Steps of the Engineering Design Process (cont.)

4. Select the best possible solution(s)
   - Determine which solution(s) best meet(s) the original requirements
5. Construct one or more prototypes and/or models
   - 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 needs of the initial problem or need
   - Discuss societal impact and tradeoffs of the solution(s)
8. Redesign
   - Modify the solution(s) based on information gathered during the tests and presentation

**The Engineering Design Process is also listed under the first content standard of the Engineering Design subtopic in this course.*

III. Mathematical Skills

Students are expected to know the content of the *Massachusetts Mathematics Curriculum Framework,* through grade 8. Below are some specific skills from the *Mathematics Framework* that students in this course should have the opportunity to apply:

- ✓ Construct and use tables and graphs to interpret data sets.
- ✓ Solve simple algebraic expressions.
- ✓ Perform basic statistical procedures to analyze the center and spread of data.
- ✓ Measure with accuracy and precision (e.g., length, volume, mass, temperature, time)
- ✓ Use both metric/standard international (SI) and U.S. Customary (English) systems of measurement.
- ✓ Convert within a unit (e.g., centimeters to meters, inches to feet).
- ✓ Use common prefixes such as *milli-, centi-,* and *kilo-*.
- ✓ Use scientific notation, where appropriate.
- ✓ Use ratio and proportion to solve problems.

The following skills are not detailed in the *Mathematics Framework*, but are necessary for a solid understanding in this course:

- ✓ Determine the correct number of significant figures.
- ✓ Determine percent error from experimental and accepted values.
- ✓ Use appropriate metric/standard international (SI) units of measurement for mass (kg); length (m); time (s); power (W); electric current (A); electric potential difference/voltage (V); and electric resistance (Ω).
- ✓ Use the Celsius and Fahrenheit scales.

WHAT IT LOOKS LIKE IN THE CLASSROOM

A Look at Energy-Efficient Homes

Adapted from *Standards for Technological Literacy*, p. 197

Technology/Engineering, High School

The city of Westlake and the surrounding areas experienced an accelerated growth in the construction industry, especially in new home construction. The local high school technology teacher, Mr. Morales, thought it would be helpful for his students, as future consumers, to have an in-depth understanding of the housing industry and to know about the latest developments in home construction techniques, materials, and practices.

Mr. Morales decided to organize a lesson where students were invited to participate in designing an energy-efficient home for a family of four. He guided the students to consider all forms of energy and not to limit their imaginations. Students were instructed to consider costs of using energy-efficient designs and how those costs might affect the resale value of a home.

He instructed the students in his technology class to individually design, draw, and build a scale model of a residential home using heating and cooling systems that were energy-efficient, aesthetically pleasing, functional, marketable, and innovative. The house also had to accommodate a family of four with a maximum size of 2100 square feet. Each student had to work within a budget of $150,000, and had nine weeks to complete the project.

The students began by researching homes in their city that already incorporated features that were required in their project. They conducted library and Internet searches to learn about the latest materials and techniques available in the housing industry. Students also interviewed local architects and building contractors to learn about current practices and how these professionals were integrating innovative features. For example, the students learned about incorporating increased day lighting, which takes into account the home's orientation, into the design of the home. They also learned about designing and installing environmentally sound, energy-efficient systems and incorporating whole-home systems that are designed to provide house maintenance, home security, and indoor air-quality management.

The students then began the process of sketching their homes. Many students had to gather additional research as they realized they needed more information to complete their sketches. Using their sketches, the students built scale models of their homes out of mat board.

A group of building industry professionals from across the area was invited to evaluate students' work and provide feedback on their ideas in several categories, including design, planning, innovation, energy conservation features, drawing presentation, model presentation, and exterior design.

As a result of this experience, the students learned firsthand what it takes to design a home for the 21st century. Students also learned how to successfully plan and select the best possible solution from a variety of design ideas in order to meet criteria and constraints, as well as how to communicate their results using graphic means and three-dimensional models.

WHAT IT LOOKS LIKE IN THE CLASSROOM

Assessment Strategies

- Students can research building codes and zoning laws in the community, then each can write a detailed informational report.
- Students can compare construction efficiency for various house designs, evaluating the advantages and disadvantages of each design (e.g., ranch vs. colonial, lumber vs. steel framework). They can then create a chart illustrating the differences.
- Students can create an engineering presentation illustrating the design and efficiency of the prototype, using appropriate visual aids (e.g., charts, graphs, presentation software). The presentation should include any other factors that impact the design of the house (e.g., site, soil conditions, climate).
- Students will use a rubric to assess design specification, heat efficiency, and final prototype of the design challenge.

Engineering Design Learning Standards

High School

1.2 Understand that the engineering design process is used in the solution of problems and the advancement of society. Identify examples of technologies, objects, and processes that have been modified to advance society, and explain why and how they were modified.

1.3 Produce and analyze multi-view drawings (orthographic projections) and pictorial drawings (isometric, oblique, perspective), using various techniques.

1.4 Interpret and apply scale and proportion to orthographic projections and pictorial drawings (e.g., ¼" = 1'0", 1 cm = 1 m).

1.5 Interpret plans, diagrams, and working drawings in the construction of prototypes or models.

Construction Technologies Learning Standards

High School

2.1 Identify and explain the engineering properties of materials used in structures (e.g., elasticity, plasticity, R value, density, strength).

2.6 Recognize the purposes of zoning laws and building codes in the design and use of structures.

Energy and Power Technologies—Thermal Systems Learning Standards

High School

4.2 Give examples of how conduction, convection, and radiation are considered in the selection of materials for buildings and in the design of a heating system.

4.3 Explain how environmental conditions such as wind, solar angle, and temperature influence the design of buildings.