimental design process in new situations.	Can explain and apply the experimental design process in assigned situations.	With assistance, can explain and apply the experimental design process in assigned situations.

Student Learning Experiences

The Engineering Design Process
Troubleshooting
Experimentation

As a set of learning experiences, the following *STL* content standards and corresponding benchmarks are addressed: **Standard 8**, Benchmarks E, F, and G; **Standard 9**, Benchmarks F, G, and H; **Standard 10**, Benchmarks F, G, H, and I; and **Standard 12**, Benchmarks H, I, J, and K. However, if you choose to use only a specific activity, please refer to Appendix B to determine exactly which standards and benchmarks are being addressed by that learning experience. See **Appendix B** for a complete listing of the *STL* content standards.

Acceptable Evidence of Student Understanding

The items listed below reflect a set of tasks that students should be able to demonstrate as evidence that the standards have been met. This will require that a variety of learning experiences are completed and assessment is conducted throughout the unit.

1. Discuss the many interpretations associated with the word design.
2. Describe the elements associated with the engineering design process.
3. Use appropriate resources to troubleshoot a product or system.
4. Apply the scientific method in an experiment.

Special note: Please keep in mind that criteria must be developed to measure the evidence that students provide in demonstrating their levels of understanding—what are we looking for and how will we know it when we see it? For example, if students are asked to build a model, how will we know if it's a good one?

When considering achievement levels and helping students to understand how they might improve, it will be necessary to know what we mean by terms such as effectively, efficiently, adequately, creatively, thoughtfully, mostly, clearly, minimally, marginally, correctly, safely, systematically, randomly, logically, thoroughly, introspectively, insightfully, and meaningfully. (See **Appendix D, Acceptable Evidence Glossary**, for definitions.)

Unit 3 Overview

Farmers in Idaho want better ways to clean their potatoes harvested from the ground. They need a new product or system to help them clean potatoes. To help them solve their problem, a designer will need to use a design process. Design is the first step in making a product or system. In this unit, students should learn about the meaning of design and the steps required in engineering design.

Begin this unit by showing students the video *The Deep Dive* (available from ABC News Store, www.abcnewsstore.com). This video documents the processes designers go through in the development of a new product. In this video, a design team is given a problem that involves taking something old and familiar (i.e., the shopping cart) and completely redesigning it in just five days. After the video, discuss with the class the role of design in the making of new products. Ask the students questions such as: Why was the video called the Deep Dive? What do designers do in the video? How were invention and innovation defined in the video? What made up a design team in the video?

Explain to students that the word "design" has many meanings and is used in various contexts. For example, design can refer to how something is made (i.e., designed), it can deal with design principles (i.e., rules regarding rhythm, balance, proportion, emphasis, etc.), it can refer to drawing or sketching (e.g., a designed set of house plans), or it can refer to a problem-solving approach. In this unit, design will refer to a problem-solving approach.

Make sure that students understand that design is a creative planning process that leads to useful products and systems. The design process is a systematic problem-solving process, with criteria and constraints, used to develop many possible solutions to solve a problem or satisfy human needs and wants and to narrow down the possible solutions to one final choice. In this unit, students must learn the engineering design process. One very popular type of design (problem-solving) approach used to solve technological problems is referred to as *Technological* or *Engineering Design Process*. The engineering design process has many variations, but basically it includes:

- Identifying/defining a problem
- Generating ideas to solve the problem
- Selecting a solution
- Testing the solution(s)
- Evaluating the solution
- Communicating the solution

Students should learn that engineering design is a major type of problem-solving process, but it is not the only one. Invention and innovation are creative ways to solve problems. Other approaches to solving technological problems include troubleshooting, research and development, and experimentation.

Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system. Troubleshooting often requires specialized knowledge. This specialized knowledge would include knowing about how other systems or parts work, or a knowledge of how to use specialized materials and tools. For example, to check the voltage in a circuit, a person would need to know how to operate a volt-ohm-multimeter (VOM).

In this unit, students must be provided with opportunities to troubleshoot a product or system. They should be introduced to common tools, materials, equipment, and machines that are used to diagnose, adjust, and repair products and systems. They must learn the importance of using resources in the troubleshooting process. Common resources used in the troubleshooting process include manuals, protocols, and experienced people.

Research and Development (R&D) is a specific problem-solving approach that is used extensively in business and industry to prepare devices and systems for the marketplace. R&D is the practical application of scientific and engineering knowledge for discovering new knowledge about products, processes, and services, and then applying that knowledge to create new and improved products, processes, and services that fill market needs. For example, much research and development went into “car air bags” before automobile makers installed them into cars. Even after installation into cars, R&D continues on air bags as auto makers look for ways to prevent injuries caused by deployment of the air bags, and look for ways to protect passengers of all sizes and weight.

Some technological problems are best solved through experimentation. In this unit, students should be given the opportunity to perform a simple experiment. In experimentation, a test is typically done under controlled conditions to test an educated guess (i.e., a hypothesis) about something. It is a systematic process that also involves tinkering, observing, tweaking, testing and documentation. One very popular approach to experimentation used in science is the “scientific method.” This method is very similar to the engineering design process and can also be used in solving technological problems (e.g., why doesn’t the telephone work?). The basic steps of the scientific method include:

Step 1: Make observations.
Step 2: Form a hypothesis.
Step 3: Make a prediction.
Step 4: Perform an experiment.
Step 5: Analyze the results of the experiment.
Step 6: Draw a conclusion.
Step 7: Report your results.

Photo courtesy of Ronald D. Yuill.

Unit 3 Content Outline

I. **Design**
   A. How something is made
   B. Design principles
   C. A problem-solving approach

II. **Design - A Problem Solving Approach**
   A. A creative and systematic planning process
   B. Results in products and systems
   C. Is guided by criteria and constraints
   D. Examines many possible solutions

III. **Engineering Design**
   A. Identifying/defining a problem
   B. Generating ideas (e.g., brainstorming or conducting research) to solve the problem
   C. Selecting a Solution(s)
   D. Testing the Solution(s) – making models and prototypes if necessary
   E. Evaluating the solution – building the actual product or system to see if it "actually" works
   F. Communicating solution and design process with others

IV. **Troubleshooting**
   A. A method of problem-solving used to isolate and diagnose a malfunction
      1. Isolate the problem or malfunction (systems and subsystems)
      2. Identify possible causes
      3. Use resources to test causes
      4. Implement a solution to fix the problem
      5. Test the solution
   B. May require specialized knowledge
   C. Typically uses additional resources
      1. Manuals
      2. Experts
      3. Diagnostic tools, materials, and equipment

V. **Research and Development**
   A. Used in business and industry
   B. Application of science and engineering knowledge

VI. **Experimentation**
   A. The Scientific Method
      1. Make observations
      2. Form a hypothesis
      3. Make a prediction
      4. Perform an experiment in a controlled situation
      5. Analyze the results of the experiment
      6. Draw a conclusion
      7. Report the results

Suggested Learning Activities

The Engineering Design Process

Time: 2-3 days

Teacher Preparation

In this activity, students are going to watch the video entitled: *Harley Davidson Birth of the V-Rod* and complete the related questions. This entertaining video, available from the Discovery Channel (http://dsc.discovery.com), details the engineering design process. After completion of the video, the class will discuss the engineering design process used in the making of the Harley V-Rod and answer the questions on the activity sheet. To learn more about the Harley Davidson V-Rod, check out Harley's Web site at www.harley-davidson.com.

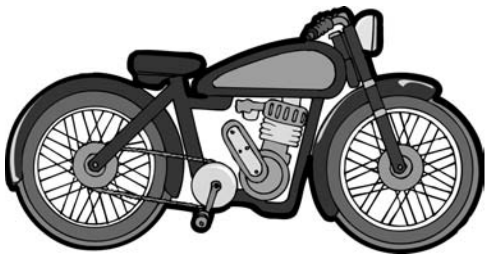
After watching the video, give students an "engineering design challenge." In this individual or small group activity, students will be given basic materials or an "engineering design kit" and be asked to design a simple product or system. The purpose of this activity is to teach students about many of the principles associated in the engineering design process. Simple products and/or systems that could be used in this activity include such things as a balloon-powered car, a mousetrap car, gliders, pop bottle rockets, etc. There are many commercial kits and resources available to teachers on this topic.

Check out the following sites for project ideas:

- Kelvin (www.kelvin.com)
- Pitsco (www.pitsco.com)
- by kids, for kids (www.bkfk.com)
- Future Scientists and Engineers of America (www.fsea.org)

Big Ideas Covered in this Activity

- The engineering design process.
- The research and development required in the development of a new product.



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Invention and Innovation

Chapter 2, Unit 3: Problem Solving: Design, Troubleshooting, Research and Development, and Experimentation

Student Activity #1

The Engineering Design Process

Introduction

The word *"design"* has many meanings and is used in various contexts. For example, design can refer to how something is made (i.e., designed), it can deal with design principles (i.e., rules regarding rhythm, balance, proportion, emphasis, etc.), it can refer to drawing or sketching (e.g., a designed set of house plans), or it can refer to a problem-solving approach. In this activity, it will refer to a "problem-solving approach."

The "design process" is a systematic problem-solving process, with criteria and constraints, used to develop many possible solutions to solve a problem or satisfy human needs and wants and to narrow down the possible solutions to one final choice. It is important to note that:

- Design is a creative process that leads to useful products and systems.
- There is no perfect design.
- Designs are influenced by criteria (e.g., purpose) and constraints (e.g., size and cost).

The **Engineering Design Process** is a problem-solving approach that has many variations, but basically includes:

- Identifying/Defining a problem
- Generating ideas (e.g., brainstorming or conducting research) to solve the problem
- Selecting a solution
- Testing the solution(s) (Making models and prototypes if necessary.)
- Evaluating the solution (Building it to see if it "actually" works)
- Communicating the solution and design process with others.

In this activity, you are going to watch the Discovery Channel's video entitled: *Harely Davidson Birth of the V-Rod.* In this video, you will learn about the engineering design process. After watching the video, you will be given a "design challenge" that will allow you to apply the engineering design process.

Objectives

Upon successful completion of this activity, you should be able to:

- Explain the major steps in the engineering design process.
- Apply the engineering design process in the making of a selected product.

Connections

During this activity, you will be applying knowledge from the following areas:

- Mathematics: numbers and operations, measuring
- Science: science and technology, properties, transfer of energy
- Language Arts: evaluation skills, research skills
- Social Sciences: marginal cost/benefit, role of incentives, markets, competition

Directions

1. Watch the video entitled: *Harley Davidson Birth of the V-Rod.* As you watch the video, answer the questions below. Your answers will be discussed in class.

   A. What was the problem Harley Davidson faced in this video?

   ____

   B. Did they use brainstorming in the making of the new V-Rod? YES NO

   C. List some examples of research they conducted as they tried to build the new V-Rod:

   ____

   ____

   D. List some problems they encountered in the making of the V-Rod prototype:

   ____

   ____

   E. What manufacturing process is used to form the V-Rod frame?

   ____

   F. How did they communicate the results of their new motorcycle?

   ____

   G. How long did it take to develop the new motorcycle? ___________________________________

2. Using an “Engineering Design Challenge Kit,” build your design project.

Time: 3-5 days

Teacher Preparation

In this activity, students will work in small groups (2-3 students) to fix an object or product that is not working. Begin this activity by reviewing the basics associated with troubleshooting. Provide students with a variety of simple objects and products (e.g., a computer printer, an object that needs to be recharged, an object that has a light burned out or a broken switch, etc.) that students can easily troubleshoot and fix. Obtain a variety of owner's manuals that have troubleshooting charts and review these with students. Obtain and demonstrate the use of simple tools and equipment (e.g., a continuity checker, VOM meter, etc.) used in troubleshooting situations. Make sure to stress the importance of SAFETY in this activity, especially if the object is electrical.

Before beginning this activity, provide students with a "simple" troubleshooting activity. For example, give students a variety of "broken" ball point pens (e.g., ink cartridge missing, spring missing, push button missing, wrong ink cartridges, etc.) that need to be fixed. Have students troubleshoot and fix the problem and share their problem and solution with the class.

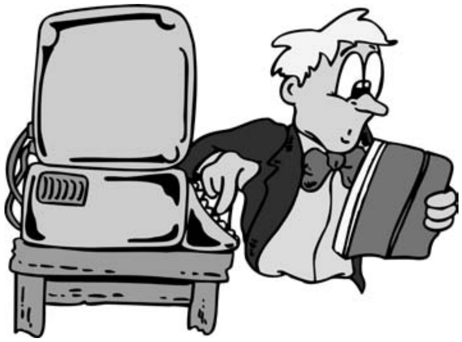
One product that seems to continually need troubleshooting is the computer and its related software programs. Use the Internet and software manuals to teach students about troubleshooting. There are many excellent resources on the Internet that review troubleshooting computers; for example:

- www.education-world.com/a_tech/techtorial/techtorialintro.shtml
- www.everythingcomputers.com/troubleg.htm
- www.findspot.com/troubleshooting-computers.htm
- http://a1computers.net/START.HTM

Big Ideas Covered in this Activity

- How to troubleshoot.
- Using an owner's manual to help in the troubleshooting process.

Photo courtesy of Alan G. Gomez.



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Invention and Innovation

Chapter 2, Unit 3: Problem Solving: Design, Troubleshooting, Research and Development, and Experimentation

Student Activity #2

Troubleshooting

Introduction

When an object or product does not work, you can "troubleshoot" it to find out what is wrong. Troubleshooting is a problem solving method used to identify the cause of a malfunction in a technological system. Troubleshooting often requires specialized knowledge. This specialized knowledge would include knowing about how other systems or parts work, or a knowledge on how to use specialized materials and tools. For example, to check the voltage in a circuit, a person would need to know how to operate a volt-ohm-multimeter (VOM). In this activity, you are going to practice troubleshooting some simple objects.

Troubleshooting Basics

When a product, for example an inkjet printer, has a problem, the owner's manual may contain a "troubleshooting" guide. Most guides will state the "situation," "possible problems," associated with that situation, and "possible solutions" to fix the problem. For example, you have an inkjet printer that has the "paper out" light flashing; however, there is paper in the printer. To fix the problem, you look at the troubleshooting guide below and use it to "troubleshoot" your problem.

