NGSS Lesson Plan – Engineering Picnic Tables

Grade/ Grade Band: 4th	Topic: Engineering Design/Forces in structures	Lesson # 1

Brief Lesson Description: Students will use an engineering design process to design and build a picnic table. The class will 1) establish design criteria, 2) build and test prototype picnic tables out of craft sticks, 3) select a final design 4) build a picnic table out of 2X6s

Prior Student Knowledge:
Cultural Connections:
Look for student experience with picnic tables or tables in general. Pay attention to how they use them, who they use them for and where they have experience with them. For example, do they talk about picnic tables at their house, going to parks with family, using them while camping or traveling. Do they talk about styles or the aesthetics of tables?
Science content:
Students may not be able to identify forces when they are balanced. Students may not identify gravity if objects aren't falling. Students may not be able to identify opposing forces like the ground pushing back up on a table being pushed down.

Performance Expectation(s):
3-5-ETS1-1. 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. 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. 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.

Science & Engineering Practices:	**Disciplinary Core Ideas:**	**Crosscutting Concepts:**
Asking Questions and Defining Problems Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. • Ask questions that can be investigated based on patterns such as cause and effect relationships. (3-PS2-3) • Define a simple problem that can be solved through the development of a new or improved object or tool. (3-PS2-4) **Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Plan and conduct an investigation collaboratively to	**ETS1.A: Defining and Delimiting Engineering Problems** • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1) **ETS1.B: Developing Possible Solutions** • Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) • At whatever stage, communicating with peers about proposed solutions is an important part of the design	**Influence of Engineering, Technology, and Science on Society and the Natural World** • People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1) • Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)

produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-PS2-1) • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (3-PS2-2)	process, and shared ideas can lead to improved designs. (3-5-ETS1-2) • Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) **ETS1.C: Optimizing the Design Solution** • Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	
Performance Expectation(s): **3-PS2-1.** Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. [Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving; and, balanced forces pushing on a box from both sides will not produce any motion at all.] [Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.]		
Science & Engineering Practices: **Asking Questions and Defining Problems** Asking questions and defining problems in 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. • Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1) **Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	Disciplinary Core Ideas: **PS2.A: Forces and Motion** • Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) (3-PS2-1)	Crosscutting Concepts: **Patterns** • Patterns of change can be used to make predictions. (3-PS2-2) **Cause and Effect** • Cause and effect relationships are routinely identified. (3-PS2-1) • Cause and effect relationships are routinely identified, tested, and used to explain change. (3-PS2-3)

Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2)		

LESSON PLAN – 5-E Model

ENGAGE: Identifying the problem/Brainstorm (Day 1)

What design features will make a model picnic table, made from craft sticks and hot glue, the strongest?

- Provide students with magazines and other material that has images of park seating. Have them talk with their table partners about what they like about the picnic tables and what they think are important features of picnic tables. Encourage them to think about picnic tables they have used with their family.
- Lead discussion with students to determine design criteria for picnic table, encourage them to address issues like strength and stability. Listen carefully for aesthetic criteria that the students suggest and references to picnic tables from their personal experience.
- Group criteria into ones that can be measured and ones that require students to make personal judgments.

EXPLORE: Prototype picnic benches (Day 2-3)

Materials

- 25 - 51/2 inch craft sticks
- Hot glue gun
- Scissors
- 1 Kg weight to test strength of bench
- Magazines and catalogs with images of park seating in them
- 11 - 2X6s
- 21/2" Deck Screws
- Cordless Screw Gun

1. Write criteria on board
2. Talk about safety procedures with hot glue guns.
3. Allow students to build prototypes of benches
4. Have groups bring prototype to testing station. During test focus on observing failure points for table. Look specifically for areas where craft sticks are under strain or are bending. Record observations in science journal
5. Repeat prototype process.

Stop during process and have groups share their designs and what they have learned during testing.
Re-evaluate design criteria to see if there are other factors students want to include.

EXPLAIN/EVALUATE: Selecting a Design

Forces acting on structures

Forces need to be balanced for a structure to stand.

Force: a push or a pull

Gravity: The attraction that all objects exert on one another. Noted primarily as the force of the Earth pulling objects toward its center. This is primarily noted as pressure applied downward on objects.

Tension: The force pulling things apart

Compression: The force pushing things together.

Shapes that help make structures stable

Triangles – strong in the plane of the triangle. The only shape that can't change the shape without changing the length of at least one side. Squares can change shape by changing the angle of a joint.

Circles – Strong in compression because forces are equally distributed across the whole perimeter of the shape.

Check students science journal for accurate use of terms to describe their picnic table design.
Exit ticket: Have students describe a feature of their picnic table using key terms from discussion.

ELABORATE: Building the Picnic table (Day 5)

Use students design to build their own picnic table and place the table in a public space where others can use it.

Share other designs for picnic tables with students and talk about how their picnic table compares. Provide examples of other structures (i.e. chairs, play structures, buildings)