The following document is in two parts.

1. **The four-part list of St. Vrain Technology Education Standards from c. 2005-2006**
2. **The full ITEA standards from the same time frame.**

The St. Vrain Technology Educators, (middle and high school teachers), met to discuss how we would craft standards for the district. I offered a rationale for using a certain approach which was adopted two weeks later.

Rationale: our technology labs had been replaced with brand new labs acquired from Paxton Patterson. These labs had 12 distinct modules, (each of our labs typically had 8 modules. Each teacher chose the eight they felt best suited the needs of their students.

The Paxton modules had already been assessed by Paxton Patterson in line with the ITEA standards, (Now ITEEA, International Technology Engineering Education Association). The ITEA content had five distinct sections.

I suggested that simply aligning our standards with theirs would be most efficient as we could then design lessons (standards-based), and refer specifically to the content that had already been aligned.

The group came to a consensus but decided to use only the first four sets of standards.

It took me two weeks to hone the trimmed set of standards down to a level that was consistent with the standards of the rest of the district in terms of format and content. When distributed to the group for review, they unanimously agreed, and the standards were adopted.

The St. Vrain standards as adopted appear first.

The last section shows the ITEA standards at the time for comparison. Section 5 of the ITEA standards is not included.

St.Vrain Valley School District, Standards for Technological Literacy, Full List

PART I

St. Vrain Valley School District
- Standards for Technological Literacy -

The Nature of Technology
Students will develop an understanding of the Nature of Technology.

9th - 12th Grade

The Nature of Technology

(SV.sh1.b1) **Essential Benchmark:** The characteristics and scope of technology.

Essential Learning:
In order to comprehend the scope of technology, students in grades 9-12 will learn:

1. Changes in technology are dependent on the environment in which it is developed.

2. Technological development continues today at a rapid pace, thanks largely to goal-specific research and profit/market motives.

(SV.sh1.b2) **Essential Benchmark:** The core concepts of technology.

Essential Learning:
In order to recognize the core concepts of technology, students in grades 9-12 will learn:

1. Systems, which are the building blocks of technology, can be simple or multi-layered and are only as stable as the individual parts with which they are comprised. Creating a system applicable in real life involves creativity, logic and appropriate, realistic goals and stipulations.

2. Creating a technological product necessitates the utilization of a set of realistic criterion (in which certain values are traded off to get the best possible product), the on-going optimization (or improvement) of the product and quality control/management of the product. Students should be aware that one result of technology creation is the need for additional, new processes.

(SV.sh1.b3) **Additional Benchmark:** The relationships among technologies and the connections between technology and other fields.

Learning:
In order to appreciate the relationships among technologies and other fields of study, students in grades 9-12 will learn:

1. Technological innovation is often the result of a conglomeration of ideas between different technologies and fields of study. These innovations are sometimes protected by patents and, in certain situations, can be used to fulfill a number of functions.

2. Technology aides in furthering studies in science and mathematics and vice versa.

PART II

St. Vrain Valley School District
- Standards for Technological Literacy -

Technology and Society
Students will develop an understanding of Technology and Society.

9th - 12th Grade

Technology and Society

(SV.sh2.b1) <u>Essential Benchmark:</u> The cultural, social, economic, and political effects of technology.

<u>Essential Learning:</u>
In order to recognize the changes in society caused by the use of technology, students in grades 9-12 will learn:

1. The effects of any given technology on any given society vary.

2. With any technology, it is necessary to weigh its various aspects, perform trade-offs depending on potentially positive or negative aspects of the product and take into account any ethical concerns as well.

(SV.sh2.b2) <u>Essential Benchmark:</u> The effects of technology on the environment.

<u>Essential Learning:</u>
In order to discern the effects of technology on the environment, students in grades 9-12 will learn:

1. The alignment of technological and natural processes can maximize technological performance and reduce negative environmental effects at the same time. Technology can be used to conserve various aspects of the environment and gain needed information from it as well.

2. Trade-offs must be made when implementing a technology that will affect the environment. New technologies are continually implemented to reduce the harm caused by older technology.

(SV.sh2.b3) <u>Additional Benchmark:</u> The role of society in the development and use of technology.

<u>Learning:</u>
In order to realize the impact of society on technology, students in grades 9-12 will learn:

1. Cultural wants and needs impact technology around the world

2. These needs decide whether a given technology will be developed and demanded, as do other factors like the economy and popular trends.

(SV.sh2.b4) Additional Benchmark: The influence of technology on history.

Learning:

In order to be aware of the history of technology, students in grades 9-12 will learn:

1. The development of technology has been a gradual process and has helped reshape society, the economy, etc. This development has resulted thanks to a greater understanding of tools, materials and technological know-how.

2. Important time periods in the development of technology have included the Iron and Middle Ages, the Renaissance, the Industrial Revolution and the Information Age.

PART III

St. Vrain Valley School District
- Standards for Technological Literacy -

Design
Students will develop an understanding of Design.

9th - 12th Grade

Design

(SV.sh3.b1) <u>Essential Benchmark:</u> Students will develop an understanding of the attributes of design.

<u>Essential Learning:</u>
In order to comprehend the attributes of design, students in grades 9-12 will learn:

1. The design process involves a number of processes, including the identification of a problem, and the development, proposal and creation of a product to solve that problem. These problems are rarely defined fully.

2. This product must continually be refined to account for things like criteria for the product and its efficiency.

(SV.sh3.b2) <u>Essential Benchmark:</u> Students will develop an understanding of engineering design.