Situation	*Possible Problems*	*Solutions*
Paper out light flashing	Paper jam	Clear paper jam
	Paper release lever in wrong position	Move the paper-release lever to the position that matches the paper loaded in the printer.

Objectives

Upon successful completion of this activity, you should be able to:

- Explain the basic procedures required in troubleshooting.
- Troubleshoot a product or device that is not working.

Connections

During this activity, you will be applying knowledge from the following areas:

- Mathematics: measurement, data analysis
- Science: properties, motions and forces
- Language Arts: reading for perspective, evaluating data, research skills, communication skills

Directions

1. Working in small groups, obtain an object or device that is not working.

   List the name of your object: ____

2. List the problem (situation) associated with your object: _____________________________________

   ____

3. List the resources (for example, an owner's manual, tools, equipment, etc.) needed to

   troubleshoot the problem: ____

   ____

4. Troubleshoot the problem and complete the following chart.

Possible Problems	*Solutions*
________________________________	______________________________________
________________________________	______________________________________
________________________________	______________________________________
________________________________	______________________________________
________________________________	______________________________________
________________________________	______________________________________
________________________________	______________________________________

5. What was the solution you used to fix the problem associated with your object?

   ____

   ____

Time: 4-6 days

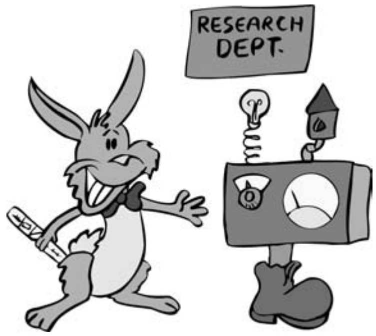
Teacher Preparation

How long does a battery last before it wears out? Which paper towel soaks up the most water? In this activity, students will use the scientific method as they conduct simple experiments in a controlled situation. As they conduct their experiments, students should be required to keep a scientific journal (i.e., a journal that lists such items as the problem to be solved, hypotheses, experimental procedures, and results of the experiment). To get students interested in the scientific method, introduce them to the "TWINKIES" experiments at www.twinkiesproject.com. There are numerous resources that deal with the scientific method. Helpful sites include:

- www.howe.k12.ok.us/~jimaskew/hsimeth.htm
- www.isd77.k12.mn.us/resources/cf/ExmSciProj.html
- www.scientificmethod.com/
- http://biology.clc.uc.edu/courses/bio104/sci_meth.htm

Big Ideas Covered in this Activity

- The scientific method.



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Invention and Innovation

Chapter 2, Unit 3: Problem Solving: Design, Troubleshooting, Research and Development, and Experimentation

Student Activity #3

Experimentation

Introduction
How long does a battery last before it wears out? Which paper towel soaks up the most water? Does a 1000 hour light bulb really last for 1000 hours? To solve some "technological problems" requires the use of a problem-solving method called "experimentation." Experimentation, often used by scientists, involves testing something under controlled conditions. In this activity, you will work in small groups to conduct an "experiment" on a selected topic.

Experimentation closely resembles the "scientific method." The scientific method is a type of problem-solving process that requires an established set of procedures. The scientific method is the "tool" that scientists use to find the answers to questions. It is the process of thinking through the possible solutions to a problem and testing each possibility to find the best solution. The scientific method typically involves the following steps:
- Doing research (observing some aspect of the universe)
- Identifying the problem
- Stating a hypothesis
- Conducting project experimentation
- Reaching a conclusion

As you conduct your experiment, you will be required to keep a "scientific journal." A scientific journal will contain a record of your experiment.

Objectives
Upon successful completion of this activity, you should be able to:
- Explain the steps required to troubleshoot an object.

Connections
During this activity, you will be applying knowledge from the following areas:
- Mathematics: measurements, data analysis and probability
- Science: scientific inquiry, science and technology
- Language Arts: reading, evaluation, communication skills

Experimentation Procedures

1. INITIAL OBSERVATION
   You notice something, and wonder why it happens. You see something and wonder what causes it. You want to know how or why something works. Every day in our lives we use a variety of products. Often, we hear advertisements from manufacturers claiming that their products are the best. Did you every wonder if these claims are really true? Do you ever wonder about the products you use, if they are really the best for the job? For example, is one AA battery better then another AA battery? Through experimentation, you can answer these questions. Label a page in your scientific journal INITIAL OBSERVATION and list at least three experimental ideas that your group would like to investigate. Share your ideas with the class, and in your group choose “one” idea to test using experimentation.

2. INFORMATION GATHERING
   Find out more about what you want to investigate. Read books, magazines, search the Internet, or ask others who might know in order to learn about the area you want to investigate. Label a page in your scientific journal INFORMATION GATHERING and list three resources you used to find out more about your idea.

3. TITLE THE PROJECT
   Choose a title that describes the effect or thing you are investigating. The title should summarize what the investigation will deal with. Place the title on the first page of your scientific journal.

4. STATE THE PURPOSE OF THE PROJECT
   What do you want to find out in this experiment? Write a statement that describes what you want to do. Label a page in your scientific journal PURPOSE OF THE PROJECT and write the purpose of experiment.

5. MAKE HYPOTHESES
   Hypotheses are educated guesses. For example, you hypothesize that insulated cups keep liquids hotter than paper cups. To test your hypothesis, you make the statement in the form of a question. Questions can be tested. For example, a hypothesis might state: Do insulated cups keep water hotter than paper cups? Or another hypothesis might ask: Do more expensive 9-volt batteries last longer than inexpensive 9-volt batteries? Label a page in your scientific journal HYPOTHESES and write one or more hypotheses related to your experiment. Write your hypotheses in question form and keep in mind that they must be stated in a way that they can be tested by an experiment.

6. DESIGN AN EXPERIMENTAL PROCEDURE TO TEST YOUR HYPOTHESES
   Design an experiment to test each hypothesis. In the scientific journal, label a page EXPERIMENTAL PROCEDURES and make a step-by-step list of what you will do to answer the questions stated in the hypotheses. As you make your experimental procedures list, follow these guidelines:
   - Select only one thing to change in each experiment. Things that can be changed are called variables.
   - Change data that will help you test your hypothesis.
   - The procedure must tell how you will change this one thing.
   - The procedure must explain how you will measure the amount of change.
   - Each type of experiment needs a “control” for comparison so that you can see what the change actually did.

7. OBTAIN MATERIALS AND EQUIPMENT
   Label a page in the scientific journal MATERIALS AND EQUIPMENT and make a list of the things you will need to do the experiment. Obtain the materials and equipment needed to do the experiment.

8. DO THE EXPERIMENT AND RECORD THE DATA
Perform the experiment. As you do the experiment, record all data (e.g., numerical measurements) made on a page in your scientific journal titled DATA COLLECTION. Data can be recorded on such things as amounts used, how long something lasted, how long something took, etc. If you are not making any measurements, you probably are not doing an experiment.

9. RECORD YOUR OBSERVATIONS
In your scientific journal, label a page OBSERVATIONS and write down "observations" or any problems that you noticed during your experiment. Keep careful notes of everything you do and everything that happens. Observations are valuable when drawing conclusions, and useful for locating experimental errors.

10. CALCULATIONS
Label a page in your scientific journal CALCULATIONS and perform any math needed to turn the "raw" data recorded during the experiments into numbers you will use to make tables, graphs, or draw conclusions.

11. SUMMARIZE RESULTS
Label a page in your scientific journal RESULTS and summarize what happened in your experiment. This could be in the form of a table of numerical data or graphs. It could also be a written statement of what occurred during the experiments.

12. DRAW CONCLUSIONS
Label a page in your scientific journal CONCLUSIONS. Using the data and observations obtained in your experiment, state your conclusions based on your hypotheses. Were your hypotheses true or false? Summarize what happened in your experiment and share your results with the class.

Chapter 2, Unit 4

Let's Invent and Innovate!

We are all inventors and innovators. Invention and innovation starts with an idea. It may be an idea to improve something, or it may be a totally new idea that no one has ever thought of. How often do people think, "Why didn't I think of that?" when they see "cool" new innovations or inventions that have made life easier and have probably made the person who came up with the idea lots of money. In this unit, students will have the opportunity to innovate and invent.

Standards for Technological Literacy Standards Addressed in Unit 4

Unit 4 addresses *STL* standards as follows:

- **Standard 11** Students will develop the abilities to apply the design process.

Big Idea

Understanding of the design process.

Student Assessment Criteria – Let's Invent and Innovate!

Achievement Level / Sub-concept	Above Target 3	At Target 2	Below Target 1
Engineering Design Process	Can explain, apply, and evaluate the engineering design process in the creation of an invention or innovation.	Can explain and apply the engineering design process in the creation of an invention or innovation.	With assistance, can explain and apply the engineering design process in the creation of an invention or innovation.
Becoming and Inventor or Innovator	Can explain and synthesize what it takes to become an inventor or innovator.	Can explain the basics of what it takes to become an inventor or innovator.	With assistance, can explain what it takes to become and inventor or innovator.
The Inventor's Notebook	Prepares an "excellent" (e.g., professional, use of multimedia, all details covered in depth, etc.) quality notebook that documents the development of a new invention or innovation.	Prepares a "good" (e.g., neat looking, all details covered, etc.) quality notebook that documents the development of a new invention or innovation.	Prepares a "fair" (e.g., missing details, mistakes, etc.) quality notebook that documents the development of a new invention or innovation.
Protecting and Marketing an Invention or Innovation	Can explain, apply, and evaluate concepts and principles related to the patenting and marketing of inventions and innovations.	Can explain and apply concepts and principles related to the patenting and marketing of inventions and innovations.	With assistance, can explain and apply concepts and principles related to the patenting and marketing of inventions and innovations.

Student Learning Experiences

Cool Gadgets!
Rube Goldberg Challenge
Stuck on a Deserted Island

As a set of learning experiences, the following *STL* content standards and corresponding benchmarks are addressed: **Standard 11**, Benchmarks H, I, J, K, and L. However, if you choose to use only a specific activity, please refer to Appendix B to determine exactly which standards and benchmarks are being addressed by that learning experience. See **Appendix B** for a complete listing of the *STL* content standards.

Acceptable Evidence of Student Understanding

The items listed below reflect a set of tasks that students should be able to demonstrate as evidence that the standards have been met. This will require that a variety of learning experiences are completed and assessment is conducted throughout the unit.

1. Apply a design process in the invention or innovation of a product or system.
2. Safely use tools, materials, equipment, and other technology resources in the invention or innovation of a product or system.
3. Maintain an "inventor's notebook" (portfolio) that details an invention or innovation.

Special note: Please keep in mind that criteria must be developed to measure the evidence that students provide in demonstrating their levels of understanding—what are we looking for and how will we know it when we see it? For example, if students are asked to build a model, how will we know if it's a good one?

When considering achievement levels and helping students to understand how they might improve, it will be necessary to know what we mean by terms such as effectively, efficiently, adequately, creatively, thoughtfully, mostly, clearly, minimally, marginally, correctly, safely, systematically, randomly, logically, thoroughly, introspectively, insightfully, and meaningfully. (See **Appendix D, Acceptable Evidence Glossary**, for definitions.)

Unit 4 Overview

Begin this unit by discussing with students that all inventions typically start as someone's idea. It may be an idea on how to improve something (innovation), or how to make something that has been made before. Innovation is the process of modifying an existing product, process, or system or system to improve it. Invention is a process of turning ideas and imagination into new products, processes, or systems.

Remind students that before becoming an inventor or innovator, it is very helpful to have a good solid knowledge about technology, the core concepts of technology, and the problem-solving process.

In Unit one, students learned about the scope of technology, about how society influences technology and technology influences society, and the importance of studying the history of technology. In Unit two, students were introduced to the core concepts of technology, including systems, resources, requirements, optimization and trade-off, processes and controls. In unit three, students learned about different types of problem solving, including engineering design, troubleshooting, research and development, and experimentation. In this unit, tell students that they will get to use what they have previously learned as they invent or innovate a product, process, or system.

What does it take to be an inventor? In a website discussing the life of Thomas Edison, the Smithsonian Institution (1997) presents a section on *How to Invent* (www.si.edu/harcourt/nmah/lemel/edison/html/how_to_invent.html). In this section, they ask, "What are the main characteristics of inventors?" and discuss "some things to know about inventions," and "provide rules for inventing." Shown below is what they feel a person needs to know to become an inventor. Share this information in a class discussion.

What are the main characteristics of inventors?

- Inventors are curious about the world.
- Inventors generate many possible solutions to a problem, choose the best idea, and pursue it with determination until it works!
- Inventors constantly ask, "How does it work?" and "How could it work better?"

Some things to know about inventions:

- Many inventions are improvements on an existing invention.
- Creativity is the key to inventing.
- There are "rules" for inventing. **Rules for inventing:**
  - ➢ Think of something that is needed! Brainstorm!
  - ➢ Get involved, motivated, and enthusiastic – investigate the possibilities of your ideas.
  - ➢ Use the library and magazines, talk to people who can help you move your idea, and check out the World Wide Web.
  - ➢ Be innovative – map out lots of approaches, experiment, and daydream.
  - ➢ Be persistent – don't become discouraged easily, but be realistic.
  - ➢ Keep good records and notes of ideas, data, and results.
  - ➢ The final rule – Don't follow RULES!

Invention and innovation both represent an approach to solving a problem or meeting a need. In applying the engineering design process to innovate a product, process, or system, students will first need to identify a problem related to the product, process, or system. Next they will need to generate ideas and solutions to solve the problem, including specifying criteria and constraints related to their problem. After a solution has been selected, students will need to make two-dimensional (sketches) and/or three-dimensional representations (e.g., a prototype or model) of the designed solution. After the design has been completed, it will need to be tested and evaluated. Finally, students should be required to build the product, process, or system and document all their work in a portfolio.

In this unit, the teacher will want to show students how to safely use tools, materials, equipment and other technology resources that students may need to complete their activities. The teacher will also want to teach students some basic drawing and sketching techniques. If available, the teacher may want to introduce students to a basic computer-aided drafting/design software package.

