Science and Innovation

A Boeing/Teaching Channel Partnership

SPY GLIDERS

Teacher Handbook

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Spy Gliders

Day 1: Define the Problem—Criteria and Constraints

Grade Level	Middle School
Lesson Length	One 50-minute session

Lesson Overview

The module begins with this introductory lesson where students are introduced to the design problem. Students learn about unmanned aerial vehicles (UAVs) and decide on a purpose for their designed systems. Students consider the criteria and constraints for the design problem.

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: Asking Questions and Defining Problems
- Disciplinary Core Ideas: ETS1.A Defining and Delimiting Engineering Problems
- Crosscutting Concepts: Influence of Engineering, Technology, and Science on Society and the Natural World

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-ETS1-1. *Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution*, taking into account relevant scientific principles and *potential impacts on people* and the natural environment that may limit possible solutions.		
Specific Connections to Classroom Activity In this lesson, students are introduced to the design challenge of building unmanned aerial vehicles. They work to define the design challenge by articulating criteria and constraints of the design problem. Later, students use these criteria and constraints to gage their success.		
Dimension	**NGSS Element**	**Connections to Classroom Activity**
Science and Engineering Practices	**Asking Questions and Defining Problems** • *Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints,* including scientific knowledge that may limit possible solutions.	Students are given an overarching design problem of engineering a UAV. Students determine a purpose for their UAV (reconnaissance, delivery, and so forth) and define criteria and constraints according to the identified purpose.

Disciplinary Core Ideas	**ETS1.A: Defining and Delimiting Engineering Problems** • *The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful.* Specification of constraints includes consideration of scientific principles and other relevant knowledge likely to limit possible solutions.	Students consider the idea that defining criteria and constraints for their design problem will help measure the success of the design solution.
Crosscutting Concepts	**Influence of Engineering, Technology, and Science on Society and the Natural World** • *The use of technologies and limitations on their use are driven by individual and societal needs, desires, and values*; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.	When students brainstorm the purpose for their UAV, they consider the needs of individuals and society. Ultimately, students must defend their design decisions based on societal needs. Students also consider societal needs as they develop criteria and constraints for their design solutions.

Basic Teacher Preparation

Students need to be organized into design teams of 3 or 4. They work in their teams throughout this module. Establish the working teams before beginning the first lesson.

This lesson sets the stage for much of the exploration and concept discussion that occurs later in the module. Preview the videos to ensure your audio-visual solution supports the media.

Ensure you have enough copies of the Spy Gliders Student Handbook for all students in your class. Review the Spy Gliders Student Handbook ahead of time so you can address any questions students might have. All documents used on Day 1 are on pages 1 through 3 in the Spy Gliders Student Handbook.

Helpful Tip

Consider giving students a "stamp" of completion each day as they work through the lessons in their handbooks.

The documents used in this lesson are:

- Engineering Design Process Graphic (page 1)
- 1.1: Define the Problem (page 2)
- 1.2: Criteria and Constraints (page 3)

Required Preparation	Links/Additional Information
❑ Download, print, and photocopy the Spy Gliders Student Handbook	Refer to the Materials List below
❑ Review all videos and resources in the Suggested Teacher Resources	Refer to the Suggested Teacher Resources at the end of this lesson

Materials List

Item	Description/Additional Information	Quantity	Where to Locate/Buy
Spy Gliders Student Handbook	Download, print, and copy for students. Bind all handouts into a Spy Gliders Handbook for students.	1 per student	[Resource Link]
Access to computers or hard copy handouts of UAV ideas (Cool Uses for Drones and The UAV)	Download and print or gain access to computers for student use.	1 per team	See Suggested Teacher Resources

Day 1: Define the Problem—Criteria and Constraints

Introduction (10 minutes)

Introduce the module by asking students what they already know about unmanned aerial vehicles (UAVs). Students may be more familiar with the term drone.

Video Link

- Amazon Prime Drones [Web Link]

Lead a short class discussion about the use of drones locally and globally. For instance, students may be interested to know that Amazon Prime plans to use drones to deliver packages. Show students one of the videos about using drones from Amazon Prime website.

Tell students that UAV's are air vehicles that lack onboard passengers and crew. They can be autonomous drones or remotely piloted vehicles. Many civilian uses exist, including, but not limited to aerial surveying of crops, search and rescue operations, counting wildlife, delivering medical supplies to remote or otherwise inaccessible regions, and surveillance. The military also has many uses for UAVs. A UAV can be used to provide battlefield intelligence, attack capability for high-risk missions, or target and decoy.

To help students better understand UAVs, show the Flite Test—What Is a Drone? Video. Consider previewing the video and selecting several relevant clips rather than showing the entire video.