<u>Essential Learning:</u>
In order to comprehend engineering design, students in grades 9-12 will learn:

1. The design process is influenced by personal skills, abilities and a number of other factors.

2. Proven design principles are used to evaluate designs, collect data about them, and guide the process as a whole. Working models called prototypes are often created to represent an actual system/product, and can be corrected, evaluated, etc.

(SV.sh3.b3) <u>Additional Benchmark:</u> Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem-solving.

<u>Learning:</u>
In order to be able to comprehend other problem-solving approaches, students in grades 9-12 will learn:

1. Technological problems must be researched and then solved with the development of a product/system. This entails problem-solving that is used in businesses and industries around the world.

2. Not all problems can be solved technologically, but even if they can, they may necessitate the use of a multidisciplinary approach.

PART IV

St. Vrain Valley School District
- Standards for Technological Literacy -

Abilities for a Technological World
Students will develop Abilities for a Technological World.

9th - 12th Grade

Abilities for a Technological World

(SV.sh4.b1) **Essential Benchmark:** Students will develop the abilities to apply the design process.

Essential Learning:
As part of learning how to apply design processes, students in grades 9-12 will:

1. Follow pre-established guidelines, create a design process in 2-D form and then apply it for real-life/lab situations, refining the process as needed.

2. Document the solution of the created product/system.

(SV.sh4.b2) **Essential Benchmark:** Students will develop the abilities to use and maintain technological products and systems.

Essential Learning:
As part of learning how to use and maintain technological products and systems, students in grades 9-12 will:

1. With the aid of computers and calculators, interpret, organize and maintain data gained from studying processes and procedures so that the data can eventually be communicated to different audiences through a variety of avenues.

2. Fix a malfunctioning system using technological knowledge and tools, and maintain that system so that it operates in the way it should.

(SV.sh4.b3)**Additional Benchmark:** Students will develop the abilities to assess the impact of products and systems.

Learning:
As part of learning how to assess the impact of products and systems, students in grades 9-12 will:

1. Collect and evaluate information about the effect of technology on today's society, individuals and environment. Then use assessment techniques to predict the development of future technology.

2. Evaluate the effects of natural system alteration by creating a forecasting system.

The following pages are the ITEA Standards from c. 2008 or 2009. These are the standards from which the St. Vrain standards were derived. This includes standards for both middle and high school.

Technology Standards

Category 1
Benchmark 1

In order to comprehend the scope of technology, students in grades 6-8 should learn that:

(I.C1.S1.BF) F. New products and systems can be developed to solve problems or to help to do things that could not be done without the help of technology. For example, engines increase the speed at which people can travel, and pumps move water to locations where it is needed. The use of technology sometimes helps to improve personal lives by lessening threats, such as disease, toil, or ignorance.
However, the desire or need for a new product or system can cause negative consequences, such as when people travel long hours to work in order to pay for improvements for their homes or child and healthcare.

(I.C1.S1.BG) G. The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative. Making life easier involves generating new products and systems through creativity and innovation. For example, from the time of the first gas cook stove in 1936 to the time of the microwave oven in 1967, the focus was on simplifying the process of cooking and reducing the time of food preparation.

(I.C1.S1.BH) H. Technology is closely linked to creativity, which has resulted in innovation. Most inventions are inspired by perceived needs and wants - the hairbrush, for example. Other inventions are linked to developing creative ideas and the way a person uses them, not necessarily their intended use. For example, the invention of the tea bag grew out of a packaging strategy to replace expensive tin containers. Although tea was packaged in small silk bags to give away as samples, some users thought it was a new way to brew the tea, and thus the tea bag was born. An invention can always be improved, and trying new ideas is often key to that improvement.

(I.C1.S1.BI) I. Corporations can often create demand for a product by bringing it onto the market and advertising it. Although market demand generally determines the success or failure of a technology, companies often develop products or systems before a need is identified. In order for a technology to be profitable, there must be a market for it - either preexisting or created through an advertising campaign. The promotion of a product or system often determines its popularity and demand.

In order to comprehend the scope of technology, students in grades 9-12 should learn that:

(I.C1.S1.BJ) J. The nature and development of technological knowledge and processes are functions of the setting. For example, the tractor, plow, and hay bailer are designed specifically for use around farms, while the pick-up truck, tanker, and tractor trailer are vehicles commonly used to move goods from farms to other areas.

(I.C1.S1.BK) K. The rate of technological development and diffusion is increasing rapidly. The rate of development of inventions and innovations is affected by many factors, such as time and money. New technologies are built on previous technologies, often resulting in quick development and dispersion. For example, the first hand-held electronic calculator was designed to perform simple arithmetic. It has quickly evolved from a bulky product owned by a few people to a miniature, multi-function version owned by many.

(I.C1.S1.BL) L. Inventions and innovations are the results of specific, goal-directed research. For example, years of research led to the design and development of a laser system used in atmospheric studies. This same laser system was then modified and reapplied to treat the buildup of plaque in the arteries through laser angioplasty.

(I.C1.S1.BM) M. Most development of technologies these days is driven by the profit motive and the market. The success of a technology is often determined by whether or not it is affordable and whether or not it works. People often develop and apply technology in a centralized and large-scale fashion to optimize efficiency and reliability, thus resulting in lower production costs.

Category 1
Benchmark 2

In order to recognize the core concepts of technology, students in grades 6-8 should learn that:

(I.C1.S2.BM) M. Technological systems include input, processes, output, and, at times, feedback. The input consists of the resources that flow into a technological system. The process is the systematic sequence of actions that combines resources to produce an output - encoding, reproducing, designing, or propagating, for example. The output is the end result, which can have either a positive or negative impact. Feedback is information used to monitor or control a system. A system often includes a component that permits revising or refining the system when the feedback information suggests such action. For example, the fuel level indicator of a car is a feedback system that lets the user know when the system needs additional fuel.

