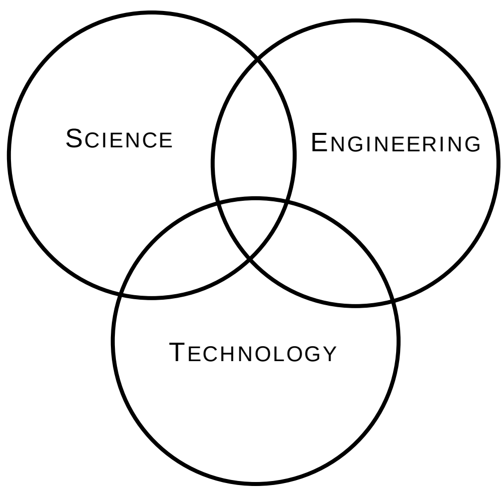
Technology/Engineering

Technology/engineering works in conjunction with science to expand our capacity to understand the world. Science investigates the natural world. The goal of engineering is to solve practical problems through the development or use of technologies, based on the scientific knowledge gained through investigation.

For example, the planning, design, and construction of the Central Artery Tunnel project in Boston (the "Big Dig") was a complex and technologically challenging project that drew on knowledge of earth science and physics, as well as on construction and transportation technologies. Scientists and engineers apply scientific knowledge of light to develop lasers, fiber optic technologies, and other technologies in medical imaging. They also apply this scientific knowledge to develop such modern communications technologies as telephones, fax machines, and electronic mail.

The Relationships Among Science, Engineering, and Technology

Science seeks to understand the natural world, and often needs new tools to help discover the answers.



Engineers use scientific discoveries to design products and processes that meet society's needs.

Technologies (products and processes) are the result of engineered designs. They are created by technicians to solve societal needs and wants.

Although the term *technology* is often used by itself to describe the educational application of computers in a classroom, computers and instructional tools that use computers are only a few of the many technological innovations in use today. The focus of this Technology/Engineering strand is on applied technologies such as engineering design, construction, and transportation, not on instructional technology such as computer applications for classrooms.

Technologies developed through engineering include the systems that provide our houses with water and heat; roads, bridges, tunnels, and the cars that we drive; airplanes and spacecraft; cellular phones, televisions, and computers; many of today's toys; and systems that create special effects in movies. Each of these came about as the result of recognizing a need or problem and creating a technological solution using the engineering design process, as illustrated in the figure on page 84. Beginning in the early grades and continuing through high school, students carry out this design process in ever more sophisticated ways. As they gain more experience and knowledge, they are able to draw on other disciplines, especially mathematics and science, to understand and solve problems.

- Even before entering **grades PreK–2**, students are experienced technology users. Their natural curiosity about how things work is clear to any adult who has ever watched a child doggedly work to improve the design of a paper airplane, or to take apart a toy to explore its insides. They are also natural engineers and inventors, builders of sandcastles at the beach and forts under furniture. Most students in grades PreK–2 are fascinated with technology. While learning the safe uses of tools and materials that underlie engineering solutions, PreK–2 students are encouraged to manipulate materials that enhance their three-dimensional visualization skills–an essential component of the ability to design. They identify and describe characteristics of natural and humanmade materials and their possible uses, and identify uses of basic tools and materials (e.g., glue, scissors, tape, ruler, paper, toothpicks, straws, spools). In addition, PreK–2 students learn to identify tools and simple machines used for specific purposes (e.g., ramp, wheel, pulley, lever). They also learn to describe how human beings use parts of the body as tools.

  Learning standards for PreK–2 fall under the following two subtopics: *Materials and Tools;* and *Engineering Design.*

- Students in **grades 3–5** learn how appropriate materials, tools, and machines extend our ability to solve problems and invent. They identify materials used to accomplish a design task based on the materials' specific properties, and explain which materials and tools are appropriate to construct a given prototype. They achieve a higher level of engineering design skill by recognizing a need or problem, learning different ways that the problem can be represented, and working with a variety of materials and tools to create a product or system to address the problem.

  Learning standards for grades 3–5 fall under the following two subtopics: *Materials and Tools;* and *Engineering Design.*

- In **grades 6–8**, students pursue engineering questions and technological solutions that emphasize research and problem solving. They identify and understand the five elements of a technology system (goal, inputs, processes, outputs, and feedback). They acquire basic safety skills in the use of hand tools, power tools, and machines. They explore engineering design; materials, tools, and machines; and communication, manufacturing, construction, transportation, and bioengineering technologies. Starting in grades 6–8 and extending through grade 10, the topics of power and energy are incorporated into the study of most areas of technology. Grades 6–8 students use knowledge acquired in their mathematics and science curricula to understand engineering. They achieve a more advanced level of skill in engineering design by learning to conceptualize a problem, design prototypes in three dimensions, and use hand and power tools to construct their prototypes, test their prototypes, and make modifications as necessary. The culmination of the engineering design experience is the development and delivery of an engineering presentation. Because of the hands-on, active nature of the technology/engineering environment, it is strongly recommended that it be taught by teachers who are certified in technology education, and who are very familiar with the safe use of tools and machines.