An important component in this unit is that students properly document their innovations or inventions in an *Inventor's Notebook* (i.e., portfolio). Students must be shown the importance of this document. For example, in the legal world, an *Inventor's Notebook* must be kept so the inventor can establish intellectual property ownership. The United States grants the right to patent something to the first person who invents it. Therefore, inventors must keep good notes and dates to show that it is "really" their invention or innovation.

In this unit, students should be required to develop an *Inventor's Notebook* that contains both written and graphic representations, and be encouraged to use multimedia techniques as part of their notebook documentation or presentation. The notebook should document the progress and achievements of an individual or group in the completion of their innovation or invention. The notebook should document students' use of the design process. Items found in an *Inventor's Notebook* may include:

- The problem or challenge to be solved. The "need" for this invention or innovation.
- Brainstorming of possible solutions, including sketches.
- Research and other background information.
- Resources used.
- Solutions to design, materials, construction and testing problems.
- Daily log of meeting dates, written record of ideas, research, experiments, and tests.
- Pictures and drawings.

In this unit, discuss with students that after an invention or innovation is completed, the inventor may want to patent it. Explain to students the concept of patenting. A patent is a way of protecting an invention or innovation. It requires documentation that is filed with the U.S. patent office. The process can take a long time and be very expensive. Discuss with students that not every invention or innovation is patented, but some are kept secret, like the formula for Coca-Cola.

Share with students that many people innovate or invent as part of their job; for example, a car designer. However, there are other people whose goal of inventing or innovating is to make money. Regardless of the purpose, once an invention or innovation has been completed, it needs to be marketed. Marketing is a process that gets the invention or innovation to the people who want to buy it. Marketing involves much more than just selling. Marketing includes decisions about appearance, name, packaging, sales literature, and advertising.

In this unit, students are given opportunities to learn about the invention and innovation process. An excellent supplement to this unit is *The Inventive Thinking Curriculum Project.* This free resource is available from the United States Patent and Trademark Office (www.uspto.gov/web/offices/ac/ahrpa/opa/projxl/invthink/invthink.htm) and provides teachers with many helpful activities that can be used when teaching about invention and innovation.

In this unit, the culminating activity will have students working in small cooperative learning groups (i.e., three to four members) to build inventions and/or innovations needed for surviving on a deserted island. The activity will focus on all aspects of the inventive process, including developing an *Inventor's Notebook.* As Thomas Edison once quoted, *"Genius is one percent inspiration and ninety-nine percent perspiration. As a result, a genius is often a talented person who has simply done all of his homework."*

Unit 4 Content Outline

I. Becoming an Inventor or Innovator – Prerequisite Knowledge
- A. The meaning of invention and innovation
- B. The scope of technology
- C. Society influences technology and technology influences society
- D. The history of technology
- E. Core concepts of technology
- F. Problem solving

II. What Does it Take to be an Inventor or Innovator?
- A. Knowledge about the scope of technology
- B. Curiosity and a wandering mind
- C. Creative thinking – generating many ideas
- D. Perseverance – keep at it until it works
- E. Continual questioning – how, why, what if, how it can be made better, etc.

III. Invention and Innovation – Where do we Start? – With Ideas!
- A. Identify needs and wants
- B. Think about problems that need to be solved
- C. Think about ways to improve something
- D. Let your mind wander

IV. Inventor's Notebook
- A. The problem or challenge to be solved – why was there a need for this invention or innovation?
- B. Brainstorming of possible solutions, including sketches
- C. Research and other background information
- D. Resources used
- E. Solutions to design, materials, construction and testing problems
- F. Daily log of meeting dates, written record of ideas, research, experiments, and tests

V. The Invention and Innovation Process
- A. Apply a design process – for example, the engineering design process
  1. Identify and select a need or want or problem to solve
  2. Generate ideas to solve the problem or meet the need or want - specify criteria and constraints
  3. Select a solution – make two-dimensional (sketches) or three-dimensional representations of the designed solution
  4. Test the solution
  5. Evaluate the solution – does it solve the problem or meet the need or want? Does it meet established criteria and constraints?
  6. Communicate the solution – build a working model or prototype of the new invention or innovation. Document the work in a portfolio or journal.

VI. Protecting Your Invention or Innovation
- A. Patents – A patent is protection against the copying of your idea.
- B. Patents are filed with the U.S. patent office, and the process can take a long time and be very expensive.
- C. Not every invention or innovation is patented. Some are kept secret, like the formula for Coca-Cola.

VII. Marketing an Invention or Innovation
- A. To make money from an invention or innovation requires getting to the people who want to buy it; this is called marketing.
- B. Marketing is more than selling. It includes:
  1. Decisions about appearance
  2. Name
  3. Packaging
  4. Sales literature
  5. Advertising

Suggested Learning Activities

Cool Gadgets!

Time: 3-5 days

Teacher Preparation

The purpose of this activity is to get students thinking about "cool gadgets" that have been made to satisfy the needs or wants of consumers. Cool gadgets in this activity refer to new inventions or innovations found in the consumer marketplace. Today, there are many stores that sell "high-tech" toys and other innovative products. In this activity, students will identify a "cool gadget" and make a short oral presentation on it and be introduced to the concept of patents. The presentation must include a picture of the item (or an actual item), its cost, and a short discussion on why it was developed. Excellent sources for this activity include:

- Gadget Universe: www.gadgetuniverse.com
- The Space Store: www.thespacestore.com
- The Discovery Store: www.discovery.com
- The Sharper Image: www.sharperimage.com
- Hammacher Schlemmer: www.hammacher.com
- Brookstone: www.brookstone.com/world.asp

To get students "thinking" about inventions, get Steven Caney's (1985) *Invention Book*. In this book he presents stories of great inventions. At the conclusion of each short story, he provides a list of "fantasy inventions." Fantasy inventions contain ideas for related products that might be invented and show how one invention can be the inspiration for other new ideas. For example, after he presents the history of the invention of Levi's, he presents some related fantasy inventions such as "stick-on pockets" or "organic self-repairing cloth." To help students get inspired, present to them an invention, and then have them come up with at least five related fantasy inventions. This can be an individual, group, or entire class activity.

Big Ideas Covered in this Activity

- Inventions and innovations are developed to satisfy a need or want.
- Many inventions or innovations require creativity.
- Patents are a way of protecting an invention or innovation.

Name: ___________________________
Date: ___________________________
Hour/Period: ______________________

Invention and Innovation

Chapter 2, Unit 4: Lets Invent and Innovate

Student Activity #1

Cool Gadgets!

Introduction

Did you ever see something and say, "Wow that is cool, I wish I had one"? The purpose of this activity is to get you thinking about the new "cool gadgets" or "high-tech" toys that are available to consumers today. In this activity, you will identify a "cool gadget" and make a short presentation on it.

Did you know that most cool gadgets are patented? After an inventor invents or innovates something, he or she *patents* it. A patent is a way of protecting an invention or innovation so that someone else won't copy it and make money from it. A patent requires documentation that is filed with the U.S. patent office. The process can take a long time and be very expensive. However, not all inventions or innovations are patented. Some are kept secret, like the formula for Coca-Cola.

Objectives

Upon successful completion of this activity, you should be able to:
- Explain the major steps in the engineering design process.

Connections

During this activity, you will be applying knowledge from the following areas:
- Science: science and technology
- Language Arts: reading, understanding the human experience, applying knowledge, evaluation, communication skills, research skills
- Social Sciences: goods and services, market prices

Directions

1. Select a "cool gadget" to present. There are many stores that sell "high-tech" toys and other innovative products. Research and select a "cool gadget" on which to do an oral presentation. To help you in your research, obtain a variety of "innovative product catalogs" or visit one of the following Internet sites:
    - Gadget Universe: www.gadgetuniverse.com
    - The Space Store: www.thespacestore.com
    - The Discovery Store: www.discovery.com
    - The Sharper Image: www.sharperimage.com
    - Hammacher Schlemmer: www.hammacher.com
    - Brookstone: www.brookstone.com/world.asp

Write the name of the gadget you selected to present below:

____

2. Prepare an oral presentation on your selected gadget. To help you in your presentation, complete the following information related to your gadget.

   A. Name of gadget: ____

   B. Cost of gadget: ____

   C. Purpose of the gadget: ____

   ____

D. Your "thoughts" about the gadget. For example, is it a good gadget or a waste of money? Would you like to own one? What kind of people buy this gadget?

____

____

____

3. Can you find a "patent" number associated with your gadget? A patent is a way of protecting an invention or innovation. What holds U.S. Patent Number 4,500,000? Answer: Pad of plastic bags with support means. If you can find a patent number, you can find out more information at the U.S. Patent and Trademark Office. Try to find a patent number associated with your gadget, and do a patent search to find out more information about it. You can begin your patent search at the U.S. Patent and Trademark Office Kids' Pages at: www.uspto.gov/go/kids/kidsearch.html#juniordet.

   If you cannot find the patent number associated with your gadget, find a patent number on another product and check out its patent information. Write the number of the patent you searched.

   Patent Number Searched: ____

   Inventor's Name: ____

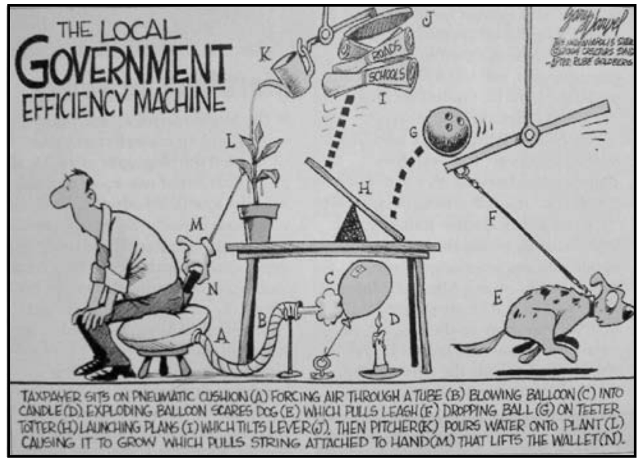
   Year Patented: ____

Time: 5-8 days

Teacher Preparation

Rube L. Goldberg (1883-1970) was a cartoonist who made fun of technology. In his cartoons, he showed difficult ways to achieve easy results. For example, it's easy to sharpen a pencil, but he made "fun of it" by showing it done in a protracted number of steps. He believed that there were two ways to do things: the simple way and the hard way, and that a surprising number of people preferred doing things the hard way. In this activity, students will be given a Rube Goldberg Challenge and asked to complete it. A Rube Goldberg challenge typically involves giving students a simple problem-solving task (e.g., put water in a cup, extinguish a candle, move a ping-pong ball, etc.) that must be made complex by requiring a minimum number of steps to complete the task.

Teachers are encouraged to develop their own Rube Goldberg "challenge kits" (e.g., using Legos) or they can purchase kits from numerous vendors including Kelvin (www.kelvin.com).



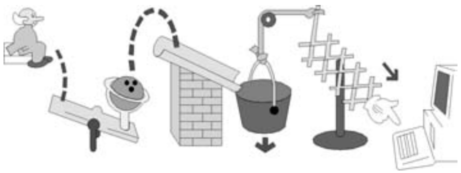
A book written and edited by Maynard Frank Wolfe and published by Simon & Schuster (ISBN 0-684-86724-9) includes a collection of Rube Goldberg's inventions, comic strips, editorial cartoons, and sketches along with a biography of Rube Goldberg. Also, there are numerous resources devoted to Rube Goldberg, including publications from the Technology Student Association (TSA). Helpful Internet sites include:

- www.rube-goldberg.com
- www.nycenet.edu/dis/mst/rube
- www.anl.gov/Careers/Education/rube

For fun, obtain the game "Mousetrap" by Milton Bradley and have students play it. It is an exciting game of mechanical gadgets and chain reactions that challenges kids to practice visual discrimination skills and follow a building plan.

Big Ideas Covered in this Activity

- Problem-solving
- Making an easy task difficult



Name: ______________________________
Date: ______________________________
Hour/Period: __________________________

Invention and Innovation

Chapter 2, Unit 4: Lets Invent and Innovate

Student Activity #2

Rube Goldberg Challenge

Introduction

Rube L. Goldberg (1883-1970) was a cartoonist who made fun of technology. In his cartoons, he showed difficult ways to achieve easy results. For example, it's easy to sharpen a pencil, but he made "fun of it" by showing it done in a number of steps. He believed that there were two ways to do things: the simple way and the "hard way," and that a surprising number of people preferred doing things the hard way. In this activity, you will be given a Rube Goldberg Challenge and asked to complete it.

Objectives

Upon successful completion of this activity, you should be able to:

- Explain who Rube Goldberg was and his thoughts about solving problems.
- Discuss the purpose of a Rube Goldberg Challenge.
- Use problem-solving skills in solving a Rube Goldberg Challenge.

Connections

During this activity, you will be applying knowledge from the following areas:

- Mathematics: numbers and operations, relations, measuring, probability
- Science: properties, motions and forces, transfer of energy, science and technology, science as a human endeavor
- Language Arts: communication skills, evaluation data, research skills
- Social Sciences: U.S. history

Directions

1. Working in small groups (3-4 students), you will be given a Rube Goldberg Challenge. For example, a Rube Golberg challenge could be: *Extinguish a candle in 10 or more steps.* Your Rube Goldberg Challenge is:

   ____

   In _______________ steps or more.

2. Compete your Rube Goldberg Challenge.

3. Share your completed Rube Goldberg Challenge with the class.

Stuck on a Deserted Island

Time: 16-23 days

Teacher Preparation

In this activity, small groups (four to six students) are stuck on a deserted tropical island after their boat crashes into the island. Their challenge is to survive. They must invent or innovate things to help them survive. Inventions and innovations required on the island may include such things as ways to trap food, cook food, grow food, warm water, or send messages. In this activity, students will apply the design process as they invent or innovate ways to survive and record all of their activities in a design portfolio.

In this activity, teachers will need to develop a "resource list" of the resources that are available to students on the deserted island. Examples of resources that were on the boat or can be found on the island include: hand tools, scissors, tin cans, plastic containers (e.g., milk jugs) cup, rope, string, wood, rocks, sand, batteries, flashlights, wire, fasteners, tape, cooking utensils, etc.