(I.C1.S2.BN) N. Systems thinking involves considering how every part relates to others. Systems are used in a number of ways in technology. Systems also appear in many aspects of daily life, such as solar systems, political systems, civil systems, and technological systems. Analyzing a system is done in terms of its individual parts or in terms of the whole system and how it interacts with or relates to other systems. For example, discussing a computer system may involve the particular parts of a single computer, or it may include the entire computer network. In contrast, discussing the solar system may involve listing the planets, stars, and other celestial bodies, or it may be discussed by comparing our solar system to other solar systems in the universe.

(I.C1.S2.BO) O. An open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback. An example of an open-loop system is a microwave oven that requires a person to determine if the food has been heated to the required temperature. An example of a closed-loop system is the heating system in a home, which has a thermostat to provide feedback when it needs to be turned on and off.

(I.C1.S2.BP) P. Technological systems can be connected to one another. Systems can be connected with the output of one system being the input to the next system. Sometimes the connection provides control of one system over another system.

(I.C1.S2.BQ) Q. Malfunctions of any part of a system may affect the function and quality of the system. When part of a system breaks or functions improperly, the results can range from a nuisance to a disaster.

(I.C1.S2.BR) R. Requirements are the parameters placed on the development of a product or system. These parameters are often referred to as criteria or constraints.

(I.C1.S2.BS) S. Trade-off is a decision process recognizing the need for careful compromises among competing factors. For example, a comparison may be made between increasing the takeoff power of a spacecraft and using lightweight materials. The increased power may result in larger engines, which may be heavier, while the use of the newly developed materials may offset weight concerns. When trade-offs are made, there is a choice or exchange for one quality or thing in favor of another.

(I.C1.S2.BT) T. Different technologies involve different sets of processes. For example, data processing includes designing, summarizing, storing, retrieving, reproducing, evaluating, and communicating, while the processes of construction include designing, developing, evaluating, making and producing, marketing, and managing.

(I.C1.S2.BU) 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 capability. All technological systems will eventually fail. Maintenance reduces the possibility of failing earlier. If maintenance is not done, failure is certain. The rate of failure depends on such factors as how complicated the system is, what kinds of conditions it must operate in, and how well it was originally built.

(I.C1.S2.BV) V. Controls are mechanisms or particular steps that people perform using information about the system that causes systems to change. The essence of a control mechanism is comparing information about what is happening to what is desired and then adjusting devices or systems to make the desired outcomes more likely. For example, a microprocessor may be used to control the performance of a microwave or traditional oven in cooking food to a desired temperature.

In order to recognize the core concepts of technology, students in grades 9-12 should learn that:

(I.C1.S2.BW) W. Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. It uses simulation and mathematical modeling to identify conflicting considerations before the entire system is developed.

(I.C1.S2.BX) X. Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems. For example, a food processor is a system made up of components and sub-systems. At the same time, a food processor is only one component in a larger food preparation system that, in turn, is a component in a larger home system.

(I.C1.S2.BY) Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. Cruise control in an automobile, for example, automatically detects and controls the speed of the car. Some delay in feedback or in functioning can cause a cycle to develop in a system.

(I.C1.S2.BZ) Z. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. Technological development involves decisions about which resources can and should be used. For example, some homes are very energy efficient, while others consume large amounts of energy.

(I.C1.S2.BAA) 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. Sometimes requirements can be constraints, criteria, or both. Balancing the two is the optimum.

(I.C1.S2.BBB) BB. Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints. Optimization is used for a specific design purpose to enhance or to make small gains in desirable characteristics. An optimum design is most possible when a mathematical model can be developed so that variations may be tested.

(I.C1.S2.BCC) CC. New technologies create new processes. The development of the computer has led to many new processes, such as the development of silicon chips, which led to smaller-sized components.

(I.C1.S2.BDD) DD. Quality control is a planned process to ensure that a product, service, or system meets established criteria. It is concerned with how well a product, service, or system conforms to specifications and tolerances required by the design. For example, a set of rigorous international standards (ISO 9000) has been established to help companies systematically increase the quality of their products and operations.

(I.C1.S2.BEE) EE. Management is the process of planning, organizing, and controlling work. Management is sometimes called getting work done through other people. Teamwork, responsibility, and interpersonal dynamics play a significant role in the development and production of technological products.

(I.C1.S2.BFF) FF. Complex systems have many layers of controls and feedback loops to provide information. Controls do not always succeed or work perfectly. The more parts and connections in a system, the more likely it is that something may not work properly; therefore, human intervention may be necessary at some point.

Category 1
Benchmark 3

In order to appreciate the relationships among technologies in other fields of study, students in grades 6-8 should learn that:

(I.C1.S3.BD) D. Technological systems often interact with one another. In automated manufacturing, for example, computer systems interact with manufacturing systems.

(I.C1.S3.BE) E. A product, system, or environment developed for one setting may be applied to another setting. For example, a computerized pump based on biological laboratory design for the Mars Viking space probe was modified for use as an insulin delivery mechanism that provides diabetics with an automatic and precise way to control blood sugar.

