Solar SPRK+ Unit Overview

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DESCRIPTION

This unit incorporates basic programming knowledge and solar energy into an engineering design challenge using Sphero SPRK+ robots. The theme for this challenge centers on the idea of Mars rovers, and the challenges faced in space exploration, specifically remote control of exploration tools and the energy generation needed to power these devices. Students will engage in basic programming challenges with their SPRK+, engage in a debate about Mars exploration, investigate the basics of photovoltaics, design chariots for their SPRK+ robots to carry their photovoltaic cells, and navigate their robots to a charging pad where solar energy will regenerate battery power for their robots.

GRADE LEVEL(S)

6, 7, 8

SUBJECT AREA(S)

Computer Programming, Electricity, Solar Energy, Solar Battery Charging, Mars Rovers

LEARNING GOAL(S)

1. Students will develop tools to use in the Engineering Design Process.
2. Students will learn drag and drop programming with Sphero Edu (formerly Lightning Lab).
3. Students will determine how series and parallel circuits affect voltage and current.
4. Students will understand how to use photovoltaic sources to charge a SPRK+.
5. Students will design a chariot to carry a photovoltaic power source for a SPRK+.
6. Students will learn to program a SPRK+ ball and chariot through a maze.

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LESSON EXPERIENCES

Table 1. Suggested Teaching Time

Lesson/Experience	Time
Engage	
L1: Introduction to Drag and Drop Coding Using Scratch	
L2: Sphero Edu Coding	
Explore	
L3: Mars Exploration Debate	50 min x 2 = 100 min (1 hr 40 min)
Explain	
L4: Electricity Fundamentals and Photovoltaics	
Elaborate	
L5: Creating a Chariot	
Evaluate	
L6: Solar SPRK+ Final Challenge and Presentation	**5 hours** over 5 class periods
Total	

NEXT GENERATION SCIENCE STANDARDS

Guiding Phenomenon	Remote (space) transportation
Supplementary Phenomena	N/A

THREE DIMENSIONAL LINKAGES

Table 2. Three-Dimensional Linkages: Performance Expectation

Performance Expectation	How is this assessed?
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.	Students will be defining criteria for success as part of their final engineering project to guide a SPRK+ through a maze to deliver solar panels to a charging station. They will outline the specific requirements for reaching these criteria as a class and discuss their process toward reaching it during their final presentations.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	Students will be required to outline their redesign process in their final project as part of their group presentations. Throughout each stage of their development, they should be

	tracking their redesign as a team in order for the teacher to monitor their progress for formative assessments.
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.	Similar to redesign, students will be required to make observations and record data that will be incorporated into their design process in the final project and discussed in their presentations.

DCI	Linkage
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 that are likely to limit possible solutions.	Students will design and program a SPRK+ to travel through a maze to a solar charging station. They will work in groups and as a class to determine what success means in a Mars rover-type scenario.
ETS1.B: Developing Possible Solutions • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.	Students will design and program a SPRK+ to travel through a maze to a solar charging station. During this process, they will engage in redesign both within a single challenge and between different challenges.
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 will be tracking changes they make to their chariots between different testing trials, ensuring that they are noting the materials and structures used.

Table 3. Three-Dimensional Linkages: Science and Engineering Practices

Science and Engineering Practices	Linkage
Asking questions and defining problems	Students will design and program a SPRK+ to travel through a maze to a solar charging station. They will discuss the purpose for transporting renewable energy in space travel.
Developing and using	Students will retrofit a Sphero SPRK+ to serve as a model rover

models	to travel over a model planet (maze).
Using mathematics and computational thinking	Students will program their Solar SPRK+ to travel through a maze using the Sphero programming app – Sphero Edu.
Developing explanations and designing solutions	Students will confer with each other to determine the best possible designs throughout this unit and must present this information coherently in their final project. This will require them to explain their reasoning behind certain strategies within their process.
Obtaining, evaluating, and communicating information	Students will engage in research and debate surrounding the usage of remote robotics for space exploration.

Table 4. Three-Dimensional Linkages: Crosscutting Concepts

Crosscutting Concepts	Linkage
Patterns	Patterns in writing code are critical to the success of generating multiple commands within a program.
Cause and effect: mechanism and evaluation	
Scale, proportion, and quantity	
Systems and system models	
Energy and matter: Flows, cycle, and conservation	The transfer of energy can be tracked as energy flows through a designed or natural system – charging a Solar SPRK+ with a battery and photovoltaic cells.
Structure and function	Students will plan and build structures to meet the needs of their solar-charged Mars rover. This includes both the chariot and determining the solar circuit needs of the device.
Stability and change	

COMMON CORE STATE STANDARDS

- 6-8.RST.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
- 6-8.RST.9: Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading text on the same topic.
- 6-8.WST.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
- 6-8.WST.9: Draw evidence from informational texts to support analysis, reflection, and research.

