



Accompanying Lesson: Engineering Design Using Wood Products

GRADES
3-5

I. OVERVIEW

A. Title

Building Challenge – Students design and build a structure using wood materials to stimulate their creativity and critical thinking skills.

B. Learner Objectives

1. Analyze the properties of building materials
2. Design a structure following set criteria
3. Build a structure and test its strength following set criteria

NEXT GENERATION SCIENCE STANDARDS

[3-5-ETS1-1 Engineering Design](#). Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

[3-5-ETS1-2 Engineering Design](#). Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

[3-5-ETS1-3 Engineering Design](#). Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

C. Materials

Assortment of wooden building materials (wooden coffee stirrers, popsicle sticks, wine corks, toothpicks, dowel rods, etc.), assortment of coupling materials (gum drops, marshmallows, clay, playdough, etc.), tape measure/meter stick, weighted items to test strength of structures such as a textbook, base to build structures at least 15'X15" (cardboard, plywood, etc.) for each group

D. Time Considerations

Preparation: 30 minutes plus time to gather materials

Activity: three 40-minute periods

E. Getting Ready

Obtain building materials for the engineering challenge for each group. Each group should have access to the same types and amounts of materials. Each group will need a sturdy table to build and test their structure.

F. Key Vocabulary

Nonrenewable Resource – substances such as oil, gas, coal, copper, and gold, which, once used, cannot be replaced in this geological age

Renewable Resource – a naturally occurring raw material or form of energy which has the capacity to replenish itself through ecological cycles and sustainable management practices

Carbon neutral – having or resulting in no net addition of carbon dioxide to the atmosphere

Structural engineering – a branch of civil engineering dealing primarily with the design and construction of structures (such as bridges, buildings, dams)

Prototype – a first full-scale and usually functional form of a new type or design of a construction (such as an airplane)

II. BACKGROUND

Building materials are used to construct all material goods...roads, televisions, toothbrushes, homes, etc. Building materials can come from renewable or nonrenewable resources. *Nonrenewable resources* are substances such as oil, gas, coal, copper, and gold, which, once used, cannot be replaced in this geological age. *Renewable resources* are a naturally occurring raw material or form of energy which has the capacity to replenish itself through ecological cycles and sound management practices. The sun, wind, falling water, and trees are examples of renewable resources.

In modern home construction in the United States, construction materials made of wood (framing, walls, trusses, flooring, cabinetry, roofing, etc.) make up a large percentage of single unit family homes. Wood makes good building materials because it is light, strong, is a good insulator, can be processed into many different shapes and sizes, net *carbon neutral*, and comes from trees, a *renewable resource*. Other building materials such as plastic lumber, stone, metal, or concrete are made from *nonrenewable resources* that must be mined or drilled to be extracted. These processes also can have a large impact and negative effect on the environment and are net carbon emitting.

Structural engineers are people who design the form and shape of man-made structures such as homes. Homes must be able to withstand the stresses and pressures of the environment (wind, earthquakes, being able to bear loads, etc.) to remain secure, stable, and safe. Structural engineers calculate the stability, strength, and rigidity of built structures. They use applied physics, geometry, and materials science to design, build, test *prototypes*, and assess structures. A prototype is an operating version of a solution. Prototypes are often made with different materials (cheaper and easier to work with) than the final version.

III. DOING THE ACTIVITY

DAY 1

A. ENGAGE – CAPTURES INTEREST, MAKES CONNECTIONS, AND PROVIDES AN OPPORTUNITY FOR STUDENTS TO EXPRESS WHAT THEY KNOW

1. Ask, “Have you ever built a club/play house, fort, tree house, or hideout in your back yard, in your home, or out in the woods? What did it look like?” Allow students to share their stories with the whole class.

2. Split students into working groups and give them these questions to discuss as a small group:

- How did you build it?
- What materials did you use?
- Did you make a plan or draw a design before building?
- Did anyone help you build it?

3. Have each group share one member’s structure and their answers to the questions.

4. Tell the students that they will be working together as a team of structural engineers to design and build a structure made out of wooden materials similar to the framework of a house. They will also test the strength, stability, and rigidity of their structure and analyze the results of their tests to try and improve their prototype.

5. Ask the students if they have heard of the career of a structural engineer or civil engineer. Explore the career of a structural engineer by watching the “Career Spotlight: Civil Engineer” video from KQED public television at: <https://www.kqed.org/quest/112856/career-spotlight-structural-engineer>. After watching, ask the students, “What types of jobs or duties does a structural engineer have?” Discuss answers.