(I.C1.S3.BF) F. Knowledge gained from other fields of study has a direct effect on the development of technological products and systems. Studying the history of technology provides people with a way to learn from the successes and failures of their predecessors. In addition, skills learned from other fields of study enhance technological developments. For example, skills learned in language arts are used in making design presentations. The concepts and principles of drawing are used in designing and rendering examples of technological products and systems. Scientific and mathematical knowledge and principles influence the design, production, and operation of technological systems. Science concepts, such as Ohm's Law, aerodynamic principles, and the periodic table of elements, are used in the development of new materials and designs. Mathematical concepts, such as the use of measurement, symbols, estimation, accuracy, and the idea of scaling and proportion are key to developing a product or system and being able to communicate design dimensions and proper function.

In order to appreciate the relationships among technologies, as well as with other fields of study, students in grades 9-12 should learn that:

(I.C1.S3.BG) G. Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function. Aerospace composite materials, for instance, were used to design an advanced wheelchair that proved to be lightweight and easy to maneuver.

(I.C1.S3.BH) H. Technological innovation often results when ideas, knowledge, or skills are shard within a technology, among technologies, or across other fields. The sharing of knowledge about irrigation techniques, for instance, can enable developing countries to try out new ideas and make innovative adjustments to their current systems to improve the delivery of water.

(I.C1.S3.BI) I. Technological ideas are sometimes protected through the process of patenting. The protection of a creative idea is central to the sharing of technological knowledge. Most often an idea is protected through the long and tedious process of obtaining a patent. The purpose of a patent is to safeguard the investment of the inventor or creator and to give credit where and when it is due.

(I.C1.S3.BJ) J. Technological progress promotes the advancement of science and mathematics. Likewise, progress in science and mathematics leads to advances in technology. The development of binary language, a digital language made up solely of ones and zeros; the invention of the transistor, a device designed to replace the vacuum tube; and the use of integrated circuits, a collection of millions of miniature transistors, helped spawn a new generation of machines, from laptop computers and compact disc players to digital television. The mathematical and scientific ideas applied in the development of these digital devices promoted further developments that resulted in new tools, such as computer modeling. These tools, in turn, are used to explore new scientific and mathematical ideas, thereby spawning additional discoveries.

Category 2
Benchmark 4

In order to recognize the changes in society caused by the use of technology, students in grades 6-8 should learn that:

(I.C2.S4.BD) D. The use of technology affects humans in various ways, including their safety, comfort, choices, and attitudes about technology's developments and use. People's attitudes toward and knowledge about a product or system, along with their subsequent actions, vary greatly and are influenced by their moral, social, or political beliefs. For example, some might support the construction of a high-voltage electric transmission line because it would provide electricity to people in remote areas, while others who live near the path of the power line might not support it because of potential effects of their health and safety. Sometimes people are well informed about a product or system, while at other times they have limited information to make their choices about whether a technology should be developed or used.

(I.C2.S4.BE) 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. For example, fossil fuels have both desired and undesired consequences. While these fuels provide a good source of energy, their use may damage the environment.

(I.C2.S4.BF) F. The development and use of technology poses ethical issues. People often wonder whether the use of some technologies is ethically acceptable. For example, should we allow everyone to purchase a gun?

(I.C2.S4.BG) G. Economic, political, and cultural issues are influenced by the development and use of technology. For example, information technology systems have been used to both inform and influence society. Technology also affects the way people of different cultures live, the kind of work they do, and the decisions they have to make.

In order to recognize the changes in society caused by the use of technology, students in grades 9-12 should learn that:

(I.C2.S4.BH) H. Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious. Those changes have resulted in people having information overload, rapid adaptation or acceptance of short-lived relationships, and the need for instant gratification. For example, when people listen to a classic album or watch television on their high-tech entertainment system, they are able to program segments of the album to play in a certain sequence or watch two television programs at once while they preview the highlights of a third and record the fourth.

(I.C2.S4.BI) I. Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects. These decisions can have lasting impacts, sometimes affecting living habits and cultural patterns on a global scale. The construction and use of the interstate system require considering the benefits of providing a safe and quick mode of transportation, as well as the effects on the economy and society.

(I.C2.S4.BJ) J. Ethical considerations are important in the development, selection, and use of technologies. For example, medical advances for prolonging life and treating illness have triggered concerns about health care providers giving more attention to the best technological solution than to human values or needs. Questions about how medical technologies should be used to sustain life and the related costs must be considered. High-tech medicine has transformed the philosophy of doing everything possible to prolong life into a consideration that living longer may not necessarily mean living better.

(I.C2.S4.BK) 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. Sharing methods to increase food production and preservation can alter a country's living habits in significant ways. For example, the idea for developing flash freezing, a method to freeze foods that preserves the flavor, appearance, and nutritional value, was based on how the people of Labrador preserved their food. The resulting invention, frozen food that is ready to heat and eat, has considerably changed the living habits and culture of many societies.

Category 2
Benchmark 5

In order to discern the effects of technology on the environment, students in grades 6-8 should learn that:

(I.C2.S5.BD) D. The management of waste produced by technological systems is an important societal issue. Recycling materials, such as glass, paper, and aluminum has decreased the waste that is sent to landfills, thereby reducing the need for new disposal sites.

(I.C2.S5.BE) 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. New building technologies and landscaping techniques can be used to reduce the effects of earthquakes and major storms. In addition, innovative ways of redoing waste production can aid in repairing the environment. For example, the use of bacteria in sewage treatment helps to clean human waste prior to being released into rivers or lakes.

(I.C2.S5.BF) F. Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another. For example, decisions on the use of nuclear power, wetlands preservation, and placement of roads and highways are sometimes in direct conflict with many different viewpoints and interests.