Teachers are encouraged to use materials for this activity based on PBS's Rough Science television show (www.pbs.org/weta/roughscience). "Rough Science" is the thinking person's reality show. The series takes a group of highly skilled scientists, drops them in a remote location and presents them with a series of challenges, all designed to test the practical side of their disciplines. At the "Rough Science" Web site, it is recommended that teachers download the free "Rough Science Adventures Activities Guide" and other useful resources (www.pbs.org/weta/roughscience/discover). The activities selected for inclusion in the guidebook are like the television series. The activities have an island theme. They have been grouped into eight scenarios: Water Quality Control Center, Weather Station, Island Power Plant, Island Observatory, Island Restaurant, Tropical Island Day Spa, and Tropical Island Party.

Another good resource can be found at the "Sites Alive" Web site (www.sitesalive.com) where they offer an "island survival" lesson plan for teachers (www.sitesalive.com/oil/tg/private/oiltgsurvival.pdf).

To get students started thinking about this activity, have them look through *The Worst-Case Scenario Survival Handbook: Travel*. Or for fun, have students watch old episodes of *Gilligan's Island* (that can now be purchased on DVD) and report on the innovations and inventions that the castaways used on the island.

Optional: Island Video. In this activity, each group of students will be required to make a video, detailing their inventions or innovations they made for the island. Students should be required to develop a script or storyboard for their video and, if available, students should be required to edit their video (e.g., using Apple's iMovie software).

Big Ideas Covered in this Activity

- The inventing and/or innovating of products, processes, and systems for survival in a deserted island
- Problem solving in teams

Name: ______________________________
Date: ______________________________
Hour/Period: ___________________________

Invention and Innovation
Chapter 2, Unit 4: Lets Invent and Innovate

Student Activity #3

Stuck on a Deserted Island

Introduction
You and your group of friends "crash" your boat on a small deserted island—what will it take to survive? In this activity, you will work in small groups and be required to use your problem solving skills to invent or innovate things that will help you to survive on the deserted island. Also in this activity, you will be required to document your inventions or innovations in an *Inventor's Notebook.*

Objectives
Upon successful completion of this activity, you should be able to:
- Use the problem-solving process to develop one or more products or systems to help you survive on a deserted island.
- Prepare a "portfolio" detailing your inventions or innovations created on the deserted island.
- Successfully work in teams to reach desired goals.

Connections
During this activity, you will be applying knowledge from the following areas:
- Mathematics: numbers and operations, measuring, data analysis, and probability
- Science: life science, science and technology, technological design, personal health, environments, natural hazards
- Language Arts: reading, evaluation, communication skills, applying knowledge, evaluating data, research skills
- Social Sciences: roles of the citizen, U.S. history, scarcity, incentives

Directions
1. Divide into small "island survivor groups."

2. The "basics" needed to survive on an island include water, food, and shelter. Your group will be assigned to one of these basic necessities.

   Your group's basic necessity relates to: ____

3. The teacher will provide you with a list of some "resources" that are available on the island. Obtain and study this list.

4. Identify "objects, processes, or systems" related to your "basic necessity" that may need to be developed in order to survive on the island. For example, if your group has been assigned to the basic necessity of *water,* your group may have to invent a water transportation system, develop a way to heat water, or even a way to purify water. If your group has been assigned to the basic necessity of *food,* your group may need to develop ways to trap food, cook food, or grow food. List below five "objects, processes, or systems" related to your "basic necessity" that may need to be developed in order to survive on the island. Discuss this list with your class or teacher for their suggestions.

   A. ____

   B. ____

   C. ____

   D. ____

   E. ____

5. Choose one or more of the objects, processes, or systems above and use the problem-solving process to "build" a new invention or innovation that can help you survive on the deserted island.

6. As you build your new inventions or innovations, keep a record of them in an *Inventor's Notebook*. Your notebook could include the following:
   - The problem or challenge to be solved.
   - The "need" for this invention or innovation.
   - Possible solutions or ideas to solve the problem.
   - Sketches, drawings, and pictures.
   - Resources and other materials used to solve the problem.
   - Evaluation and testing of solutions.

7. Share your inventions and innovations with the class.

Chapter 2, Unit 5

Impacts of Invention and Innovation

What inventions or innovations have impacted our lives the most? Could we live without automobiles, television, or computers? How about electricity or medicine? Do we really need nuclear power and clean water? In this unit, students will have opportunities to assess how innovations and inventions have impacted their lives, especially those innovations and inventions related to medical technologies, and agricultural and related biotechnologies.

Standards for Technological Literacy Standards Addressed in Unit 5

Unit 5 addresses *STL* standards as follows:

- **Standard 4** Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- **Standard 5** Students will develop an understanding of the effects of technology on the environment.
- **Standard 13** Students will develop the abilities to assess the impact of products and systems.
- **Standard 14** Students will develop an understanding of and be able to select and use medical technologies.
- **Standard 15** Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.

Big Idea

The ability to assess the impacts of inventions and innovations.

Student Assessment Criteria – Impacts of Invention and Innovation

Achievement Level / Sub-concept	Above Target 3	At Target 2	Below Target 1
Impacts of Inventions and Innovations on Humans	Can describe (e.g., give examples), analyze, and evaluate the impacts that inventions and innovations have had on humans.	Can describe (e.g., give examples) and analyze the impacts that inventions and innovations have had on humans.	With assistance, can describe (e.g., give examples) and analyze the impacts that inventions and innovations have had on humans.
Impacts of Inventions and Innovations on Society	Can describe (e.g., give examples), analyze, and evaluate the impacts that inventions and innovations have had on society.	Can describe (e.g., give examples) and analyze the impacts that inventions and innovations have had on society.	With assistance, can describe (e.g., give examples) and analyze the impacts that inventions and innovations have had on society.
Impacts of Inventions and Innovations on the Environment	Can describe (e.g., give examples), analyze, and evaluate the impacts that inventions and innovations have had on the environment.	Can describe (e.g., give examples) and analyze the impacts that inventions and innovations have had on the environment.	With assistance, can describe (e.g., give examples) and analyze the impacts that inventions and innovations have had on the environment.
Data Collection	Can obtain, explain, and evaluate data used to assess impacts of innovation and invention.	Can obtain and explain data used to assess impacts of innovation and invention.	With assistance, can obtain and explain data that is used to assess the impacts of innovation and invention.

Student Learning Experiences

Soda Pop

Where Does the Trash Go?

As a set of learning experiences, the following *STL* content standards and corresponding benchmarks are addressed: **Standard 4**, Benchmarks D, E, F, and G; **Standard 5**, Benchmarks D, E, and F; **Standard 13**, Benchmarks F, G, H, and I; **Standard 14**, Benchmark G; and **Standard 15**, Benchmarks F and G. However, if you choose to use only a specific activity, please refer to Appendix B to determine exactly which standards and benchmarks are being addressed by that learning experience. See **Appendix B** for a complete listing of the *STL* content standards.

Acceptable Evidence of Student Understanding

The items listed below reflect a set of tasks that students should be able to demonstrate as evidence that the standards have been met. This will require that a variety of learning experiences are completed and assessment is conducted throughout the unit.

1. Choose an invention or innovation and discuss how it has impacted society.
2. Describe important inventions or innovations in medical technologies, and agricultural and related biotechnologies that have impacted our lives.
3. Describe the life cycle of a product.
4. Discuss the importance of using data in making meaningful decisions.

Special note: Please keep in mind that criteria must be developed to measure the evidence that students provide in demonstrating their levels of understanding—what are we looking for and how will we know it when we see it? For example, if students are asked to build a model, how will we know if it's a good one?

When considering achievement levels and helping students to understand how they might improve, it will be necessary to know what we mean by terms such as effectively, efficiently, adequately, creatively, thoughtfully, mostly, clearly, minimally, marginally, correctly, safely, systematically, randomly, logically, thoroughly, introspectively, insightfully, and meaningfully. (See **Appendix D, Acceptable Evidence Glossary**, for definitions.)

Unit 5 Overview

Begin this unit by explaining that "technology" has provided us with many innovations and inventions. For example, technology has given us sport utility vehicles (SUVs). Many people like and have purchased these vehicles. They like the comfort, ride, and safety provided by these vehicles as well as the ability to go "off-road." However, there are other groups of people who oppose these large "gas guzzling" vehicles because they feel they are harming our natural resources due to the poor gas mileage they get and the amount of pollution they produce. In this unit, students will learn about the impacts inventions and innovations have on humans.

Explain to students that "economic, political, and cultural issues" are influenced by the development and use of technology. The use of technology affects people in various ways. It affects their safety, comfort, choices, and attitudes about technology's development and use. For example, not too long ago (1980s), most "soda pop" sold in the United States was in glass bottles, with a deposit required on the bottle. This is not the situation today, as most soda pop sold in the U.S. comes in either plastic or aluminum cans. However, many states now require deposits on these containers. Also, some parts of the world still use glass pop bottles. Discuss these trends with students.

In this unit, students should learn that most technology by itself is neither "good" nor "bad." Is plastic a "bad" material? No, plastic is not a bad material. When "pop" is packaged in plastic soda containers, the plastic is used in a positive and desirable manner. People like the convenience and portability of plastic soda containers. However, when billions of plastic bottles are dumped into our landfills instead of being recycled, this represents plastic being used in an undesirable and negative manner.

Discuss with students inventions and innovations related to home video games. Discuss how home video games have influenced people. Talk about the desirable and undesirable consequences associated with playing home video on the television or computer. Have students consider ethical issues related to home video games. Ethical concerns of home video games can include issues related to illegal copying of games or the playing of video games that encourage illegal behavior, such as vandalism, assault, theft, destruction of property, or murder.

Discuss with students that "technology" has provided society with many inventions and innovations. But where do all of these products or systems go when they are no longer needed? Ask students what happens to all the old computers that are quickly being amassed. In this unit, students will need to learn about the effects of technology on the environment. Students should be given opportunities to explore how a "waste product" can be recycled, reused, or re-manufactured into a new product.

To help students to begin to understand the effects of technology on the environment, it is helpful to introduce the concepts associated with the "life cycle" of a product. The life cycle of a product deals with its origins and eventual fate. A good resource for this activity is Reeske and Ireton's (2001) book *The Life Cycle of Everyday Stuff* published by the National Science Teachers Association (www.nsta.org). In its publication, it identifies the stages in the life cycle of a product. These stages include: design, raw material acquisition, manufacturing, packaging and distribution, useful life, and end-of-life and disposal.

In this unit, students should learn the important role society plays in the acceptance or rejection of new inventions or innovations. For example, if society does not like a new product, or if "research" proves that it is bad, it will probably fail. Also, students must learn that, when they judge a new invention, or innovation, they must base their judgement on facts. For example, if a person says "SUVs get worse gas mileage than compact cars," the person must be able to back up the statement with credible evidence.

In this unit, students should be introduced to the meaning of data. Data typically involves gathering factual information in order to make meaningful decisions. It can be used to analyze the positive or negative effects of a technology, to identify trends, and to determine if information obtained is accurate and useful. Data is typically gathered through some type of sensing instrument and is often in numerical form. For example, if you wanted to find the average temperature for the month of January where you live, you could collect daily temperature readings (data) for the month and divide all your readings by 31. Using this information, you could recommend the appropriate type of clothing that a person should wear during the month of January.

Unit 5 Content Outline

I. Invention and Innovation Affect Society
- A. Cultural
- B. Social
- C. Economic
- B. Political

II. Invention and Innovation Affect Humans
- A. Safety
- B. Comfort
- C. Choices
- D. Attitudes
- E. Technology by itself is neither positive nor negative.
- F. Products and systems can have both desirable and undesirable consequences.
- G. Ethical Issues

III. Technology and the Environment
- A. Recycle, re-used, or re-manufactured
- B. Product life cycle
  1. Design
  2. Raw material acquisition
  3. Manufacturing, packaging, and distribution
  4. Useful life
  5. End-of-life and disposal

IV. Using Data to Make Informed Decisions
- A. Analyzing positive or negative effects of a technology
- B. Identifying trends
- C. Determining if information obtained is accurate and useful

Suggested Learning Activities

Soda Pop

Time: 2-3 days

Teacher Preparation

How has the invention of soda pop affected society? When was the first aluminum soda can introduced? What did Dr. John S. Pemberton do in 1886? Why is most "pop" in the U.S. sold in cans or plastic bottles? How has technology influenced the development of soda pop? In this activity, students (individually or in groups) will prepare a poster related to inventions and innovations in the world of soda pop and present the information to the class. The poster should highlight inventions or innovations related to soda pop and state how they impacted society. Good information about the history of soda pop, including inventions and innovations can be found on the Internet at:

- *Soda Pops Dream Magazine* (www.pww.on.ca/dreams.htm)
- Inventors Section at About (http://inventors.about.com/mbody.htm)

Alternative Activities

1. The National Inventors Hall of Fame (www.invent.org) honors the women and men responsible for the great technological advances that make human, social and economic progress possible. In this activity, have students visit the site and explore the *Hall of Fame Invention Channels*. Require students to pick a topic (e.g., agriculture), and report on the impact of an invention that they find. For example, "Eli Whitney (1765 - 1825) invented the Cotton Gin. The impact of this invention gave birth to the American mass-production concept."

2. What are the top technological inventions and innovations of the year? How about the top innovations of all time? Was it electricity? How about the automobile, computer, or refrigeration? In this activity, present students with a listing of recent innovations and inventions or with a list of those from the past and have students discuss their past, present or, future impacts. Good reference sites for this activity include:
   - Popular Science (www.popsci.com)
   - Lucent Technologies (www.bell-labs.com/about/history/timeline.html)
   - Top Ideas (www.topideas.com/)
   - The Inventors Museum (www.inventorsmuseum.com)
   - Yearly Design Winners, the Industrial Designers Society of America (www.idsa.org)

3. Focus this activity on new innovations and inventions that have occurred in the medical

technologies and the agricultural and related biotechnologies and how they have impacted society. For example, innovations in medical technology have provided society with improved surgical techniques, new medicines, and methods to straighten teeth.

