Science and Innovation

A Boeing/Teaching Channel Partnership

SPY GLIDERS

Teacher Handbook

Tch TeachingChannel®

Spy Gliders

Days 4 and 5: Spy Glider Materials

Grade Level	Middle School
Lesson Length	Two 50-minute sessions

Lesson Overview

On Days 4 and 5, student teams explore what materials to use based on strength and weight. Part of the time involves brainstorming and researching materials used on other planes and gliders. The rest of the time is dedicated to hands-on material testing. Finally, students use an argument scale (see Suggested Teacher Resources) to reach consensus on the best materials to use.

Connecting to the Next Generation Science Standards

In this lesson, students make progress toward developing understanding across the following three dimensions:

- Science and Engineering Practices: Planning and Carrying Out Investigations, Analyzing and Interpreting Data, Constructing Explanations and Designing Solutions
- Disciplinary Core Ideas: ETS1.B Developing Possible Solutions
- Crosscutting Concepts: Cause and Effect

In the following table, the specific components addressed in this lesson are underlined and italicized. The specific connections to classroom activity are stated.

Performance Expectations		
This lesson contributes toward building understanding of the following *engineering* performance expectations: MS-ETS1-3. *Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each* that can be combined into a new solution to better meet the criteria for success.		
Specific Connections to Classroom Activity In this lesson, students develop a strategy to test various materials for strength and weight. Students gather data for different materials and compare results across materials. Based on their findings, students select materials to use for their gliders.		
Dimension	**NGSS Element**	**Connections to Classroom Activity**
Science and Engineering Practices	**Planning and Carrying Out Investigations** • *Plan an investigation individually and collaboratively* and, in the design, identify independent and dependent variables *and controls, what tools are needed to do the gathering, and how many data are needed to support a claim.* **Analyzing and Interpreting Data**	Students design an investigation to determine which materials are strongest and lightest. Students carry out the investigation to determine which materials to use for their gliders. Students collect and analyze data to determine which materials to use for their gliders.

	• *Analyze and interpret data to determine similarities and differences in findings.* **Constructing Explanations and Designing Solutions** • *Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system.*	Students develop a final explanation for their material selection. The explanation is based on evidence and takes into consideration possible design alternatives.
Disciplinary Core Ideas	**ETS1.B: Developing Possible Solutions** • *A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.* **ETS1.C: Optimizing the Design Solution** • *Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process-that is, some of those characteristics may be incorporated into the new design.*	Students test multiple materials and determine which materials to use for their gliders. Students test materials for both weight (of the material) and strength. Students find that although one material might perform well on the weight test, it might not necessarily perform well on the strength test. Ultimately, students make a design decision that balances both weight and strength.
Crosscutting Concepts	**Cause and Effect** • *Cause and effect relationships may be used to predict phenomena in natural or designed systems.*	Students work with the idea that different amounts of weight cause different materials to break.

Basic Teacher Preparation

Gather and set out all necessary materials for Days 4 and 5. Review all resources, including the identified videos and How to Use a Spring Scale presentation, and ensure they can be shown for the class.

Web Resources

▶ How to Use a Spring Scale presentation [Web Link]

Consider ways students might be able to use the provided items to test the various construction materials. Refer to the Spy Gliders Student Handbook ahead of time so you can address any questions students might have. All documents used on Days 4 and 5 are on pages 15 through 18 in the Spy Glider Student Handbook. The documents used in this lesson are:

- 4.1: Materials Warm Up (page 15)
- 4.2: Controlled Investigation: Materials Testing (page 16)
- 5.1: Materials Testing Data Table (page 17)
- 5.2: Materials Debrief (page 18)

Required Preparation	Links/Additional Information
❑ Gather and set out all necessary materials	Refer to the Materials List below
❑ Preview all identified videos and the Spring Scale Presentation	

❑ Review all videos and resources in the Suggested Teacher Resources	Refer to the Suggested Teacher Resources at the end of the lesson

Materials List

Item	Description/Additional Information	Quantity	Where to Locate/Buy
Triple beam balance		1 per class	Available in most schools
Small action camera	An action camera is an engaging way for students to capture aerial footage during the final engineering design challenge. If it is cost prohibitive, a battery would be a suitable alternative.	1 per class	Already used on Day 3
Foam (polystyrene) gliders	The longer the wing span, the better.	1 per team	Already used On Day 3
Metal washers		10 per team	Already used on Day 3
Paper clips	These can be used as fasteners or weights if smaller gliders are used.	1 box per class	Already used on Day 3
Duct tape		1 roll per class	Already used on Day 3
Hot glue gun		1 for every 2 teams	Hot glue gun [Web Link]
Balsa wood		1 per team	Balsa wood [Web Link]
Foam board		1 per team	Foam board [Web Link]
Scrap cardboard		1 large box per team	From school cafeterias or home
Very fine sanding blocks		1 per team	Sanding blocks [Web Link]
S hooks		1 per team	S hooks [Web Link]
Fishing line, twine, or yarn		1 package	Local store or home

Day 4: Spy Glider Materials

Introduction (10 minutes)

Instruct students to complete the writing exercise on 4.1: Materials Warm Up on page 15 in the Spy Gliders Student Handbook. In this writing exercise, students think about the properties of materials used to make a successful glider. Students also brainstorm the materials that they would like to use to create their final gliders.