In order to discern the effects of technology on the environment, students in grades 9-12 should learn that:

(I.C2.S5.BG) G. Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing and recycling. For example, water treatment and filtering technologies can facilitate the reuse of water; wind and water erosion can be reduced by no-till farming; and aluminum containers can be recycled.

(I.C2.S5.BH) H. When new technologies are developed to reduce the use of resources, the considerations of trade-offs are important. Examples include the cost and limited output of photo voltaic cells to produce electricity mainly in remote areas and the potential long-term side effects of new drugs.

(I.C2.S5.BI) I. With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. The development of a wide range of instrumentation to monitor the effects of human-made gases, such as CFCs or monitor the effects of weather patterns (meteorology) and other atmospheric conditions are examples of these technologies.

(I.C2.S5.BJ) J. The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. For example, buildings can be strategically oriented to the sun to maximize solar gain, and biodegradable materials can be used as compost to make the soil more productive.

(I.C2.S5.BK) K. Humans devise technologies to reduce the negative consequences of other technologies. Examples include scrubbers for coal burning generation facilities, fuels that burn more clearly and, materials separation processes that aid in the recycling process.

(I.C2.S5.BL) L. Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment. For example, the implementation of advanced transportation technologies, such as shuttles and metro rails, has had an enormous impact on the ability to travel. At the same time, roadways, urban sprawl, and automobile emissions have directly affected the environment. Indirect effects include factors such as pollution caused by manufacturing and junked cars.

Categort 2
Benchmark 6

In order to realize the impact of society on technology, students in grades 6-8 should learn that:

(I.C2.S6.BD) D. Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies. The development of the typewriter helped speed the preparation of documents for many businesses, while the development of the photocopying machine revolutionized the process of duplicating documents. The typewriter and photocopying machine were followed by many other innovations including an electronic facsimile (fax) machine, and electronic mail (e-mail), which continue to change the way people correspond and keep records.

(I.C2.S6.BE) E. The use of inventions and innovations has led to changes in society and the creation of new needs and wants. For example, the initial creation of radios, televisions, and sound systems has led to an ever-growing demand for entertainment and information. Thus, the development of technology sometimes creates the demand.

(I.C2.S6.BF) F. Social and cultural priorities and values are reflected in technological devices. For example, an unenthusiastic attitude toward the use of genetically engineered foods has affected the development of this technology, yet many seed-producing companies are pressed to develop insect- and disease-resistant plants. Likewise, consumer tastes influence technological designs, such as the color and contours of household appliances. For example, new appliances are not marketed in the rounded shapes of the 1950s or the avocado green color of the 1970s.

(I.C2.S6.BG) G. Meeting societal expectations is the driving force behind the acceptance and use of products and systems. Whether or not a technology is accepted by society depends, first, on whether is does its job and, second, on how well it accords with various economic, political, cultural, and environmental concerns. With little regard to underlying technology, people expect buildings to provide shelter, bridges to span water, and dams to provide power and recreation.

In order to realize the impact of society on technology, students in grades 9-12 should learn that:

(I.C2.S6.BH) H. Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and values. American transportation systems are closely linked to freedom and independence, whereas other cultures might place more value on the speed and convenience associated with mass transportation systems.

(I.C2.S6.BI) I. The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. The technological expertise to develop a particular product or system may be available, but if the public reaction to such a development is in opposition, or if a corporation refuses to adjust to new and complex ideas, the development is most often limited or stopped.

(I.C2.S6.BJ) 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. Sometimes these forces are consistent with one another. At other times, they may compete. The general public may or may not be aware of the influences that shape technology or of how technological development will impact the environment.

Category 2
Benchmark 7

In order to be aware of the history of technology, students in grades 6-8 should learn that:

(I.C2.S7.BC) C. Many inventions and innovations have evolved by using slow and methodical processes of tests and refinements. For example, during the development of the incandescent light bulb, Thomas Edison and a team of 20 highly skilled technical personnel performed more than 1,000 tests before they narrowed their ideas to the one that worked. Since that first light bulb burned for 13 hours in 1879, there have been many innovations and design changes.

(I.C2.S7.BD) D. The specialization of function has been at the heart of many technological improvements. For example, the early steam engine was originally designed with a single chamber in which steam expanded and then was condensed - thus performing both of the two very different functions of the steam engine in the same place. Fifty years later, by isolating the functions of the cylinder and steam condenser into separate components, James Watt created a more efficient steam engine.

(I.C2.S7.BE) 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. For example, the purpose of Roman aqueducts was to provide a service by moving water from the surrounding hills to the city. The water flowed through channels, some above ground on high arches or tiers, while most were underground and were designed with a slight downward grade. Building the aqueducts required much organization, as well as an understanding of the materials and terrain.

(I.C2.S7.BF) F. In the past, and invention or innovation was not usually developed with the knowledge of science. The introduction of science knowledge combined with technological knowledge led to a great increase in engineering and technological development. The development of a new product or system often happens in areas that have not been analyzed by science or in areas where science knowledge is being gathered alongside the technological development, such as is space programs.

In order to be aware of the history of technology, students in grades 9-12 should learn that:

(I.C2.S7.BG) G. Most technological development has been evolutionary, the result of a series of refinements to a basic invention. For example, the development of the pencil was a long and tedious process. Engineers, designers, and technicians developed many different techniques and processes to use a variety of materials in order to develop the best pencil possible. Often a product of system will have a direct impact or dependence on another, which will affect the pact and nature of the change in one or both of them. For example, information and communication technologies have had an enormous impact on the development of the transportation system.