Big Ideas Covered in this Activity

- History of soda pop and its related inventions and innovations
- Impacts of soda pop inventions and innovations

Name: ________________________________
Date: ________________________________
Hour/Period: ____________________________

Invention and Innovation

Chapter 2, Unit 5: Impacts of Inventions and Innovations

Student Activity #1

Soda Pop

Introduction

How has the invention of soda pop affected society? When was the first aluminum soda can introduced? What did Dr. John S. Pemberton do in 1886? Why is most "pop" in the U.S. sold in cans or plastic bottles? How has technology influenced the development of soda pop? In this activity, you will identify an invention or innovation related to soda pop, and develop a class poster that highlights the invention or innovation.

Objectives

Upon successful completion of this activity, you should be able to:

- Gather information on a selected invention or innovation related to soda pop.
- Discuss the "impacts" related to the invention or innovation.

Connections

During this activity, you will be applying knowledge from the following areas:

- Science: science and technology, science as a human endeavor
- Language Arts: reading, understanding of the human experience, communication, evaluating data, research skills.
- Social Sciences: U.S. history, markets, entrepreneurship

Procedures

1. Choose an invention or innovation related to soda pop. There are hundreds of inventions and innovations related to soda pop. For example, the soda can, the beginning of different soda brands (e.g., Pepsi, Coke, Dr. Pepper, 7-Up, etc.) the pop vending machine, the "pop top" can, the shape of the bottle, and product advertising (e.g., neon lights) are all inventions or innovations related to soda pop. List the "pop" invention or innovation you chose below:

   ____

2. Gather information about your “pop” invention or innovation and complete the information below. Use books and other resources to help you search for information. On the Internet, information about the history of soda pop, including inventions and innovations can be found at the *Soda Pops Dream Magazine* (www.pww.on.ca/dreams.htm) or in the Inventors section at About.com (http://inventors.about.com/mbody.htm). Find the following information:

   A. Year it was invented or innovated: ____

   B. Who invented it or innovated it?: ____

   C. Where it was invented it or innovated?: ____

3. How did your soda pop invention or innovation “impact” society? Consider both the “positive” and “negative” consequences associated with your invention or innovation. Describe “impacts” related to your invention or innovation below. For example, was the invention of the “soda vending machine” considered by most people a “good” invention because it kept pop cold and increased its availability to the public?

   Impacts: ____

   ____

   ____

   ____

4. Develop a “poster” containing the above information and share it with the class. If possible, obtain the actual invention or innovation (e.g., a pop bottle) and attach it to your poster.

Time: 4-5 days

Teacher Preparation

In this activity, students working in small groups of three, will identify three different waste materials (e.g., glass, aluminum, paper, dirt, rubber tires, wastewater, oil, etc.) and explore how these materials can be recycled, reused, or re-manufactured into new products. In this activity, each group must research "different" waste materials to determine how they affect the environment. To begin this activity, you will want to obtain a variety of waste materials (e.g., an old tire) and discuss disposal options (e.g., old tires can be ground up and reused in road pavements—most landfills will not permit the dumping of old tires). Present to students "Fast Facts about Trash" (www.metro-region.org/ article.cfm?articleid=5579).

In this activity, make sure to discuss "recycling" and the pros and cons of various disposal options (e.g., recycling, solid waste disposal sites, etc.) and reuse. Introduce students to Earth Day (www.earthday.net). A good print resource for this activity is *The Life Cycle of Everyday Stuff* published by the National Science Teachers Association (www.nsta.org). Other good teacher resources on recycling can be found on the Internet at:

- www.theteachersguide.com/ Recyclinglessonplans.htm
- www.eduplace.com/
- www.cln.org/themes/ recycle.html
- www.epa.gov/epaoswer/osw/ kids/index.htm
- www.epa.gov/recyclecity/
- www.obviously.com/recycle/

Big Ideas Covered in this Activity

- Society creates a lot of waste that must be disposed of properly.
- There are options to how waste can be disposed.

Name: ______________________________
Date: ______________________________
Hour/Period: __________________________

Invention and Innovation

Chapter 2, Unit 5: Impacts of Inventions and Innovations

Student Activity #2

Where Does the Trash Go?

Introduction

Society creates lots of trash each day, and most of it goes to city landfills where it slowly decomposes. But some things take a long time to decompose. How long will it take for that glass bottle you threw out to decompose in the landfill? How about a million years!

We Americans create a lot of trash. The Environmental Protection Agency (EPA) estimates that "*Each individual generates about 1.5 tons of solid waste per year—about 4.5 pounds per person, per day. If we continue this pattern, we will have each created 90,000 pounds of trash in our lifetimes.* In this activity, you will work in small groups and identify three different waste materials (e.g., glass, aluminum, paper, dirt, rubber tires, wastewater, oil, etc.), and explore how these materials can be recycled, reused, or re-manufactured into new products.

Objectives

Upon successful completion of this activity, you should be able to:

- Describe how various "waste materials" can be recycled, reused, or re-manufactured into new products.
- Discuss the impacts of "waste materials" on the environment.

Connections

During this activity, you will be applying knowledge from the following areas:

- Mathematics: measuring, data analysis
- Science: properties, life science, resources, environments
- Language Arts: reading, evaluation, communication skills, evaluating data, research skills
- Social Sciences: politics, citizenship, scarcity

Procedures

1. Break into small groups of three students. In your group, identify three different "waste materials" in our society. List your three choices below.

   Waste Material #1: ____

   Waste Material #2: ____

   Waste Material #3: ____

   How can you create less waste in school? Find out on the Internet by visiting *Creating Less Trash at School* at www.moea.state.mn.us/campaign/school. Or find out about Waste Free Lunches at www.wastefreelunches.org.

2. Each group member should gather information about a selected waste material. Use books and other resources, such as the Internet, to help you in your search for information. First, find out if the material is "recyclable" and discuss how it can be recycled, reused, or re-manufactured. For example, plain white paper can be recycled by taking it to a "paper recycling bin" found in front of the local supermarket. Paper from the "recycling bin" is used to make recycled paper. Complete the following information related to each material.

   Waste Material #1: Can it be recycled?   YES   NO
   If YES, how can it be recycled, reused, or re-manufactured:______________________________
   ____
   ____

   Waste Material #2: Can it be recycled?   YES   NO
   If YES, how can it be recycled, reused, or re-manufactured:______________________________
   ____
   ____

   Waste Material #3: Can it be recycled?   YES   NO
   If YES, how can it be recycled, reused, or re-manufactured:______________________________
   ____
   ____

3. Share your waste materials (actual examples if possible) with the class and tell them the results of how these materials can be recycled, reused, or re-manufactured.

Chapter 3

Appendix

> I have not failed 700 times. I have not failed once. I have succeeded in proving that those 700 ways will not work. When I have eliminated the ways that will not work, I will find the way that will work.
>
> ***Thomas Edison***

Chapter 3 – Appendix A

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Chapter 3 – Appendix B

Listing of Technology Content Standards in Standards for Technological Literacy

The Nature of Technology

Standard 1. Students will develop an understanding of the characteristics and scope of technology.

Grade Level		Benchmarks: *In order to comprehend the scope of technology, students should learn that:*
K-2	A.	The natural world and human-made world are different.
	B.	All people use tools and techniques to help them do things.
3-5	C.	Things that are found in nature differ from things that are human-made in how they are produced and used.
	D.	Tools, materials, and skills are used to make things and carry out tasks.
	E.	Creative thinking and economic and cultural influences shape technological development.
6-8	F.	New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.
	G.	The development of technology is a human activity and is the result of individual and collective needs and the ability to be creative.
	H.	Technology is closely linked to creativity, which has resulted in innovation.
	I.	Corporations can often create demand for a product by bringing it onto the market and advertising it.
9-12	J.	The nature and development of technological knowledge and processes are functions of the setting.
	K.	The rate of technological development and diffusion is increasing rapidly.
	L.	Inventions and innovations are the results of specific, goal-directed research.
	M.	Most development of technologies these days is driven by the profit motive and the market.

Standard 2. Students will develop an understanding of the core concepts of technology.

Grade Level		Benchmarks: *In order to comprehend the core concepts of technology, students should learn that:*
K-2	A.	Some systems are found in nature, and some are made by humans.
	B.	Systems have parts or components that work together to accomplish a goal.
	C.	Tools are simple objects that help humans complete tasks.
	D.	Different materials are used in making things.
	E.	People plan in order to get things done.
3-5	F.	A subsystem is a system that operates as a part of another system.
	G.	When parts of a system are missing, it may not work as planned.
	H.	Resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time.
	I.	Tools are used to design, make, use, and assess technology.
	J.	Materials have many different properties.
	K.	Tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing.
	L.	Requirements are the limits to designing or making a product or system.
6-8	M.	Technological systems include input, processes, output, and, at times, feedback.
	N.	Systems thinking involves considering how every part relates to others.
	O.	An open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback.
	P.	Technological systems can be connected to one another.
	Q.	Malfunctions of any part of a system may affect the function and quality of the system.
	R.	Requirements are the parameters placed on the development of a product or system.
	S.	Trade-off is a decision process recognizing the need for careful compromises among competing factors.
	T.	Different technologies involve different sets of processes.
	U.	Maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its quality.

Standard 2, cont.

Grade Level		Benchmark
	V.	Controls are mechanisms or particular steps that people perform using information about the system that causes systems to change.
9-12	W.	Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems.
	X.	Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems.
	Y.	The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.
	Z.	Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.
	AA.	Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.
	BB.	Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.
	CC.	New technologies create new processes.
	DD.	Quality control is a planned process to ensure that a product, service, or system meets established criteria.
	EE.	Management is the process of planning, organizing, and controlling work.
	FF.	Complex systems have many layers of controls and feedback loops to provide information.

Standard 3. Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Grade Level **Benchmarks:** *In order to appreciate the relationships among technologies as well as with other fields of study, students should learn that:*

Grade Level		Benchmark
K-2	A.	The study of technology uses many of the same ideas and skills as other subjects.
3-5	B.	Technologies are often combined.
	C.	Various relationships exist between technology and other fields of study.
6-8	D.	Technological systems often interact with one another.
	E.	A product, system, or environment developed for one setting may be applied to another setting.
	F.	Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.
9-12	G.	Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.
	H.	Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.
	I.	Technological ideas are sometimes protected through the process of patenting.
	J.	Technological progress promotes the advancement of science and mathematics.

Technology and Society

Standard 4. Students will develop an understanding of the cultural, social, economic, and political effects of technology.

Grade Level **Benchmarks:** *In order to recognize the changes in society caused by the use of technology, students should learn that:*

Grade Level		Benchmark
K-2	A.	The use of tools and machines can be helpful or harmful.
3-5	B.	When using technology, results can be good or bad.
	C.	The use of technology can have unintended consequences.
6-8	D.	The use of technology affects humans in various ways, including their safety, comfort, choices, and attitudes about technology's development and use.
	E.	Technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences.
	F.	The development and use of technology poses ethical issues.
	G.	Economic, political, and cultural issues are influenced by the development and use of technology.
9-12	H.	Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.
	I.	Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects.
	J.	Ethical considerations are important in the development, selection, and use of technologies.

Standard 4, cont.

K. The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees.

Standard 5. Students will develop an understanding of the effects of technology on the environment.

Grade Level **Benchmarks:** *In order to discern the effects of technology on the environment, students should learn that:*

K-2
A. Some materials can be reused and/or recycled.

3-5
B. Waste must be appropriately recycled or disposed of to prevent unnecessary harm to the environment.
C. The use of technology affects the environment in good and bad ways.

6-8
D. The management of waste produced by technological systems is an important societal issue.
E. Technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems.
F. Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another.

9-12
G. Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling.
H. When new technologies are developed to reduce the use of resources, considerations of trade-offs are important.
I. With the aid of technology, various aspects of the environment can be monitored to provide information for decision making.
J. The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment.
K. Humans devise technologies to reduce the negative consequences of other technologies.
L. Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment.

Standard 6. Students will develop an understanding of the role of society in the development and use of technology.

Grade Level **Benchmarks:** *In order to realize the impact of society on technology, students should learn that:*

K-2
A. Products are made to meet individual needs and wants.

3-5
B. Because people's needs and wants change, new technologies are developed, and old ones are improved to meet those changes.
C. Individual, family, community, and economic concerns may expand or limit the development of technologies.

6-8
D. Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.
E. The use of inventions and innovations has led to changes in society and the creation of new needs and wants.
F. Social and cultural priorities and values are reflected in technological devices.
G. Meeting societal expectations is the driving force behind the acceptance and use of products and systems.

9-12
H. Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and values.
I. The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures.
J. A number of different factors, such as advertising, the strength of the economy, the goals of a company, and the latest fads contribute to shaping the design of and demand for various technologies.

Standard 7. Students will develop an understanding of the influence of technology on history.

Grade Level **Benchmarks:** *In order to be aware of the history of technology, students should learn that:*

K-2
A. The way people live and work has changed throughout history because of technology.

3-5
B. People have made tools to provide food, to make clothing, and to protect themselves.

6-8
C. Many inventions and innovations have evolved by using slow and methodical processes of tests and refinements.
D. The specialization of function has been at the heart of many technological improvements.
E. The design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships.

Standard 7, cont.

9-12

F. In the past, an invention or innovation was not usually developed with the knowledge of science.
G. Most technological development has been evolutionary, the result of a series of refinements to a basic invention.
H. The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials.
I. Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.
J. Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how.
K. The Iron Age was defined by the use of iron and steel as the primary materials for tools.
L. The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society.
M. The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology.
N. The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time.
O. The Information Age places emphasis on the processing and exchange of information.

Design

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

Grade Level **Benchmarks:** *In order to comprehend the attributes of design, students should learn that:*

K-2

A. Everyone can design solutions to a problem.
B. Design is a creative process.

3-5

C. The design process is a purposeful method of planning practical solutions to problems.
D. Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.

6-8

E. Design is a creative planning process that leads to useful products and systems.
F. There is no perfect design.
G. Requirements for design are made up of criteria and constraints.

9-12

H. The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.
I. Design problems are seldom presented in a clearly defined form.
J. The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.
K. Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.

Standard 9. Students will develop an understanding of engineering design.

