Lesson 3: BUILDING A SKYSCRAPER

grade level: elementary (2-4)

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▶ OVERVIEW

Students will inductively discover how secure foundations, solid frames, and material and structural choices affect building stability and height. They will learn how technological innovations and engineering design enable the construction of tall buildings, both historically and in the present-day.

▶ GUIDING QUESTIONS

- How does a skyscraper stand up?
- What factors must architects and engineers consider when designing a skyscraper?
- What technological innovations allowed skyscrapers to be built?

LEARNING OBJECTIVES

Students will:

- Analyze pictures of building construction to identify structural elements
- Understand the innovations that have changed (and are continuing to change) the design of buildings in New York City and beyond
- Use higher-order thinking skills to make decisions about skyscraper construction

View over 300 photographs documenting construction of the Bankers Trust Building at www.skyscraper.org/bankerstrust

MATERIALS to download

- Activity Sheet 1: Exploration Station (two pages); Activity Sheet 2: Parts of a Skyscraper
- Skyscraper Photograph Master
- Optional: Overhead projector and a transparency of Activity Sheet 2

▶ MATERIALS and PREPARATION

- Copies of both Activity Sheets for each student, as well as skyscraper images from the Skyscraper Photograph Master.
- Prepare four exploration stations with the following materials:

  Power in Numbers: *Drinking straws, masking tape, two or three books of different sizes*

  Whatever the Weather: *Simple tower (conical or cylindrical) made of newsprint or butcher paper, fan (electric or improvised), masking tape, various weighted objects (ie: tape dispenser or stapler)*

  Hard Hats Only: *Newspaper, masking tape, paper towel tubes, cereal boxes, soda bottles, craft sticks, plastic straws, anything that might work for construction of a tall tower*

  Blocks in Socks: *Blocks (or a similar item from a math manipulatives kit), knee-length pantyhose or socks to use as mortar, rulers (optional)*

I. INTRODUCTION: *HOW ARE SKYSCRAPERS BUILT?*

Distribute Activity Sheet 1: Exploration Stations. Explain to students that they will be visiting a number of exploration stations today as they consider the guiding question, "How are skyscrapers built?" Circulate among the groups to encourage higher-order thinking and to find connections with real-life skyscrapers. Students should hypothesize strategies, predict outcomes, explain reasoning, and analyze and revise strategies that are not working.

Power in Numbers
Students will explore the need for strength when constructing a skeleton frame
Activity: Students will attempt to balance a book on top of straws, much as a roof stands on columns. First, they will attempt the straws individually, then they will try again with groups of straws taped together.
Discussion Questions: Which worked better—straws together or separate—and why? How does this understanding relate to the skeleton frame of a skyscraper?

Whatever the Weather
Students will explore building stability and the effect of weather on tall buildings
Activity: Students will test the stability of the paper tower under "wind conditions" caused by a fan. They will attempt to stabilize the tower using provided materials.
Discussion Questions: What methods effectively stabilized the building? What additional materials would have helped? What types of conditions must skyscrapers be built to endure? How are skyscrapers built to survive stressful situations such as storms and earthquakes?

Hard Hats Only
Students will explore the challenge of building a tall structure.
Activity: Students will use the materials at their station to construct the tallest possible structure.
Discussion Questions: What factors determined whether a tower would stand up successfully? Compare materials used at the base of the tower with those used at the top. What conclusions can you draw?

Blocks in Socks
Students will explore the challenge of using bricks to construct a tall building.
Activity: Students will stack blocks as tall as possible before they fall over, measuring the height. They will then stack the blocks within some form of sock in an attempt to increase the final height of the structure.
Discussion Questions: What were the challenges of making a tower from blocks? What building material did the blocks remind you of? How did the sock ("mortar") help hold the blocks together? Could bricks be used to build a skyscraper?

Reconvene the class after each group has tested each station, and solicit conclusions for each activity. These will form the basis for instruction in the next section.