Video Link

- Flite Test—What Is a Drone? [YouTube Link]

Recently, there has been a greater need to develop UAVs for military and civilian needs. Specifically, there is a need to develop UAVs that can carry a payload. Introduce students to the engineering design problem for the module, *How can we engineer a glider that can carry a payload for the longest distance?* Have students write the engineering design problem on 1.1: Define the Problem on page 2 in the Spy Gliders Student Handbook.

Design Work: Decide on a Purpose (10 minutes)

Tell students to determine a purpose for their UAV. The only requirement is that the UAV must carry a payload. Have students explore several resources about the uses for drones.

Cool Uses for Drones offers ideas for civilian use, and The UAV offers ideas for military uses.

Video Link

- Cool Uses for Drones [Web Link]
- The UAV [Web Link]

Students may also decide to explore additional websites or create their own ideas.

After students decide on the purpose for their UAVs, have them share their justifications with the class. Record each team's purpose and justification on the board.

NGSS Key Moment

As students brainstorm purposes for their UAVs, they should think about individual and societal demands, and how the demands influence their design decisions. Doing so emphasizes the crosscutting concept—Influence of Engineering, Technology, and Science on Society and the Natural World.

Extension

Consider creating a master list of uses for drones to support students who may not be familiar with drones. Potential uses include:

Civilian
- Mail/package delivery
- Sports photography
- Highway monitoring
- Wildlife research
- Disaster relief

Military
- Target and decoy
- Reconnaissance
- Combat
- Research and development

Whole Group Discussion: Engineering Design Process (5 minutes)

Tell students that over the next several days, their task is to use the engineering design process to solve the design problem. To introduce students to the engineering design process, show MIT's Introduction to the Engineering Design Process video and then review the Engineering Design Process graphic, shown on page 1 in the Spy Gliders Student Handbook and Appendix A in the Spy Gliders Teacher Handbook.

Video Link

▶ MIT's Introduction to the Engineering Design Process video [YouTube Link]

Consider relating the engineering design process to a simple problem with which students are familiar. For instance, use a simple math problem, a riddle, or an everyday problem, such as deciding on what to eat for dinner. Relating the engineering design process to a simple, everyday problem helps students start thinking about the problem solving and redesign process.

NGSS Key Moment

Engineers often refer to the **engineering design process** when they discuss their work. In the NGSS, the Science and Engineering Practices are used in place of the engineering design process. Students should understand that the engineering design process is not linear in practice. Rather, engineers engage in all of the steps, often jumping between steps. Students may want to think of the engineering design process as a web of practices.

Whole Group Discussion: Define Criteria and Constraints (5 minutes)

If students are not familiar with the terms criteria and constraints, lead a class discussion to develop a consensus definition for the terms. Tell students that as they start an engineering design project, they need to determine the criteria and constraints that the design solution must meet. Ask students to try to define criteria and constraints. Ask them to share some examples.

Design Work: Our Questions (10 minutes)

Have students turn to 1.1: Define the Problem on page 2 in the Spy Gliders Student Handbook. Students should have already recorded the Engineering Design Challenge, *How can we engineer a glider that can carry a payload for the longest distance?*

- For several minutes, have students think to themselves and jot down a few questions that will help set up the criteria and constraints for this engineering design challenge.
- Then, for several minutes, have students talk with their partners as a pair to come up with the best set of questions.
- For the last several minutes, invite students to share their questions with the class to develop the criteria and constraints.

Design Work: Criteria and Constraints (10 minutes)

Tell students that when they engage in an engineering design problem, they must have a way to measure success. Engineers often measure success by assessing how successfully they have met the criteria and constraints of a design problem. Tell students to brainstorm what a successful solution will entail.

NGSS Key Moment

As students brainstorm criteria and constraints, they should take into account individual and societal demands and the impact on society and the natural world.

Have students complete 1.2: Criteria and Constraints on page 3 in the Spy Gliders Student Handbook. Have students discuss with a partner and then add additional criteria and constraints. Invite students to share their ideas with the class.

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 1.1: Define the Problem and 1.2: Criteria and Constraints.
- Whole class share-outs and discussions allows for formative assessment of student ideas and building content knowledge.
- When students are meeting in small groups, spend time with each group, 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

Research and share companies in the region that engage, use, or develop UAVs. Consider inviting an employee of a company using UAVs to talk with the class.

Suggested Teacher Resources

Engineering Design Process	Spy Gliders Teacher Handbook, Appendix A
Meeting the Needs of All Learners	Spy Gliders Teacher Handbook, Appendix B
Spy Glider Student Handbook	[Resource Link]
Amazon Prime Drones (video)	[Web Link]
MIT—Engineering Design Process (video)	[YouTube Link]
Flite Test—What Is a Drone? (video)	[YouTube Link]
Cool Uses for Drones	[Web Link]
The UAV	[Web Link]