Grade Level **Benchmarks:** *In order to comprehend engineering design, students should learn that:*

K-2

A. The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.
B. Expressing ideas to others verbally and through sketches and models is an important part of the design process.

3-5

C. The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.
D. When designing an object, it is important to be creative and consider all ideas.
E. Models are used to communicate and test design ideas and processes.

6-8

F. Design involves a set of steps, which can be performed in different sequences and repeated as needed.
G. Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.
H. Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

9-12

I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.
J. Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.
K. A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.

Standard 9, cont.

L. The process of engineering design takes into account a number of factors.

Standard 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Grade Level **Benchmarks:** *In order to be able to comprehend other problem-solving approaches, students should learn that:*

K-2
A. Asking questions and making observations helps a person to figure out how things work.
B. All products and systems are subject to failure. Many products and systems, however, can be fixed.

3-5
C. Troubleshooting is a way of finding out why something does not work so that it can be fixed.
D. Invention and innovation are creative ways to turn ideas into real things.
E. The process of experimentation, which is common in science, can also be used to solve technological problems.

6-8
F. Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system.
G. Invention is a process of turning ideas and imagination into devices and systems. Innovation is the process of modifying an existing product or system to improve it.
H. Some technological problems are best solved through experimentation.

9-12
I. Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.
J. Technological problems must be researched before they can be solved.
K. Not all problems are technological, and not every problem can be solved using technology.
L. Many technological problems require a multidisciplinary approach.

Abilities for a Technological World

Standard 11. Students will develop the abilities to apply the design process.

Grade Level **Benchmarks:** *As part of learning how to apply design processes, students should be able to:*

K-2
A. Brainstorm people's needs and wants and pick some problems that can be solved through the design process.
B. Build or construct an object using the design process.
C. Investigate how things are made and how they can be improved.

3-5
D. Identify and collect information about everyday problems that can be solved by technology, and generate ideas and requirements for solving a problem.
E. The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many.
F. Test and evaluate the solutions for the design problem.
G. Improve the design solutions.

6-8
H. Apply a design process to solve problems in and beyond the laboratory-classroom.
I. Specify criteria and constraints for the design.
J. Make two-dimensional and three-dimensional representations of the designed solution.
K. Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.
L. Make a product or system and document the solution.

9-12
M. Identify the design problem to solve and decide whether or not to address it.
N. Identify criteria and constraints and determine how these will affect the design process.
O. Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.
P. Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.
Q. Develop and produce a product or system using a design process.
R. Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.

Standard 12. Students will develop the abilities to use and maintain technological products and systems.

Grade Level	Benchmarks: *As part of learning how to use and maintain technological products and systems, students should be able to:*
K-2	A. Discover how things work.
	B. Use hand tools correctly and safely and name them correctly.
	C. Recognize and use everyday symbols.
3-5	D. Follow step-by-step directions to assemble a product.
	E. Select and safely use tools, products, and systems for specific tasks.
	F. Use computers to access and organize information.
	G. Use common symbols, such as numbers and words, to communicate key ideas.
6-8	H. Use information provided in manuals, protocols, or by experienced people to see and understand how things work.
	I. Use tools, materials, and machines safely to diagnose, adjust, and repair systems.
	J. Use computers and calculators in various applications.
	K. Operate and maintain systems in order to achieve a given purpose.
9-12	L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.
	M. Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.
	N. Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision.
	O. Operate systems so that they function in the way they were designed.
	P. Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate.

Standard 13. Students will develop the abilities to assess the impact of products and systems.

Grade Level	Benchmarks: *As part of learning how to assess the impact of products and systems, students should be able to:*
K-2	A. Collect information about everyday products and systems by asking questions.
	B. Determine if the human use of a product or system creates positive or negative results.
3-5	C. Compare, contrast, and classify collected information in order to identify patterns.
	D. Investigate and assess the influence of a specific technology on the individual, family, community, and environment.
	E. Examine the trade-offs of using a product or system and decide when it could be used.
6-8	F. Design and use instruments to gather data.
	G. Use data collected to analyze and interpret trends in order to identify the positive and negative effects of a technology.
	H. Identify trends and monitor potential consequences of technological development.
	I. Interpret and evaluate the accuracy of the information obtained and determine if it is useful.
9-12	J. Collect information and evaluate its quality.
	K. Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment.
	L. Use assessment techniques, such as trend analysis and experimentation, to make decisions about the future development of technology.
	M. Design forecasting techniques to evaluate the results of altering natural systems.

The Designed World

Standard 14. Students will develop an understanding of and be able to select and use medical technologies.

Grade Level	Benchmarks: *In order to select, use, and understand medical technologies, students should learn that:*
K-2	A. Vaccinations protect people from getting certain diseases.
	B. Medicine helps people who are sick to get better.
	C. There are many products designed specifically to help people take care of themselves.
3-5	D. Vaccines are designed to prevent diseases from developing and spreading; medicines are designed to relieve symptoms and stop diseases from developing.
	E. Technological advances have made it possible to create new devices, to repair or replace certain parts of the body, and to provide a means for mobility.

Standard 14, cont.

Grade Level		Benchmarks
	F.	Many tools and devices have been designed to help provide clues about health and to provide a safe environment.
6-8	G.	Advances and innovations in medical technologies are used to improve health care.
	H.	Sanitation processes used in the disposal of medical products help to protect people from harmful organisms and disease, and shape the ethics of medical safety.
	I.	The vaccines developed for use in immunization require specialized technologies to support environments in which a sufficient amount of vaccines is produced.
	J.	Genetic engineering involves modifying the structure of DNA to produce novel genetic make-ups.
9-12	K.	Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained.
	L.	Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology.
	M.	The sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures.

Standard 15. Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.

Grade Level		**Benchmarks:** *In order to select, use, and understand agricultural and related biotechnologies, students should learn that:*
K-2	A.	The use of technologies in agriculture makes it possible for food to be available year round and to conserve resources.
	B.	There are many different tools necessary to control and make up the parts of an ecosystem.
3-5	C.	Artificial ecosystems are human-made environments that are designed to function as a unit and are comprised of humans, plants, and animals.
	D.	Most agricultural waste can be recycled.
	E.	Many processes used in agriculture require different procedures, products, or systems.
6-8	F.	Technological advances in agriculture directly affect the time and number of people required to produce food for a large population.
	G.	A wide range of specialized equipment and practices is used to improve the production of food, fiber, fuel, and other useful products and in the care of animals.
	H.	Biotechnology applies the principles of biology to create commercial products or processes.
	I.	Artificial ecosystems are human-made complexes that replicate some aspects of the natural environment.
	J.	The development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food.
9-12	K.	Agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products.
	L.	Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering.
	M.	Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality.
	N.	The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna.

Standard 16. Students will develop an understanding of and be able to select and use energy and power technologies.

Grade Level		**Benchmarks:** *In order to select, use, and understand energy and power technologies, students should learn that:*
K-2	A.	Energy comes in many forms.
	B.	Energy should not be wasted.
3-5	C.	Energy comes in different forms.
	D.	Tools, machines, products, and systems use energy in order to do work.
6-8	E.	Energy is the capacity to do work.
	F.	Energy can be used to do work, using many processes.
	G.	Power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done.
	H.	Power systems are used to drive and provide propulsion to other technological products and systems.
	I.	Much of the energy used in our environment is not used efficiently.
9-12	J.	Energy cannot be created or destroyed; however, it can be converted from one form to another.

Standard 16, cont.

K. Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.
L. It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings.
M. Energy resources can be renewable or nonrenewable.
N. Power systems must have a source of energy, a process, and loads.

Standard 17. Students will develop an understanding of and be able to select and use information and communication technologies.

Grade Level **Benchmarks:** *In order to select, use, and understand information and communication technologies, students should learn that:*

K-2
A. Information is data that has been organized.
B. Technology enables people to communicate by sending and receiving information over a distance.
C. People use symbols when they communicate by technology.

3-5
D. The processing of information through the use of technology can be used to help humans make decisions and solve problems.
E. Information can be acquired and sent through a variety of technological sources, including print and electronic media.
F. Communication technology is the transfer of messages among people and/or machines over distances through the use of technology.
G. Letters, characters, icons, and signs are symbols that represent ideas, quantities, elements, and operations.

6-8
H. Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human.
I. Communication systems are made up of a source, encoder, transmitter, receiver, decoder, and destination.
J. The design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message.
K. The use of symbols, measurements, and drawings promotes clear communication by providing a common language to express ideas.

9-12
L. Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information.
M. Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine.
N. Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate.
O. Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.
P. There are many ways to communicate information, such as graphic and electronic means.
Q. Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.

Standard 18. Students will develop an understanding of and be able to select and use transportation technologies.

Grade Level **Benchmarks:** *In order to select, use, and understand transportation technologies, students should learn that:*

K-2
A. A transportation system has many parts that work together to help people travel.
B. Vehicles move people or goods from one place to another in water, air or space, and on land.
C. Transportation vehicles need to be cared for to prolong their use.

3-5
D. The use of transportation allows people and goods to be moved from place to place.
E. A transportation system may lose efficiency or fail if one part is missing or malfunctioning or if a subsystem is not working.

6-8
F. Transporting people and goods involves a combination of individuals and vehicles.
G. Transportation vehicles are made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively.
H. Governmental regulations often influence the design and operation of transportation systems.
I. Processes, such as receiving, holding, storing, loading, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently.

9-12
J. Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.

Standard 18, cont.

K. Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another.
L. Transportation services and methods have led to a population that is regularly on the move.
M. The design of intelligent and non-intelligent transportation systems depends on many processes and innovative techniques.

Standard 19. Students will develop an understanding of and be able to select and use manufacturing technologies.

Grade Level **Benchmarks:** *In order to select, use, and understand manufacturing technologies, students should learn that:*

K-2
A. Manufacturing systems produce products in quantity.
B. Manufactured products are designed.

3-5
C. Processing systems convert natural materials into products.
D. Manufacturing processes include designing products, gathering resources, and using tools to separate, form, and combine materials in order to produce products.
E. Manufacturing enterprises exist because of a consumption of goods.

6-8
F. Manufacturing systems use mechanical processes that change the form of materials through the processes of separating, forming, combining, and conditioning.
G. Manufactured goods may be classified as durable and non-durable.
H. The manufacturing process includes the designing, development, making, and servicing of products and systems.
I. Chemical technologies are used to modify or alter chemical substances.
J. Materials must first be located before they can be extracted from the earth through such processes as harvesting, drilling, and mining.
K. Marketing a product involves informing the public about it as well as assisting in selling and distributing it.

9-12
L. Servicing keeps products in good operating condition.
M. Materials have different qualities and may be classified as natural, synthetic, or mixed.
N. Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time.
O. Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production.
P. The interchangeability of parts increases the effectiveness of manufacturing processes.
Q. Chemical technologies provide a means for humans to alter or modify materials and to produce chemical products.
R. Marketing involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it.

Standard 20. Students will develop an understanding of and be able to select and use construction technologies.

Grade Level **Benchmarks:** *In order to select, use, and understand construction technologies, students should learn that:*

K-2
A. People live, work, and go to school in buildings, which are of different types: houses, apartments, office buildings, and schools.
B. The type of structure determines how the parts are put together.

3-5
C. Modern communities are usually planned according to guidelines.
D. Structures need to be maintained.
E. Many systems are used in buildings.

6-8
F. The selection of designs for structures is based on factors such as building laws and codes, style, convenience, cost, climate, and function.
G. Structures rest on a foundation.
H. Some structures are temporary, while others are permanent.
I. Buildings generally contain a variety of subsystems.

9-12
J. Infrastructure is the underlying base or basic framework of a system.
K. Structures are constructed using a variety of processes and procedures.
L. The design of structures includes a number of requirements.
M. Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use.
N. Structures can include prefabricated materials.

Chapter 3 – Appendix C

Instructor Resources

Reference Book Resources

Bridgman, R. (2002). *1000 Inventions and discoveries.* New York, NY: DK Publishing. ISBN 0-7894-8826-4.

Brown, D. E. (2002). *Inventing modern America: From the microwave to the mouse*. Cambridge MA: The MIT Press. ISBN 0-262-02508-6.

Bud, Robert. (2000). *Inventing the modern world: Technology since 1750*. New York, NY: Dorling Kindersley. ISBN 078946828X.

Brown, A. E. & Jeffcoat, H. A. (1932). *World's wackiest inventions*. Mineola, NY: Re-Published 2001 by Dover Publications, Inc. ISBN: 0-486-22596-8.

Caney, S. (1985). *Invention book*. New York, NY: Workman Publishing. ISBN 0-89480-076-0.

Ebert, C. & Ebert, E. (1998). *The Inventive Mind in Science: Creative Thinking Activities.* Englewood CO: Teachers Ideas Press. ISBN 1-56308-387-6.

Egan, L. H. (1997). *Inventors and inventions.* New York, NY: Scholastic Professional Books. ISBN: 0-590-10388-1.

Erlbach, E. (1997). *The kids' invention book*. Minneapolis, MN: Lerner Publications Company. ISBN 0-8225-9844-2.

Evans, H., Buckland, G., & Lefer, D. (2004). *They Made America: Two Centuries of Innovators from the Steam Engine to the Search Engine*. New York, NY: Little, Brown & Company. ISBN: 0-316-27766-5.

Flatow, I. (1992). *They all laughed...* New York, NY: Harper Perennial. ISBN 0-06-092415-2.

Harms, H. R. & Swernofsky. (2003). *Technology interactions*. New York, NY: Glencoe McGraw-Hill.

Jones, C. F. (1991). *Mistakes that worked*. New York, NY: Delacorte Press. ISBN: 0-385-32043-4.

Karwatha, D. K. (1996). *Technology's past*. Ann Arbor, MI: Prakken Publications, Inc. ISBN 0-911168-91-5.

Karwatha, D. K. (1999). *Technology's past, vol. 2: More heroes of invention and innovation.* Ann Arbor, MI: Prakken Publications, Inc. (ISBN 0-911168-96-6).

Karwatha, D. K. (2002). *History of technology series.* Ann Arbor, MI: Prakken Publications, Inc. ISBN 0-911168-96-6.

Petroski, H. (2002). *Invention by design; How engineers get from thought to thing*. Cambridge, MA: Harvard University Press. ISBN: 0674-46368-4.