▶ VOCABULARY

Beams	Horizontal supports that attach to columns within the frame
Bedrock	Solid rock found deep underground below the dirt and soil; the foundation is usually built on top of this rock
Column	A vertical support within the frame
Excavate	To remove material from the ground by digging
Façade	The outer walls of a building made from glass or stone that rest on the frame; also called a curtain wall.
Foundation	The lowest part of a building, usually underground
Reinforced Concrete	Concrete that is made stronger by adding steel rods or wires. It also protects the steel from changes in temperature due to fire or weather.
Skeleton Frame	A system of columns and beams that carries the weight and load of a building
Steel	A strong metal made from a mixture (*alloy*) of iron and carbon that can be shaped into columns and beams

▶ II. INSTRUCTION: *CONNECTING CONCLUSIONS TO CONTENT*

Distribute Student Activity Sheet 2, and use this as a basis for student notetaking during delivery of the following content. A transparency of the Activity Sheet may simplify this. Remind students that they will begin writing at the bottom of the page, just as building construction begins at the base. As you go, help students to connect this information to the conclusions they drew from the Exploration Stations.

Like the roots of a tree, a skyscraper's **foundation** is actually laid below ground to create the most stability. In order to do this, A construction site must first be **excavated**, which involves digging out sand and dirt in order to get to the **bedrock**. Once the foundation has been laid, the **skeleton frame** is constructed by connecting **steel columns** and **beams** in a grid pattern. Sometimes, **reinforced concrete** is used as well, in order to protect the steel from extreme temperature changes. The skeleton frame is strong enough to hold up the entire weight of the building.

The **façade,** usually made from stone, brick, metal, or glass, is laid over the skeleton frame to create the exterior wall of the building. The façade hangs on the frame like a curtain, but does not support the building in any way. Workers often begin constructing the façade on the ground floor of the building while the upper floors of the skeleton frame are still being erected. [*Online images at www.skyscraper.org will illustrate this point.*] As the façade rises, interior systems, such as electric wiring, telephone and internet cables, heating and cooling systems, and plumbing, are installed. After these systems are inspected, walls, floors, and ceilings are installed. In the final stages of construction, the interior of the building is painted and decorated.

▶ III. APPLICATION AND EVALUATION

Give individuals or small groups of students pictures of skyscrapers to label. These may be printed from the Skyscraper Photograph Master (see "Materials to Download"), or you may select your own images at www.skyscraper.org/bankerstrust or www.skyscraper.org/viva.

- Instruct students to label each feature of the skyscraper they recognize from the vocabulary they have just learned, including **foundation**, **frame**, **columns**, **beams**, **elevator shaft**, and **façade.**
- Choose one element for each group to share with the class as a wrap-up. Be sure to allow students to share the name of the building so that other students can become acquainted with these notable parts of the New York City skyline.

▶ IV. LEARNING EXTENSIONS

- Students create a simple four- or six-frame "comic strip" to illustrate skyscraper construction. Each frame should illustrate four distinct stages of skyscraper construction accompanied by a one-sentence caption.
- Students write a short procedural manual (ie: "Skyscrapers for Dummies") explaining and illustrating the process of constructing a skyscraper.
- Students make a "flip book" of skyscraper construction, with captions and key vocabulary words written on the back of corresponding pages.
- Students can explore the similarities between their bodies and the structure of a skyscraper (bones are like a skeleton frame, skin is like a façade): as an art project, students draw skyscrapers modeled after their bodies; they write paragraphs using skyscraper vocabulary to explain how bodies stand up; or they trace a skyscraper on one side or tracing paper and a human body on the other.

▶ New York State LEARNING STANDARDS

- Math, Science, & Technology Standards 1, 4, 7.

The Impact of Technology

Many innovations from the 1800s paved the way for skyscraper construction. Before the invention of steam-powered **digging and drilling machines** in the 1830s, it would have been impossible to excavate a construction site in order to build on bedrock. Likewise, though **steel** was first created in the 13th Century BC, it was impractical until Henry Bessemer invented a simple method of mass production in 1855. Finally, the **elevator** was invented by Elisha Otis in 1853, allowing people and goods to travel to the top floor of buildings quickly and easily.

Other innovations of the time allowed people to exist comfortably on the top floors of skyscrapers. Such technological improvements as **electric lighting** (1870s), **steam heating** (1830s), and **indoor plumbing** (1830s) were also crucial to the popularity of skyscrapers.

More recent technological innovations, such as **fire-resistant materials, sprinkler systems, cranes and bulldozers, central air conditioning, high-speed elevators** and the like, allow skyscrapers to reach new heights.