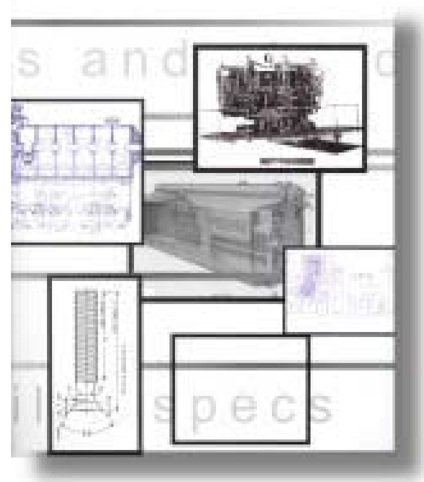
ACHIEVEMENT #10:

Codes and Standards

Teacher's Guide

Introduction



In 1900 most people never traveled more than 30 miles from home. If they traveled by rail, chances are they had to keep changing trains, because the size of the tracks was different in every state. That's because there were no measurements or rules followed by everybody. There were no standards. Life before standards was often inconvenient, and even dangerous.

In 1904, a terrible fire was raging through Baltimore. Fire engines were racing from all over town to help. They even came from as far away as New York. But when they got there they were shocked to discover that the couplings were all different – and they couldn't connect their hoses to the fire hydrants. The fire brigades were useless, and within 30 hours more than 1500 buildings burned to the ground.

Later, engineers got together and wrote a standard so that this would never happen again. All the fire hydrants and all the fire hose couplings all over the country had to be the same size. It didn't take long before engineers and others deduced that more standards were needed in many industries. Today, in the United States alone, there are about 50,000 voluntary standards that make products safe and life orderly. That's why all electrical plugs will fit in any outlet, and why a bicycle chain you buy in Massachusetts will fit a bike you buy in Texas.

Take a look at the hot water heater in your house -- you will see the ASME code symbol stamped on it. This means that you never have to worry about your water heater exploding --which happened quite often at the beginning of the century.

Lesson Focus: codes and standards, metrology

Lesson Synopsis: Students evaluate the reliability of the cubit as an early unit of measure, use calipers and other measuring tools to measure circumferences and diameters, and create a paper tower that meets a specified set of standards.

Related National Science Education Standards:

Content Standard E (Science and Technology):

As a result of activities in grades 5-8, all students should develop Abilities of Technological Design, including the ability to

- Design a Solution or Product, to
- Implement a Proposed Design, and to
- Evaluate Completed Technological Designs and Products.

As a result of activities in grades 5-8, all students should develop Understandings About Science and Technology. Fundamental concepts and principles that underlie this standard include:

- Technological designs have constraints. Some constraints are unavoidable, for example, properties of materials, other constraints limit choices in the design, for example, human safety.

Related Benchmarks from Benchmarks for Science Literacy:

Section 3A (Technology and Science):

By the end of 8th grade, students should know that:

- Engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems, but they usually have to take human values and limitations into account as well.

Section 3B (Design and Systems):

By the end of 8th grade, students should know that:

- Design usually involves taking constraints into account. Some constraints are unavoidable … Other constraints … limit choices.

Section 3C (Issues in Technology):

By the end of 5th grade, students should know that:

- Scientific laws, engineering principles, properties of materials, and construction techniques must be taken into account in designing engineering solutions to problems.

Section 9D (Uncertainty):

By the end of 8th grade, students should know that:

- The mean, median, and mode tell different things about the middle of a data set.

Section 12B (Computation and Estimation):

By the end of the 8th grade, students should be able to:

- Find the mean and median of a set of data.

Related National Standards for Technological Literacy:

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

- Trade-off is a decision process recognizing the need for careful compromises among competing factors.

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

- Requirements for a design are made up of criteria and constraints.

Glossary:

standard A set of technical definitions and guidelines designed to serve as "how to" instructions for voluntary use by designers and manufacturers. Standards may relate to performance (what the product is supposed to do) or to design (composition of the product and how the product is to be made).

code A standard that has been adopted by one or more governmental bodies and has the force of law.

metrology The branch of science that deals with quantifying the measures of physical quantities.

Important Concepts:

- Standards for product design and/or performance may promote product quality, safety, and/or interchangeability of components.
- The standardization of measurement in the industrial world allows countries to produce and consume goods and services in the world economy.

Materials for Each Inquiry Team:

Materials for Engagement Activity:

- Meter stick
- Hand calculator
- Graph paper or graphing software

Materials for Exploration Activity:

- Variety of manufactured circular objects
- String
- Paper
- Metric ruler
- Calipers or mechanical compass

Materials for Engineering Challenge:

- 2 sheets of newspaper
- 10 inches of cellophane tape
- Scissors

Teacher's Guide (Continued)

Safety Precautions: Remind students of safety rules for use of laboratory equipment, as appropriate.

Procedure:

Engagement:

If you have not shown the video to the class, you may do so and then proceed with the Exploration activity. If you have already shown the video, you may want to use the activity "How Long is a Cubit?" as an Engagement activity.

Exploration:

Have students do the activity "From Cubits to Calipers: How Can We Measure Length?".

Explanation, and Extension:

Have students do the activity "Why are Standards Important?", including the Engineering Challenge, "Paper Towers".

Evaluation:

Have students brainstorm and evaluate a potential set of standards for classroom furniture. (They should consider safety, durability, comfort, etc.)

Ideas for Further Exploration:

1. Have students research the history of various units of measure.
2. Have students research local building and fire codes. (Contact the municipal building inspector and fire marshal.)
3. Have students research the functions of organizations such as the American National Standards Institute (ANSI) and the National Institute of Standards and Technology (NIST).
4. Have students revise their paper tower design and test their revised design.
5. Use the online applet at http://phy.ntnu.edu.tw/~hwang/ruler/vernier.html to have students practice measuring with Vernier calipers.