(I.C2.S7.BH) H. The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials. Communication, agriculture, and transportation have evolved out of the political, economic, and social interests and values of the times. The use of electricity, farm tractors, and airplanes have enhanced safety and comfort, aided in different means of communication, and helped provide food and transportation.

(I.C2.S7.BI) I. Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape. The study of the history of technology helps determine possible scenarios for the future. For example, the development of the mechanical clock in the fourteenth century changed how people regarded their use of time.

(I.C2.S7.BJ) 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. The Stone Age started with the development of stone tools used for hunting, cutting and pounding vegetable and meat and progressed to the harnessing of fire for heating, cooking, and protection. The Bronze Age began with the discovery of copper and copper-based metals. Agricultural techniques were developed to improve the cultivation of food and its supply. This period also involved the development of better ways to communicate through the development of paper, ink, and the alphabet, to navigate with boats made of timbers, and to understand human anatomy with the aid of an embalming process.

(I.C2.S7.BK) K. The Iron Age was defined by the use of iron and steel as the primary materials for tools. During this period, sustained technological advancement caused many people to migrate from farms to developing towns and cities. Other influential developments in this age included weaving machines and the spinning wheel, which advanced the making of cloth, and gunpowder and guns, which were an improvement over previous weapons for both hunting and protection. The wide application of new agricultural technologies, such as the sickle, the plow, the windmill, and irrigation, enabled fewer farmers to grow more food.

(I.C2.S7.BL) L. The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society. This period saw the development of the waterwheel, the block printing process, paper money, the magnetic compass, and the printing press. In many ways, all of these devices are still being used today, although they have been greatly modified from their earlier designs.

(I.C2.S7.BM) M. The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology. Leonardo Da Vinci, an Italian painter, architect, and engineer, created drawings and written descriptions of the human flying machine, a helicopter, parachutes, diving bell suit, articulated chains, a giant crossbow, and circular armored vehicles. Gunsmiths, while seeking a means to adjust their gun mechanisms, invented the first screwdriver. The camera obscura, silk knitting machines, the telescope, the submarine, the hydraulic press, and the calculating machine also were developed during this time period.

(I.C2.S7.BN) N. The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time. Major developments of this period included the continuous-process flour mill, power loom and pattern-weaving loom, steam engine, electric motor, gasoline and diesel engines, vulcanized rubber, airplane, telegraph, telephone, radio, and television. The concepts of Eli Whitney's interchangeable parts and Henry Ford's movable conveyor added to the advances made in the production of goods. Extended free time was possible as a result of increased efficiency, and consequently, widespread education became possible because children were not needed on the farm and could stay in school longer.

(I.C2.S7.BO) O. The Information Age places emphasis on the processing and exchange of information. The development of binary language, transistors, microchips, and an electronic numerical integrator and calculator (ENIAC) led to an explosion of computers, calculators, and communication processes to quickly move information from place to place. Holography, cybernetics, xerographic copying, the breeder reactor, the hydrogen bomb, the lunar landing ship, communication satellites, prefabrication, biotechnology, and freeze-drying have all been major developments during this time period.

Category 3
Benchmark 8

In order to comprehend the attributes of design, students in grades 6-8 should learn that:

(I.C3.S8.BE) E. Design is a creative planning process that leads to useful products and systems. The design process typically occurs in teams whose members contribute different kinds of ideas and expertise. Sometimes a design is for a physical object such as a house, bridge, or appliance and sometimes it is for a non-physical thing, such as software.

(I.C3.S8.BF) F. There is no perfect design. All designs can be improved. The best designs optimize the desired qualities - safety, reliability, economy, and efficiency - within the given constraints. All designs build on the creative ideas of others.

(I.C3.S8.BG) G. Requirements for a design are made up of criteria and constraints. Criteria identify the desired elements and features of a product or system and usually relate to their purpose or function. Constraints, such as size and cost, establish the limits on a design.

In order to recognize the attributes of design, students in grades 9-12 should learn that:

(I.C3.S8.BH) 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. The design process is a systematic, iterative approach to problem solving that promotes innovation and yields design solutions. To systematically seek an optimum design solution, engineers and other design professionals use experience, education, established design principles, creative intuition, imagination, and culturally specific requirements.

(I.C3.S8.BI) I. Design problems are seldom presented in a clearly defined form. Design goals and requirements must be established and constraints must be identified and prioritized during the time when designs are being developed. Design decision typically involve individual, familial, economic, social, ethical, and political issues. Often, these issues lead to conflicting solutions. For example, what may be politically popular may not make good economic or social sense. Based on these issues and depending on the impact of the design, certain design solutions should not be developed.

(I.C3.S8.BJ) J. The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. The design process also involves considering how designs will be developed, produced, maintained, managed, used, and assessed. As a result, multiple solutions are possible. More knowledge or competing technologies cause a design to change with time.

(I.C3.S8.BK) K. Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. When such competition happens, trade-offs occur, and the design is modified to accommodate these requirements. Different people may choose different solutions, depending on how they weigh factors.

Category 3
Benchmark 9

In order to comprehend engineering design, students in grades 6-8 should learn that:

(I.C3.S9.BF) F. Design involves a set of steps, which can be performed in different sequences and repeated as needed. Each design problem is unique and may require different procedures or demand that the steps be performed in a different sequence. In addition, engineers and designers also have their preferences and problem-soling styles and may choose to approach the design process in different ways.

(I.C3.S9.BG) G. Brainstorming is a group problem-soling design process in which each person in the group presents his or her ideas in an open forum. In this process, no person is allowed to criticize anyone else's ideas regardless of how inane they may seem. After all of the ideas are recorded, the group selects the best ones, and then further develops them.