CONTENT BACKGROUND

STUDENT BACKGROUND

At the start of this unit, students participating in this lesson should be familiar with the following:

- Engineering Design Process (the model used in this lesson is from Engineering is Elementary)
- Basics of energy transformation
- Basics of electricity, i.e. what is electric current and voltage
- Drag and drop programming such as Scratch (this is not necessary but extremely helpful)

EDUCATOR BACKGROUND

Educators leading this lesson should be familiar with the following:

- Drag and drop programming
- Wiring a circuit with PV cells and the requirements needed to charge a battery
- Technical challenges associated with SPRK+'s

SPHERO SPRK+ TIPS AND TRICKS

Each time a Sphero robot is turned on, it needs to be "aimed". This means setting the direction that Sphero will treat as a heading of 0 degrees. Aiming is accomplished via Sphero's small blue "tail light". Sphero's tail light is inside the robot where Ollie's is located around the USB charge plug. Each Sphero app has a button that lets you set the tail light. To use this button, touch and hold on it and then slowly move your finger around the circle. You will see the blue tail light rotate. When the blue light is pointing directly at you, remove your finger. Now, if you tell the Sphero to move at a heading of 0 degrees, it will move directly away from you. The student guides for all of the MacroLab lessons lead you through how to do this. For an interactive introduction on how to aiming, use the Sphero app.

VOCABULARY

Variable	Energy
Voltage	Current
Photovoltaic cell	Resistance
Engineering design process: imagine, plan, create, experiment, improve, ask	AC and DC
Prototype	Circuits

Electricity	Parallel circuit
Power	Series circuit

MATERIALS LIST

HANDOUTS/PAPER MATERIALS

- Student Project Journals (1 per student)

CLASSROOM SUPPLIES

- Painter's tape for maze (optional)
- 250+ Watt portable halogen work light, such as Designer's Edge L860 Portable Halogen Work Light, Orange, 250 Watt
- Additional Maze supplies: wood blocks, bridges, ramps and other devices to simulate Martian (or other) terrain

ACTIVITY SUPPLIES (PER GROUP: 2 STUDENTS IS IDEAL BUT 3-4 WILL WORK)

- (1) Sphero SPRK+
- (1) Micro-USB to double alligator clip test cable
- (3+) 2 Volt x 500 mA photovoltaic modules (solar panels)
- (1) Maze ruler tape and protractor (these come with SPRK+ ball)
- (1) SPRK+-compatible device (any Bluetooth Low Energy device, such as iOS and Android devices, Chromebooks, and Kindle Fire. Search google "What device is Sphero SPRK+ compatible with?" for more details from sphero.com
- Building "blocks" with wheels, such as K'NEX and/or Legos
- Assortment of cardboard for building chariot and maze
- Assortment of loads to test using solar modules, e.g. LEDs, DC motors/fans, and small battery-powered radios

UNIT PROGRESSION

LESSON SEQUENCE

Prior to working on the Solar SPRK+ Challenge (Lesson 6), students should be familiar with the Engineering Design Process and have a basic understanding of how to use the SPRK+ programming app and Sphero Edu. Additionally, a basic understanding of electricity, solar energy, and Mars Rovers is helpful. These concepts are built into the preceding lessons, but if students are completely unfamiliar with these concepts, the lessons may require more time than allocated. Note that each lesson can easily be adjusted for time and rearranged within this progression. See attached Google Slides presentation for more information.

UNIT OVERVIEW

LESSON 1: INTRODUCTION TO DRAG AND DROP CODING USING SCRATCH

Students work through select activities within the Scratch Learner Workbook to familiarize or expand familiarity with drag-and-drop coding.

LESSON 2: SPHERO EDU CODING

Students work through Sphero Edu workbook to prepare for challenge (program sphero to navigate maze)

LESSON 3: MARS EXPLORATION DEBATE

Students engage in research to debate the value of Mars exploration via robotic and/or human means.

LESSON 4: ELECTRICITY FUNDAMENTALS AND PHOTOVOLTAICS

Students work through a number of solar circuit explorations that culminate in a challenge to charge the Sphero SPRK+ devices with solar panels.

LESSON 5: CHARIOT ENGINEERING DESIGN

Students will work through the design process to engineer a chariot to allow a Solar SPRK+ to carry solar panels.

LESSON 6: SOLAR SPRK+ FINAL CHALLENGE AND PRESENTATION

This lesson will require you to set up a maze. The maze itself can take whatever form the teacher chooses, even incorporating changes in elevation to complicate the coding necessary on the student end.

ASSESSMENT

Summative:

- Lightning Lab assessment
- Mars Rover Debate
- Maze coding and completion
- Final Presentation

LESSON EXTENSIONS

MIT App Inventor (appinventor.mit.edu/) is a visual programming environment that allows students to build fully functional apps for smartphones and tablets. The blocks used for programming are very similar to the ones used in Scratch and Sphero Edu.

For an additional extension, students can charge cell phones with PV cells and a work light. See Brett McFarland’s Off the Grid Unit or Luke Robbins’ Solar Battery Charging Unit on the CE Educator Library for more ideas about solar battery charging.