References:

Paper Towers, exercise available online at: http://www.zoology.duke.edu/cibl/exercises/paper_towers.htm

Introduction to ASME Codes and Standards, available online at: http://www.asme.org/codes/

NIST Virtual Museum Exhibit on the history of standardization of weights and measures in the US, online at http://museum.nist.gov/exhibits/ex1/index.html

NIST in Your House, an online exhibit showing NIST's unseen role in setting standards for a variety of household products, online at http://www.nist.gov/public_affairs/nhouse

NIST at 100: Foundations for Progress, links to information on the history of the National Bureau of Standards (now called the National Institute of Standards and Technology), online at http://www.100.nist.gov/

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Student Handout

"How Long is a Cubit?"

Overview:

One of the earliest recorded units of length is the **cubit**, first used in ancient Egypt. Defined as the length of the forearm from the elbow to the tips of the fingers, this was the unit of length used to measure and position the blocks used to construct the Great Pyramid of Giza.

Materials for Each Inquiry Team:

- Meter stick
- Hand calculator
- Graph paper or graphing software

Procedure:

1. Working in pairs, use a meter stick to measure each partner's arm length from the elbow to the tips of the fingers. Do this by resting your elbow on your desktop and placing the meter stick next to your forearm.
2. Record each "personal cubit" in mm and tabulate the data for the class.

   Length of a cubit according to my arm = __________
3. Find the range, mean, median, and mode for the class data:

Range = _________ to ___________   Mean = _____________

Median = ______________   Mode = _____________

4. Create a histogram from the class data. (If graphing software is available, use it.)
5. Switch partners and measure each other's arms again. Do the two measurements agree exactly? If not, how do you account for the difference?
6. Since the length of a cubit varies according to whose arm is used and perhaps even from one use to the next, suggest a way that the Egyptians could have ensured that all the stones used in one construction project were about the same size?

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Student Handout

"From Cubits to Calipers: How Can We Measure Length?"

Overview

Can you imagine not being able to buy an accurate ruler, yardstick, or tape measure? What if you had to make your own by using someone else's ruler to mark a stick or a length of ribbon? What if **no** rulers were available? The discovery of "cubit sticks" and blocks of black granite or marble cut to a standard length at Egyptian archeological sites is the earliest evidence of efforts to "standardize" a unit of measure initially related to body proportions.

Materials for Each Inquiry Team:

- Variety of manufactured circular objects
- String
- Paper
- Metric ruler
- Calipers or mechanical compass

Procedure:

Goal: To use the tools available to measure as accurately as possible the circumference and diameter of each of the circular objects provided to you.

1. Use different tools to measure the same object. (Be creative.)

2. If your measurements of the same object are different, decide which is probably the most accurate and why.

3. Be prepared to report your "most accurate" measurements and to explain how you obtained each measurement.

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Student Handout

"Why Are Standards Important?"

The Development of Standards and Codes

In modern usage, a **standard** is a set of technical definitions and guidelines designed to serve as "how to" instructions for voluntary use by designers and manufacturers. Standards promote quality, safety, and/or interchangeability. Standards may relate to performance (what the product is supposed to do) or to design (composition of the product and how the product is to be made). A **code** is a standard that has been adopted by one or more governmental bodies and has the force of law.

As you examine the **Timeline** for this engineering achievement, you will see some of the events that created a need for standards and some of the ways that standards have contributed to product quality, safety, mass-production, and convenience. Can you see why having standardized units of measure and more-precise measuring tools has been important to our being able to develop and apply product standards?

Engineering Challenge:

Meeting Standards for Building a Paper Tower:

Your challenge is to use only 2 sheets of newspaper and 10 inches of cellophane tape to build the tallest tower that can withstand a strong wind, in this case a strong breath from one arm's length away. You may fold, cut, or tear your paper any way you want to. The tape may only be used to attach paper to paper (not to attach the tower to the floor). Your instructor will inform you of the time limit for construction.

Drawing Conclusions:

Having observed the outcomes of the "wind tests," what advice would you give to future students who attempt this engineering challenge?

Timeline of Important Events Related to Achievement 10:

3000 BC In ancient Egypt, the “cubit” is defined as the length of the arm from the elbow to the fingertips.

2000 BC The cubit is redefined as the length of a designated block of marble or black granite.

1120 AD The “ell” is defined as the length of King Henry I’s arm from the tip of his nose to the tips of his fingers.

1689 Boston requires bricks to all be 9X4X4 inches to allow rapid rebuilding after a devastating fire.

1780 Eli Whitney (the Father of Standardization) uses standardized musket parts to mass-produce 10,000 muskets for the US government.

1799 A platinum bar designated as 1 meter long and a platinum bar designated as having a mass of 1 kilogram are deposited in Paris as standards for length and mass in the Metric System.

1880 The American Society of Mechanical Engineers (ASME) is founded.

1883 An ASME committee on standards and gauges is created**.**

1884 The first code of practice for boiler testing is published by ASME.

1886 Track gauges for US railroads are standardized.

1901 National Bureau of Standards established (now called the National Institute of Standards and Technology (NIST)

1904 A fire in Baltimore destroys 1500 buildings in 30 hours and points out the need for inter-compatibility of hydrants and fire hose couplings.

1905 A boiler explosion in Brockton Shoe Factory in Massachusetts levels the factory and results in 58 deaths and 117 injuries.

1915 The ASME Boiler and Pressure Vessel Code is published.

1927 A national code for colors for traffic signals is established.

1960 The name International System of Units (SI) is given to our current system of metric units.