(I.C3.S9.BH) H. Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. Historically, this process has centered on creating and testing physical models. Models are especially important for the design of large items, such as cars, spacecraft, and airplanes because it is cheaper to analyze a model before the final products and systems are actually made. Evaluation is used to determine how well the designs meet the established criteria and to provide direction for refinement. Evaluation procedures range from visually inspecting to actually operating and testing products and systems.

In order to comprehend engineering design, students in grades 9-12 should learn that:

(I.C3.S9.BI) I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. The design principles include flexibility, balance, function, and proportion. These principles can be applied in many types of design and are common to all technologies.

(I.C3.S9.BJ) J. Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. Individuals and groups of people who possess combinations of these characteristics tend to be good at generating numerous alternative solutions to problems. The design process often involves a group effort among individuals with varied experiences, background, and interests. Such collaboration tends to enhance creativity, expand the range of possibilities, and increase the level of expertise directed toward design problems.

(I.C3.S9.BK) K. A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. Prototyping helps to determine the effectiveness of a design by allowing a design to be tested before it is built. Prototypes are vital to the testing and refinement of a product or system with complicated operations (e.g., automobiles, household appliances, and computer programs).

(I.C3.S9.BL) L. The process of engineering design takes into account a number of factors. These factors include safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics).

Category 3
Benchmark 10

In order to be able to comprehend other problem-solving approaches, students in grades 6-8 should learn that:

(I.C3.S10.BF) F. Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system. These kinds of problems typically require some type of specialized knowledge. For example, knowledge about how a derailleur works is needed in order to find out why a bicycle does not shift properly. Once the cause of the problem has been identified, the next step is to repair and test it.

(I.C3.S10.BG) 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. All technological refinement occurs through the process of innovation.

(I.C3.S10.BH) H. Some technological problems are best solved through experimentation. These include experimentation with technological products and systems. This process closely resembles the scientific method. The difference between these methods is the goals that each pursue. The goal of science is to understand how nature works, while the goal of technology is to create the human-made world. In both cases, the process is systematic and involves tinkering, hypothesizing, observing, tweaking, testing, and documenting.

In order to be able to comprehend other problem-solving approaches, students in grades 9-12 should learn that:

(I.C3.S10.BI) 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. Research on specific topics of interest to the government or business and industry can provide more information on a subject, and, in many cases, it can provide the knowledge to create an invention or innovation. Development helps to prepare a product or system for final production. Product development of this type frequently requires sustained effort from teams of people having diverse backgrounds.

(I.C3.S10.BJ) J. Technological problems must be researched before they can be solved. When a problem appears, it is first necessary to learn enough about it to decide the best type of problem-solving method.

(I.C3.S10.BK) K. Not all problems are technological, and not every problem can be solved using technology. Technology cannot be used to provide successful solutions to all problems or to fulfill every human need or want. Instead, some problems do best with non-technological solutions. For example, recycling to reduce pollution and conserve resources is a behavioral solution to a technological problem. In the area of healthcare, healthy living practices, such as good nutrition and regular exercise, can often prevent and solve problems that surgery and medications cannot.

(I.C3.S10.BL) L. Many technological problems require a multidisciplinary approach. Depending on the nature of a problem, a wide range of knowledge may be required. For example, the research and development of a new video game could benefit from knowledge of physiology (e.g., reaction times and hand-eye coordination) as well as psychology (e.g., attention span and).

Category 4
Benchmark 11

As part of learning how to apply design processes, students in grades 6-8 should be able to:

(I.C4.S11.BH) H. Apply a design process to solve problems in and beyond the laboratory-classroom. Perform research, then analyze and synthesize the resulting information gathered through the design process. Identify and select a need, want, or problem to solve, which could result in a solution that could lead to an invention (an original solution) or an innovation (a modification of an existing solution). Identify goals of the problem to be solved. These goals specify what the desired result should be.

(I.C4.S11.BI) I. Specify criteria and constraints for the design. Examples of criteria include function, size, and materials, while examples of constraints are costs, time, and user requirements. Explore various processes and resources and select and use the most appropriate ones. These processes and resources should be based on the criteria and constraints that were previously identified and specified.

(I.C4.S11.BJ) J. Make two-dimensional representations of the designed solution. Two-dimensional examples include sketches, drawings, and computer-assisted designs (CAD). A model can take many forms, including graphic, mathematical, and physical.

(I.C4.S11.BK) K. Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed. Testing and evaluation determine if the proposed solution is appropriate for the problem. Based on the results of the tests and evaluation, students should improve the design solution. Problem-solving strategies involve applying prior knowledge, asking questions, and trying ideas.

(I.C4.S11.BL) L. Make a product or system and document the solution. Group process skills should be used, such as working with others in a cooperative team approach and engaging in appropriate quality and safety practices. Students should be encouraged to use design portfolios, journals, drawings, sketches, or schematics to document their ideas, processes, and results. There are many additional ways to communicate the results of the design process to others, such as a World Wide Web page or a model of a product or system.

As part of learning how to apply design processes, students in grades 9-12 should be able to:

(I.C4.S11.BM) M. Identify the design problem to solve and decide whether or not to address it. It is important to determine whether the design problem is worthy of being addressed or solved. If the problem is worthy of being solved, students should research, investigate, and generate ideas for the design. Brainstorming is an excellent technique for generating ideas and encouraging creative thinking. Designers often use this technique. Next, synthesize the research and specify the goals of the design. Deductive thinking processes should be used to limit the possible solutions to a few good ones.