Reeske M. & Ireton, S. W. (2001). *The life cycle of everyday stuff.* Arlington, VA: National Science Teachers Association. ISBN 0-87355-187-7.

Science Museum of London. *(1991). Inventions* (DK Pockets series). New York, NY: Dorling Kindersley. ISBN 1564588890.

Sobey, E. (2002). *Inventing toys: Kids having fun learning science*. Tucson, AZ: Zephyr Press. ISBN: 1-56976-124-8.

St. George, J. & Small, D. (2002). *So, you want to be an inventor*. New York, NY: Philomel Books. ISBN: 0-399-23593.

Thode, B. & Thode, T. (2002). *Technology in action, second edition.* New York, NY: Glencoe McGraw-Hill.

Tucker, T. (1995). *Brainstorm!: The stories of twenty American kid inventors*. New York, NY: Farrar, Straus and Giroux. ISBN 0-374-30944-2.

Valiant Technology Ltd. (n.d.). *The Inventa book of mechanisms.* London: Valiant Technology Ltd. ISBN 0-9523651-0-3.

VanCleave, T. (2001). *Totally absurd inventions.* Kansas City, MO: Andrews McMeel Publishing. ISBN: 0-7407-1025-7.

Wright, R. T. (2000). *Technology.* Tinley Park, IL: Goodheart-Willcox.

Wright, R. T. & Smith H. (1998). *Understanding technology.* Tinley Park, IL: Goodheart-Willcox.

Wulffson D. L. (1997). *The Kid Who Invented the Popsicle.* New York, NY: Penguin Books. ISBN: 0525-65221-3.

Internet Resources

Academy of Applied Sciences: www.aas-world.org

All About Inventions: http://inventors.about.com/mbody.htm

Ben Franklin: www.ushistory.org/franklin/
Bill Nye the Science Guy: www.nyelabs.com/core.html
Discover Engineering: www.discoverengineering.org/eweek/default.asp
Disney Educational: http://dep.disney.go.com/educational/index
Edison Historical Site: www.nps.gov/edis/home.htm
Flying Turtle Science and Technology: www.ftexploring.com/
Future Scientists & Engineers of America, Middle School Projects: www.fsea.org/frprojct/midllist.htm#BR1
Girls' Invention Site: www.girltech.com/Index_home.html
Globe Science Program: www.globe.gov/fsl/welcome.html
Highschool Hub: http://highschoolhub.org/hub/hub.cfm
History of Levi Straus: www.levistrauss.com/about/history/founder.htm
Ideation International: www.ideationtriz.com/
Information about Edison and Teaching Kits: www.charlesedisonfund.org/home2.html
Invention Emporium: www.patentstuff.com/emporium.htm
The Inventor's Directory: www.inventionfind.com/activities.html
Inventors and Inventions: http://192.107.108.56/portfolios/t/tomaselli_l/gopage.htm
Inventors & Inventions for K-12 Education: http://falcon.jmu.edu/~ramseyil/inventors.htm
Inventors and Inventions Theme Page: www.cln.org/themes/inventors.html
Inventions of the Millennium, a Top Ten List: www.everything2000.com/news/life/inventionsofmm.asp
Inventor's Museum: www.inventorsmuseum.com
Jet Propulsion Laboratory: www.jpl.nasa.gov/technology/index.cfm
Kids Hall of Fame: www.thekidshalloffame.com
Museum Link: www.museumstuff.com
Museum of Science and Industry: www.msichicago.org/index.html
NASA Student Involvement Program: www.nsip.net/competitions/journalism/index.cfm
National Engineering Week: www.new-sng.com/maintemplate.cfm
National Geographic: www.nationalgeographic.com/
New Inventions: www.inventionconnection.com
Northwest Invention Center: www.invention-center.com
Optics for Kids: www.opticsforkids.org/index.cfm
Patent and Trademark Links: www-wsl.state.wy.us/sis/ptdl/links.html
PBS – Forgotten Inventors: www.pbs.org/wgbh/amex/telephone/sfeature/index.html
The Pro Teacher: www.proteacher.com/110031.shtml
Puzzle Maker: www.puzzlemaker.com/
Rubrics: www.rubrics.com/
Science Fair Information: www.scifair.org/
Science Fair Project Ideas: www.imagineeringezine.com/e-zine/science.html
Science Made Simple: www.sciencemadesimple.com
Science and Technology Links: http://f2.org/links/sci.html
Science Toys: http://scitoys.com
Sites for Teachers: www.sitesforteachers.com
Smitshsonian: www.si.edu
Teachers Corner: www.theteacherscorner.net/index.htm
Teachers Net: http://teachers.net
Teacher Resources: www.bigchalk.com
United Inventors Association: www.inventorhelp.com
United States Patent and Trademark Office for Kids: www.uspto.gov/go/kids

Audio & Video Resources

Videos Available from Hearlihy (www.pitsco.com)
- *Invention of the Automobile*
- *GM Design Process*
- *How a Car is Built*

Sample video titles available from The Discovery Channel (http://dsc.discovery.com)
- *Ancient Inventions*
- *Connections3*
- *Understanding Television*
- *Robots Rising*
- *Incredible Robots*
- *Engineering the Impossible*
- *Extreme Machines*
- *Extreme Machines for Kids*
- *Birth of the V-Rod Video*

Sample video titles available from The Arts and Entertainment (A&E) Television Network (http://store.aetv.com)
- *Biography – Alexander Graham Bell: Voice of Invention*
- *Modern Marvels – Captured Light: The Invention of Still Photography*

- *Modern Marvels – Great Inventions*
- *In Search of History – Ancient Inventions*
- *Biography – Wilbur & Orville Wright: Dreams of Flying*

Sample video titles available from Library Video Company (www.libraryvideo.com)
- *A History of Invention*
- *Inventions & Innovations*
- *Inventors of the World Video Series*
- *Just the Facts: Inventions That Changed Our Lives Series*

Other Recommended Video Titles:
- *African Americans in Science, Mathematics, Medicine, and Invention.* Available from the Mathteacher Store: www.mathteacherstore.com
- *Inventioneering* and *Invent It!* Available from Insights Visual Productions Inc.: http://sciencevideos.com
- *Super Solvers, Gizmos and Gadgets.* Published by the Learning Company
- *Just the Facts: Inventions that Changed Our Lives* (Series of Videos). Goldhil Home Video
- *The Deep Dive.* Nightline Series. Available from ABC NEWStore: www.abcnewsstore.com

Computer-Based Resources

- The Edison CD-ROM: www.pe.net/~jnes/jnes-ecd.html
- *The New Way Things Work* CD-ROM. Dorling Kindersley: http://us.dk.com
- NASA Free Software: http://www.grc.nasa.gov/WWW/K-12/freesoftware_page.htm
- Toy Tech CD-ROM: www.invention-center.com
- Engineering Software: http://hometown.aol.com/engware/index.htm
- Science Navigator CD-ROM: McGraw Hill
- Car Builder CD-ROM

Magazines and Journals

American Heritage of Invention & Technology
Discover Magazine
Newsweek
Popular Mechanics
Tech Directions
The Technology Teacher
Technology Review
Time

Kits

- Basic Kid Inventor Kit (www.hometrainingtools.com)
- Fiber Optic Kits (www.fiberopticproducts.com/Kits.htm)
- Invention Explore-A-Pack: www.pitsco.com
- Inventor's Workshop (www.discoverthis.com/inventors-workshop.html)
- Lego Mindstorms: http://mindstorms.lego.com/eng/default.asp
- Reinventing Science Kits: (www.harris-educational.com)
- Robot Inventor's Workshop Kit (www.discoverthis.com/robot-inventors.html)
- Science Fair Kits (www.super-science-fair-projects.com)
- Science Kits: (http://storeforknowledge.com)

Chapter 3 – Appendix D

Acceptable Evidence Glossary

Adequately – Sufficient for a specific requirement; also, barely sufficient or satisfactory.

Clearly – In a clear manner (easily heard, easily visible, free from obscurity or ambiguity, easily understood, unmistakable).

Correctly – 1. Conforming to an approved or conventional standard. 2. Conforming to or agreeing with fact, logic, or known truth. 3. Conforming to a set figure. 4. Conforming to the strict requirements of a specific ideology.

Create – 1. To make or bring into existence something new. 2. To invest with a new form, office, or rank; to produce or bring about through a course of action or behavior. 3. Cause, occasion. 4. To produce, through imaginative skill; to design.

Creatively – 1. The quality of being creative. 2. The ability to create.

Effectively – In an effective manner (producing a decided, decisive effect [result]).

Efficiently – Producing desired effects; productive without waste.

Insightfully – Exhibiting or characterized by insight (the power or act of seeing into a situation; the act or result of apprehending the inner nature of things or of seeing intuitively).

Introspectively – Behaving with introspection (a reflective looking inward; an examination of one's own thoughts and feelings).

Logically – Employing or behaving in accordance with logic (capable of reasoning or of using reason in an orderly, cogent fashion).

Marginally – Close to the lower limit of qualification, acceptability, or function; barely exceeding the minumum requirements.

Meaningfully – 1. Having meaning or purpose; full of meaning, significant.

Mimimally – Relating to or being a minimum: the least possible; barely adequate.

Mostly – For the greatest part; mainly.

Randomly – 1. Lacking a definite plan, purpose, or pattern. 2. Being or relating to a set (or to an element of a set) each of whose elements has equal probability of occurrence.

Safely – Free from harm or risk; unhurt; secure from threat or danger, harm, or loss; affording safety or security from danger, risk, or difficulty.

Systematically – 1. Presented or formatted as a coherent body of ideas or principles. 2. Methodical in procedure or plan; marked by thoroughness and regularity.

Thoroughly – 1. Carried through to completion. 2. Marked by full detail; painstaking; complete in all respects.

Thoughtfully – 1. Absorbed in thought. 2. Characterized by careful reasoned thinking. 3. Given to or chosen or made with heedful anticipation of the needs and wants of others.

Chapter 3 – Appendix E

Invention and Innovation Glossary

Agriculture – The process of raising crops and animals for food, feed, fibre, fuel, or other useful products.

Anthropometrics – The study of human body size and motion.

Assessment – An evaluation technique for technology that requires analyzing benefits and risks, understanding the trade-offs, and then determining the best action to take in order to ensure that the desired positive outcomes outweigh the negative consequences.

Student Assessment – An exercise, such as an activity, portfolio, written test, or experiment that seeks to measure a student's skills or knowledge in a subject area. Information may be collected about teacher and student performance, student behavior, and classroom atmosphere.

Benchmark – 1. A written statement that describes specific developmental components by various grade levels (K-2, 3-5, 6-8, and 9-12) that students should know or be able to do in order to achieve a standard. 2. A criteria by which something can be measured or judged.

Biodegradable – The ability of a substance to be broken down physically and/or chemically by natural biological processes, such as by being digested by bacteria or fungi.

Bioengineering – Engineering applied to biological and medical systems, such as biomechanics, biomaterials, and biosensors. Bioengineering also includes biomedical engineering as in the development of aids or replacements for defective or missing body organs.

Biological processes – The processes characteristic of, or resulting from, the activities of living organisms.

Biotechnology – Any technique that uses living organisms, or parts of organisms, to make or modify products, improve plants or animals, or to develop microorganisms for specific uses.

Brainstorming – A method of shared problem solving in which all members of a group, spontaneously and in an unrestrained discussion, generate ideas.

British Thermal Unit (BTU) – An English standard unit of energy. One BTU is the amount of thermal energy necessary to raise the temperature of one pound of pure liquid water by one degree Fahrenheit at the temperature at which water has its greatest density (39 degrees Fahrenheit). This is equivalent to approximately 1055 joule (or 1055 watt-seconds).

Bronze Age – The stage or level of development of human culture that followed the Stone Age and was characterized by the use of bronze tools and weapons and ended with the advent of the Iron age; about 3000 B.C.E. to 1100 B.C.E.

Build – To make something by joining materials or components together into a composite whole.

By-product – Something produced in the making of something else; a secondary result; a side effect.

CAD (Computer-Aided Design or Drafting) – 1. (Design) The use of a computer to assist in the process of designing a part, circuit, building, etc. 2. (Drafting) The use of a computer to assist in the process of creating, storing, retrieving, modifying, plotting, and communicating a technical drawing.

Capital – One of the basic resources used in a technological system. Capital (money) is the accumulated finances and goods devoted to the production of other goods.

Closed-loop system – A system that uses feedback from the output to control the input.

Composite – A combination of two or more materials that are bonded together in an effort to provide better properties.

Computer – A machine for carrying out calculations and performing specified transformations of information, such as storing, sorting, correlating, retrieving, and processing data.

Concurrent engineering – A systematic approach to the integrated, simultaneous design of products and their related processes, including manufacturing and support.

Constraint – A limit to the design process. Constraints may be such things as appearance, funding, space, materials, and human capabilities.

Construction – The systematic act or process of building, erecting, or constructing buildings, roads, or other structures.

Content Standard – A written statement about what students should know and be able to do.

Control – An arrangement of chemical, electronic, electrical, and mechanical components that commands or directs the management of a system.

Cost/benefit analysis – Does the cost justify the product? A company would add up the benefits of a course of action, and subtract the costs associated with it.

Creative thinking – The ability or power used to produce original thoughts and ideas based upon reasoning and judgment.

Criterion – A desired specification (element or feature) of a product or system.

Critical thinking – The ability to acquire information, analyze and evaluate it, and reach a conclusion to answer by using logic and reasoning skills.

Curriculum – The subject matter that teachers and students cover in their studies. It describes and specifies the methods, structure, organization, balance, and presentation of the content.

Cybernetics – Study of automatic control systems: the science or study of communication in organisms, organic processes, and mechanical or electronic systems.

Data – Raw facts or figures that can be used to draw a conclustion.

Decision making – The act of examining several possible behaviors and selecting from them the one most likely to accomplish the individual's or group's intention. Cognitive processes such as reasoning, planning, and judgment are involved.

Design – An iterative decision-making process that produces plans by which resources are converted into products or systems that meet human needs and wants or solve problems.

Design brief – A written brief that identifies a problem to be solved, its criteria, and its constraints. The design brief is used to encourage thinking of all aspects of a problem before attempting a solution.