Have students focus their writing on the importance of material selection in glider construction. After students finish writing, engage in a whole class discussion. Have students share their ideas about the materials needed for their final gliders.

Tell students that their next step in the design process is to determine which materials to use for their gliders.

Mini-Lesson: Preparing for the Materials Investigation (15 minutes)

Show and discuss the Boeing Wing Failure Test video. Then show and discuss the Mythbusters video, which shows the use of a force gauge. Discuss how the videos relate to the challenge of selecting materials for use in the gliders.

Use How to Use a Spring Scale to lead a class discussion about the appropriate use of spring scales. Discuss how students could use a spring scale to measure the strength of materials.

Video Links

- Boeing Wing Failure Test [YouTube Link]
- Mythbusters force gauge [YouTube Link]

Web Resources

- How to Use a Spring Scale presentation [Web Link]

Design Work: Materials Hypothesis and Testing Procedures (25 minutes)

Tell students to turn to 4.2: Controlled Investigation: Materials Testing on page 16 in the Spy Gliders Student Handbook. Have them work individually to generate a hypothesis about the various glider construction materials. Then have students collaborate as a team to develop a strength testing procedure. Review and sign off on each team's procedure.

NGSS Key Moment

Designing an investigation to determine the strengths of different materials helps students make progress on the practice of Planning and Carrying Out Investigations.

One basic method of strength testing is to have a rectangular piece of material suspended lengthwise between two desktops. A string is then wrapped down the middle, width-wise, with an S hook suspended from it. Washers or hooked gram stackers are added until the material breaks.

Day 5: Spy Glider Materials

Design Work: Materials Testing (25 minutes)

Inform students that they will strength test at least three construction materials to the point of failure. Instruct them to refer to 5.1: Materials Testing Data Table on page 17 in the Spy Gliders Student Handbook. As students conduct their testing, they must note the specific type of material, mass of the material, and amount of mass that each material can support prior to collapse. They should also note the pros and cons of each material and provide a summary in the Results section.

NGSS Key Moment

Completing the data table helps students make progress on the practice of Analyzing and Interpreting data. Encourage students to carefully interpret data prior to listing the pros and cons of the material.

Design Work: Materials Debrief (25 minutes)

Have students individually reflect on the testing process as they complete the journal activity on 5.2 Materials Debrief on page 18 in the Spy Gliders Student Handbook.

Next, have students work in their teams to come to a consensus about which materials to use to build their gliders. Have students record notes from their team consensus discussions.

Helpful Tip

Consider using one of the argumentation activities to help each group come to a consensus.

NGSS Key Moment

Although the word *argument* is used in the student handbook, students are really developing an explanation for why they believe their material selection is the best option.

Assessment

Several opportunities for formative assessment exist in this lesson:

- Spy Gliders Student Handbook entries can be used to monitor student progress during the module. For this lesson, focus specifically on 4.2: Controlled Investigation: Materials Testing (page 16) and 5.2: Materials Debrief (page 18) to gage student progress on MS-ETS1-3.

- Whole class share-outs and discussions allows for formative assessment of student ideas and building content knowledge.
- When students are meeting in their teams, spend time with each team, listening in on their process and providing support as needed.

Use the identified assessment opportunities to monitor student progress on disciplinary core ideas, science and engineering practices, and crosscutting concepts. Provide appropriate supports or extensions when necessary.

Reference Appendix B for suggestions for meeting the needs of all learners.

Community Connections

If any student's parents, guardians, family members, or relatives work as aerospace engineers, materials engineers, pilots, or aviation mechanics, consider inviting them, or other local professionals in these fields, to visit the classroom as volunteers or to share their work experiences.

Suggested Teacher Resources

Meeting the Needs of All Learners	Spy Gliders Teacher Handbook, Appendix B
Boeing Wing Failure Test videos	[YouTube Link]
Mythbusters Force Gauge video	[YouTube Link]
How to Use a Spring Scale presentation	[Web Link]
Argumentation Activity	[Web Link]