Learning standards for grades 6–8 fall under the following seven subtopics: *Materials, Tools, and Machines; Engineering Design; Communication Technologies; Manufacturing Technologies; Construction Technologies; Transportation Technologies;* and *Bioengineering Technologies.*

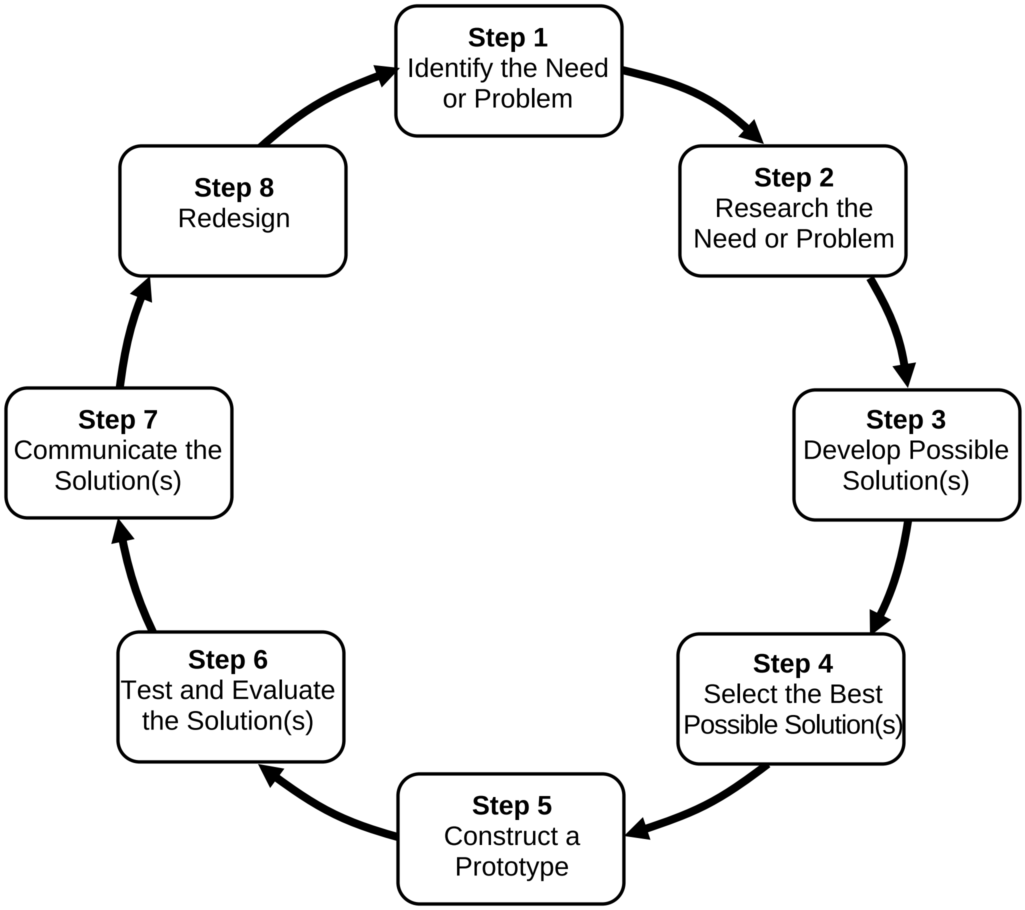
- In **high school,** students develop their ability to solve problems in technology/engineering using mathematical and scientific concepts. High school students are able to relate concepts and principles they have learned in science with knowledge gained in the study of technology/engineering. For example, a well-rounded understanding of energy and power equips students to tackle such issues as the ongoing problems associated with energy supply and energy conservation.

  In a high school technology/engineering course, students pursue engineering questions and technological solutions that emphasize research and problem solving. They achieve a more advanced level of skill in engineering design by learning how to conceptualize a problem, develop possible solutions, design and build prototypes or models, test the prototypes or models, and make modifications as necessary. Throughout the process of engineering design, high school students are able to work safely with hand and/or power tools, various materials and equipment, and other resources. In high school, courses in technology/engineering should be taught by teachers who are certified in that discipline and who are familiar with the safe use of tools and machines.

  Learning standards for high school fall under the following seven subtopics: *Engineering Design; Construction Technologies; Energy and Power Technologies—Fluid Systems; Energy and Power Technologies—Thermal Systems; Energy and Power Technologies—Electrical Systems; Communication Technologies;* and *Manufacturing Technologies.*

Technology/Engineering learning standards are also grouped under Broad Topics in Appendix I, which highlights the relationships of standards among grade spans..

Steps of the Engineering Design Process



1. Identify the need or problem
2. Research the need or problem
   - Examine the current state of the issue and current solutions
   - Explore other options via the Internet, library, interviews, etc.
3. Develop possible solution(s)
   - Brainstorm possible solution(s)
   - Draw on mathematics and science
   - Articulate the possible solution(s) in two and three dimensions
   - Refine the possible solution(s)
4. Select the best possible solution(s)
   - Determine which solution(s) best meet(s) the original need or solve(s) the original problem
5. Construct a prototype
   - Model the selected solution(s) in two and three dimensions
6. Test and evaluate the solution(s)
   - Does it work?
   - Does it meet the original design constraints?
7. Communicate the solution(s)
   - Make an engineering presentation that includes a discussion of how the solution(s) best meet(s) the initial need or the problem
   - Discuss societal impact and tradeoffs of the solution(s)
8. Redesign
   - Overhaul the solution(s) based on information gathered during the tests and presentation