Design principle – Design rules regarding rhythm, balance, proportion, variety, emphasis, and harmony, used to evaluate existing designs and guide the design process.

Design process – A systematic problem-solving strategy, with criteria and constraints, used to develop many possible solutions to solve a problem or satisfy human needs and wants and to winnow (narrow) down the possible solutions to one final choice.

Design proposal – A written plan of action for a solution to a proposed problem.

Develop – To change the form of something through a succession of states or stages, each of which is preparatory to the next. The successive changes are undertaken to improve the quality of or refine the resulting object or software.

Diagnose – To determine, by analysis, the cause of a problem or the nature of something.

Discovery – An insight into the existence of something previously unknown. The act of finding out something new.

Drawing – A work produced by representing an object or outlining a figure, plan, or sketch by means of lines. A drawing is used to communicate ideas and provide direction for the production of a design.

Economy – The production and consumption of goods and services of a community regarded as a whole.

Efficient – Operating or performing in an effective and competent manner with a minimum of wasted time, energy, or waste products.

Emergent – Occurring as a consequence.

Energy – The ability to do work. Energy is one of the basic resources used by a technological system.

Engineer – A person who is trained in and uses technological and scientific knowledge to solve practical problems.

Engineering – The profession of or work performed by an engineer. Engineering involves the knowledge of the mathematical and natural sciences (biological and physical) gained by study, experience, and practice that are applied with judgment and creativity to develop ways to utilize the materials and forces of nature for the benefit of mankind.

Engineering design – The systematic and creative application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.

Engineering ethics – 1. The study of moral issues and decisions confronting individuals and organizations involved in engineering. 2. The study of related questions about moral conduct, character, ideals, and relationships of people and organizations involved in technological development.

Environment – The circumstances or conditions that surround one; surroundings.

Ergonomics – The study of workplace equipment design or how to arrange and design devices, machines, or workspace so that people and things interact safely and most efficiently. Also called human factors analysis or human factors engineering.

Ethical – Conforming to an established set of principles or accepted professional standards of conduct.

Evaluation – 1. The collection and processing of information and data in order to determine how well a design meets the requirements and to provide direction for improvements. 2. A process used to analyze, evaluate, and appraise a student's achievement, growth, and performance through the use of formal and informal tests and techniques.

Experimentation – 1. The act of conducting a controlled test or investigation. 2. The act of trying out a new procedure, idea, or activity.

Feedback – Using all or a portion of the information from the output of a system to regulate or control the processes or inputs in order to modify the output.

Figure – A written symbol, other than a letter, representing an item or relationship, especially a number, design, or graphic representation.

Finite Element Analysis (FEA) – Finite element analysis software products can solve all types of linear and nonlinear stress, dynamics, composite, and thermal engineering analysis problems.

Flow Chart – Diagram showing a sequence of actions: a diagram that represents the sequence of operations in a process.

Forecast – A statement about future trends, usually as a probability, made by examining and analyzing available information. A forecast is also a prediction about how something will develop, usually as a result of study and analysis of available pertinent data.

Forming – The process that changes the shape and size of a material without cutting it.

Group Dynamics – Behavior of individuals within groups: the interpersonal processes, conscious and unconscious, that take place in the course of interactions among a group of people (*takes a singular verb*).

Human Factors Engineering – The study of the human body, its size and motions, as it is related to the design of a product or a system (See Ergonomics).

Human wants and needs – "Human wants" refers to something desired or dreamed of, and "human needs" refers to something that is required or a necessity.

Impact – The effect or influence of one thing on another. Some impacts are anticipated, and others are unanticipated.

Industrial Revolution – A period of inventive activity, beginning around 1750 in Great Britain. During this period, industrial and technological changes resulted in mechanized machinery that replaced much of what was previously manual work. The Industrial Recolution was responsible for many social changes, as well as changes in the way things were manufactured.

Informational Technology – Processes associated with generating, storing, retrieving, transferring, and modifying information and data.

Innovation – An improvement of an existing technological product, system, or method of doing something.

Input – Something put into a system, such as resources, in order to achieve a result.

Intelligence – The capacity to acquire knowledge and the skilled use of reason; the ability to comprehend.

Integration – The process of bringing all parts together into a whole.

Internet – The worldwide network of computer links, begun in the 1970s, which today allows computer users to connect with other computer users in nearly every country, and speaking many languages.

Invention – A new product, system, or process that has never existed before, created by study and experimentation.

KEVLAR® – A material that is five times stronger than steel on an equal weight basis, yet, at the same time, is lightweight, flexible, and comfortable.

Knowledge – 1. The body of truth, information, and principles acquired by mankind. 2. Interpreted information that can be used.

Laboratory classroom – The formal environment in school where the study of technology takes place. At the elementary school, this environment will likely be a regular classroom. At the middle and high school levels, a separate laboratory, with areas for hands-on activities as well as group instruction, could constitute the environment.

Literacy – Basic knowledge and abilities required to function adequately in one's immediate environment.

Machine – A device with fixed and moving parts that modifies mechanical energy in order to do work.

Maintenance – The work needed to keep something in proper condition; upkeep.

Manufacturing – The process of making a raw material into a finished product; especially in large quantities.

Manufacturing system – A system or group of systems used in the manufacturing process to make products for an end user.

Material – The tangible substance (chemical, biological, or mixed) that goes into the makeup of a physical object. One of the basic resources used in a technological system.

Measurement – The process of using dimensions, quantity, or capacity by comparison with a standard in order to mark off, apportion, lay out, or establish dimensions.

Medical Technology – Of or relating to the study of medicine through the use of and advances of technology, such as medical instruments and apparatus, imaging systems in medicine, and mammography. Related terms: bio-medical engineering and medical innovations.

Medicine – The science of diagnosing, treating, or preventing disease and other damage to the body or mind.

Mesolithic – The middle period of the Stone Age, between the Paleolithic and Neolithic.

Mobility – The quality or state of being mobile; capable of moving or being moved.

Model – A visual, mathematical, or three-dimensional representation in detail of an object or design, often smaller than the original. A model is often used to test ideas, make changes to a design, and to learn more about what would happen to a similar, real object.

Module – A self-contained unit.

Multimeter – An instrument that reads and measures the values of several different electrical parameters such as current, voltage, and resistance.

Neolithic – The latest period of the Stone Age, between about 8000 BC and 5000 BC, characterized by the development of settled agriculture and the use of polished stone tools and weapons.

Obsolescence – Loss in the usefulness of a product or system because of the development of an improved or superior way of achieving the same goal.

Optimization – An act, process, or methodology used to make a design or system as effective or functional as possible within the given criteria and constraints.

Orthographic projection – That projection which is made by drawing lines, from every point to be projected, perpendicular to the plane of projection. Such a projection of the sphere represents its circles as seen in perspective by an eye supposed to be placed at an infinite distance, the plane of projection passing through the center of the sphere perpendicularly to the line of sight.

Output – The results of the operation of any system.

Paleolithic – The early part of the Stone Age, when early human beings made chipped-stone tools—from 750,000 to 15,000 years ago.

Patent – A document issued from the government granting the exclusive right to produce or sell an invention for a certain period of time.

Peer Evaluation – A way for a group to evaluate its members according to their participation on a project.

Pharmaceuticals – A natural or artificial substance that is given to treat, prevent, or diagnose a disease or to lessen pain.

Photovoltaic – Capable of producing a voltage when exposed to radiant energy, especially light.

Pictogram – The instructions in "cartoon" format so that language is not a problem for people.

Plan – A set of steps, procedures, or programs, worked out beforehand in order to accomplish an objective or goal.

Polymer – Any of numerous natural and synthetic compounds of usually high molecular weight consisting of up to millions of repeated linked units, each a relatively light and simple molecule.

Portfolio – A systematic and organized collection of a student's work that includes results of research, successful and less successful ideas, notes of procedures, and data collected.

Problem solving – The process of understanding a problem, devising a plan, carrying out the plan, and evaluating the plan in order to solve a problem or meet a need or want.

Process – 1. Human activities used to create, invent, design, transform, produce, control, maintain, and use products or systems; 2. A systematic sequence of actions that combines resources to produce an output.

Produce – To create, develop, manufacture, or construct a human-made product.

Product – A tangible artifact produced by means of either human or mechanical work, or by biological or chemical processes.

Product lifecycle – Stages a product goes through from concept and use to eventual withdrawal from the marketplace. Product life cycle stages include research and development, introduction, market development, exploitation, maturation, saturation, and finally decline.

Prototype – A full-scale working model used to test a design concept by making actual observations and necessary adjustments.

Quality control – A system by which a desired standard of quality in a product or process is maintained. Quality control usually requires feeding back information about measured defects to further improvements of the process.

Recycling – To reclaim or reuse old materials in order to make new products.

Renaissance – The transitional movement in Europe between medieval and modern times beginning in the fourteenth century in Italy, lasting into the seventeenth century, and marked by a humanistic revival of classical influence expressed in a flowering of the arts and literature and the beginnings of modern science.

Requirements – The parameters placed on the development of a product or system. The requirements include the safety needs, the physical laws that will limit the development of an idea, the available resources, the cultural norms, and the use of criteria and constraints.

Research and Development (R&D) – The practical application of scientific and engineering knowledge for discovering new knowledge about products, processes, and services, and then applying that knowledge to create new and improved products, processes, and services that fill market needs.

Resources – The things needed to get a job done. In a technological system, the basic technological resources are: energy, capital, information, machines and tools, materials, people, and time.

Risk – The chance or probability of loss, harm, failure, or danger.

Risk benefit analysis – Does the risk of building the product outweigh the negative societal impact? *Risk = probability of event X cost of event.*

Rubric – An established rule, tradition, or custom.

R-Value – The resistance level of a material. This number can be associated with building materials lists or can be derived from an experiment that can be done to determine the R-value of a material.

Scale – A proportion between two sets of dimensions used in developing accurate, larger or smaller prototypes, or models of design ideas.

Schematic – A drawing or diagram of a chemical, electrical, or mechanical system.

Science – The study of the natural world through observation, identification, description, experimental investigation, and theoretical explanations.

Scientific inquiry – The use of questioning and close examination using the methodology of science.

Service – 1. The installation, maintenance, or repairs provided or completed by a dealer, manufacturer, owner, or contractor. 2. The performance of labor for the benefit of another.

Side effect – A peripheral or secondary effect, especially an undesirable secondary effect. Some side effects become the central basis for new developments.

Sketch – A rough drawing representing the main features of an object or scene and often made as a preliminary study.

Skill – An ability that has been acquired by training or experience.

Society – A community, nation, or broad grouping of people having common traditions, institutions, and collective activities and interests.

Social – Relating to human society and how it is organized.

Solution – A method or process for solving a problem.

Source Reduction – Often called waste prevention, means consuming and throwing away less.

Standardization – The act of checking or adjusting by comparison with a standard.

Stone Age – The first known period of prehistoric human culture characterized by the use of stone tools.

Structural system – A system comprised of the framework or basic structure of a vehicle.

Structure – Something that has been constructed or built of many parts and held or put together in a particular way.

Subsystem – A division of a system that, in itself, has the characteristics of a system.

Suspension system – A system of springs and other devices that insulates the passenger compartment of a vehicle from shocks transmitted by the wheels and axles.

Sustainable – 1. Of or relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged. 2. Relating to a human activity that can be sustained over the long term, without adversely affecting the environmental conditions (soil conditions, water quality, climate) necessary to support those same activities in the future.

Symbol – An arbitrary or conventional sign that is used to represent operations, quantities, elements, relations, or qualities or to provide directions or alert one to safety.

Synthetic material – Material that is not found in nature, such as glass, concrete, and plastic.

System – A group of interacting, interrelated, or interdependent elements or parts that function together as a whole to accompish a goal.

Systems-oriented thinking – A technique for looking at a problem in its entirety, looking at the whole, as distinct from each of its parts or components. Systems-oriented thinking takes into account all of the variables and relates social and technological characteristics.

Teamwork – A cooperative effort by the members of a group or team to achieve a common goal.

Technological design – See Engineering design.

Technological literacy – The ability to use, manage, understand, and assess technology.

Technological literacy standard – A written statement that specifies the knowledge (what students should know) and process (what students should be able to do) students should possess in order to be technologically literate.

Technology – 1. Human innovation in action that involves the generation of knowledge and processes to develop systems that solve problems and extend capabilities. 2. The innovation, change, or modification of the natural environment to satisfy perceived human needs and wants.

Technology education – A study of technology, which provides an opportunity for students to learn about the processes and knowledge related to technology that are needed to solve problems and extend human capabilities.

Test – 1. A method for collecting data. 2. A procedure for critical evaluation.

Thumbnail sketching – Small drawings/sketches used during brainstorming. These are not to scale and usually small, hence the name thumbnail.

Tolerances – Allowed amount of variation from the standard or from exact conformity to the specified dimensions, weight, etc., as in various mechanical operations.

Tool – A device that is used by humans to complete a task.

Trade-off – An exchange of one thing in return for another; especially relinquishment of one benefit or advantage for another regarded as more desirable.

Transistor – A solid-state electronic device; a small low-powered solid-state electronic device consisting of a semiconductor and at least three electrodes, used as an amplifier and rectifier and frequently incorporated into integrated circuit chips.

Transportation system – The process by which passengers or goods are moved or delivered from one place to another.

Trend – 1. A tendency. 2. A general direction.

Trial and error – A method of solving problems in which many solutions are tried until errors are reduced or minimized.

Troubleshoot – To locate and find the cause of problems related to technological products or systems.

U-Factor – The combined thermal conductivity of materials (1/R Value).

Virtual – Simulation of the real thing in such a way that it presents reality in essence or in effect though not in actual fact.

Vulcanize – To treat gum (crude rubber) with sulfur under heat to increase its strength and elasticity; to thermoset its structure so that it can no longer be melted.

Waste – Refuse or by-products that are perceived as useless, and must be consumed, left over, or thrown away.

Work – The transfer of energy from one physical system to another, expressed as the product of a force and the distance through which it moves a body in the direction of that force.

World Wide Web (WWW) – An abstract (imaginary) space of information that includes documents, color images, sound, and video.

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