B. EXPLORE – ACTIVITIES TO EXPLORE THE CONCEPT OR SKILL

6. Ask the students if they know what building materials their homes are made of and discuss responses. Explain that in the U.S., most single-dwelling homes are made of many wooden building materials. Tell the students that they will watch a video about a tree from a forest who had a dream. Ask the students to try and figure out what was the dream of the tree. Show the video, “A Tree’s Dream” at: <https://www.youtube.com/watch?v=777wq0VIEFg&t=447s>. Ask the students to also pay attention to how the home in the video was built and what materials were used to build it.

7. After watching the video, ask the students:

- What was the dream of Tim the Tree? (to be part of a home)
- What materials were used to build the home? (dimensional lumber, electrical wiring, paint, drywall, molding, bark dust/mulch, metal plumbing, etc.)

How did the carpenters build the home? (poured concrete foundation, laid floors, built framework for walls and rooms, raised trusses for roof, shingles, siding, electricity, plumbing, painting, landscaping)

8. Define the engineering design challenge for the working groups:

“Your team must build the framework of a home using your given building materials. The framework must be rigid, strong, and stable enough to remain intact. Your framework must be at least 12 inches wide, 12 inches long, and 12 inches tall and stand independently (rigidity test). Your framework must be able to hold the weight of a textbook (strength test). Your framework must also be able to hold the weight while the base is shaking (stability test). Your team must create a blueprint for your design, include a list of materials, and your team must explain to the teacher the reasoning behind your design before beginning to build.”

9. Give the groups their materials (all groups get the same types and quantities) and allow them time to investigate their physical properties. Groups should discuss various building designs and then create a design. Each group will present their design to the teacher and explain the reasoning behind their design.

DAY 2

10. Give each group 20 minutes to build their framework using their design as a guide.

11. Test each group’s framework and have all students record testing data for each prototype:

Group Name	Rigidity: Does it stand independently? (Yes or No)	Strength: Does it hold the weight of a textbook? (Yes or No; # of seconds if yes)	Stability: Does it remain intact while the base is shaking? (Yes or No; # of seconds if yes)
Group 1			
Group 2			

C. EXPLAIN – STUDENTS DEVELOP EXPLANATIONS FOR THE CONCEPT OR SKILL THEY HAVE EXPERIENCED

12. Give each group time to look at the data. Tell each group they will present ideas on ways they could improve their prototype if the activity was done again. Give the groups guiding questions such as:

- How did your framework perform in the tests?
- Why do you think it did well or poorly in the rigidity, strength, and stability tests?
- What similarities in building materials did you see in frameworks that failed or had success?
- What similarities in building design did you see in frameworks that failed or had success?
- If your team was to do this activity again, how would you change your design?
- If you could choose one different wooden building material and one different coupling material, what and why would you choose those materials?

13. Give groups time to discuss guiding questions. Allow students to bring in new materials to design a second prototype for Day 3.

DAY 3

D. ELABORATE & EVALUATE – ACTIVITIES TO APPLY LEARNING TO NEW SITUATIONS AND DISCUSS/COMPARE IDEAS WITH OTHERS & STUDENTS REVIEW/REFLECT ON THEIR OWN LEARNING AND PROVIDE EVIDENCE FOR CHANGES TO THEIR LEARNING

14. Give groups 20 minutes to design a new prototype and draw a blueprint of the new design. Groups will discuss the success of their first prototype and present their new design.

15. Working groups will present their design and answer the following questions:

- How did your prototype perform in the tests?
- Explain why you think it had successes or failures.
- Explain your new design, choice of materials and how you think it could improve in the rigidity, strength, and stability tests.

IV. ENRICH: EXERCISES THAT EXTEND OR ENRICH THE LEARNING EXPERIENCE

A. Option 1 – Have students research various careers in forestry or working with wood materials.

Students can create publications or presentations to highlight their jobs. More information about forestry careers can be found on the “People of Forestry” YouTube channel at: <https://www.youtube.com/playlist?list=PLjo3SIjzmraevdt7ssk6EqXzncElylZna>

B. Option 2 – Have students build a second prototype using their new designs. Allow each group to choose to incorporate a new wooden building material or coupling material. Test each prototype using the same tests for rigidity, strength, and stability.

C. Option 3 – Have students create their own tests for rigidity, strength, and stability using different parameters than the original.

V. ADDITIONAL RESOURCES:

1. Project Learning Tree – www.plt.org

Project Learning Tree is an award-winning environmental education program designed for teachers and other educators, parents, and community leaders working with youth from preschool through grade 12.

2. Next Generation Science Standards – Engineering Design 3-5 - <https://www.nextgenscience.org/topic-arrangement/3-5engineering-design>

Within the Next Generation Science Standards (NGSS), there are three distinct and equally important dimensions to learning science. These dimensions are combined to form each standard—or performance expectation—and each dimension works with the other two to help students build a cohesive understanding of science over time.

3. The Engineering Design Process: Engineering is Elementary - <https://www.eie.org/>