(I.C4.S11.BN) N. Identify criteria and constraints and determine how these will affect the design process. Identifying criteria and specifying constraints will provide the basis for what the design should be and what its limits are. Carefully consider concept generation, development, production, marketing, fiscal matters, use, and disposability of a product or system. Test, experiment with, select, and use a variety of resources to optimize the development of the design. If sufficient resources could be modified or new ones could be identified. Identify and consider trade-offs among the proposed solutions. Next, plan and select the best possible solution that takes into account the constraints and criteria obtained from research and personal preference. This involves synthesizing various factors, including the constraints, criteria, and information gathered by research.

(I.C4.S11.BO) O. Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. Evaluate proposed or existing designs in the real world. Modify the design solution so that it more effectively solves the problem by taking into account the design constraints in order to consider the next step.

(I.C4.S11.BP) 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. Checking the design solutions against criteria and constraints is central to the evaluation process. Assess previously ignored solutions, perhaps with modifications, as possible choices. When previously favored solutions are discarded, they may be still appropriate for consideration later in the design process.

(I.C4.S11.BQ) Q. Develop and produce a product or system using a design process. Sometimes items can be produced in single quantity, while others can be made in batches or volume production. Quality control ensures that the product is of high enough quality to be sold.

(I.C4.S11.BR) 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. The final results should be compared to the original goals, criteria, and constraints.

Category 4
Benchmark 12

As part of learning how to use and maintain technological products and systems, students in grades 6-8 should be able to:

(I.C4.S12.BH) H. Use information provided in manuals, protocols, or by experienced people to see and understand how things work. This information is helpful in learning how to use a product and determining if it works properly. In addition, many manuals provide tips on how to troubleshoot a product or system.

(I.C4.S12.BI) I. Use tools, materials, and machines safely to diagnose, adjust, and repair systems. For many consumer products, federal and state laws require safety information. Safety procedures should be learned through formal education.

(I.C4.S12.BJ) J. Use computers and calculators in various applications. Computers can be used to control production systems and to research answers to problems.

(I.C4.S12.BK) K. Operate and maintain systems in order to achieve a given purpose. The understanding of how a system works is vital if one is to operate and maintain is successfully. Examples of everyday systems could include the Internet, control systems such as robots, and gating circuits for digital processing of information.

As part of learning how to use and maintain technological products and systems, students in grades 9-12 should be able to:

(I.C4.S12.BL) L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. Examples of such techniques include flow charts, drawings, graphics, symbols, spreadsheets, graphs, time charts, and World Wide Web pages. The audiences can be peers, teachers, local community members, and the global community.

(I.C4.S12.BM) M. Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it. Various items, such as digital meters or computer utility diagnostic tools, can be used in the maintenance of a system.

(I.C4.S12.BN) N. Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision. Monitoring the operation, adjusting the parts, cleaning, and oiling of a system represent examples of how a product or system can be properly maintained.

(I.C4.S12.BO) O. Operate systems so that they function in the way they were designed. These systems may include two-way communication radios, transportation systems that move goods from one place to another, and power systems that convert solar energy to electrical energy. Using safe procedures and following directions is absolutely essential to ensuring an accident-free working environment.

(I.C4.S12.BP) P. Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. Many resources, such as library books, the Internet, word processing, and spreadsheet software, in addition to computer aided design (CAD) software can be used to access information.

Category 4
Benchmark 13

As part of learning how to assess the impact of products and systems, students in grades 6-8 should be able to:

(I.C4.S13.BF) F. Design and use instruments to gather data. Examples of these instruments could be a data-collection instrument for interviews, questionnaires to be mailed, or computer-baed forms on the World Wide Web. Assessment tools also could include devices designed to conduct tests on such things as water quality, air purity, and ground pollution.

(I.C4.S13.BG) G. Use data collected to analyze and interpret trends in order to identify the positive or negative effects of a technology. Technologically literate citizens are able to fulfill their personal and social responsibility to assess technology.

(I.C4.S13.BH) H. Identify trends and monitor potential consequences of technological development. Trends are patterns of technological activities that show a tendency or take a general direction. Trends are used to provide direction in deciding if a product or system should be used.

(I.C4.S13.BI) I. Interpret and evaluate the accuracy of the information obtained and determine if it is useful. Developing specific criteria for what is useful is important in making these judgments. Sometimes determining accuracy is easy - taking information from physical measuring devices like a water-purity tester, for example. At other times, accuracy is more difficult to determine, as when assessments are based on public opinion, which can differ greatly from group to group and from time to time.

As part of learning how to assess the impact of products and systems, students in grades 6-8 should be able to:

(I.C4.S13.BJ) J. Collect information and evaluate its quality. This may include using such methods as comparing and contrasting sources, examining relevancy, and investigating the background of experts.

(I.C4.S13.BK) K. Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment. Deductive thinking and synthesis techniques can assist in this process. Students should take into account historical events, global trends, and economic factors, and they should evaluate and consider how to manage the risks incurred by technological developments.

(I.C4.S13.BL) L. Use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology. Assessment is an evaluation technique involving iterative steps and procedures that requires analyzing trade-offs, estimating risks, and choosing a best course of action. The assessment of a product or system can prove that it is dangerous, but it cannot prove that it is safe.

(I.C4.S13.BM) M. Design forecasting techniques to evaluate the results of altering natural systems. These techniques should include testing and assessment. These natural systems could be lakes (building homes around the shore), rain forests (cutting them down for the wood), or land (strip mining for coal).