Mission to Mars: A Lego™ Engineering Adventure

Teacher's Guide

Overview

This teaching unit was created to provide any classroom teacher with all the tools necessary to help her students learn and apply engineering and design skills and computer science concepts in the context of a Next Generation Science Standards (NGSS) style investigation.

This curriculum requires the following:

- Lego WeDo 2.0 Core Set
- Lego WeDo App
- Two laptops (Chromebooks) / team
- Washers for the Gears Workshop (look for 1 oz/washer)
- Springs for the Storm Detection System
- Tape measure or meter sticks
- Carabiners (optional, but nice)
- Other supplies readily found in your classroom such as tape, scissors, etc.

Students learn in the context of a storyline that winds throughout each of the five workshops in the unit. Each workshop introduces a new phase of their ongoing "Mission to Mars." Every workshop begins with a video that provides students an overview of the problem or situation encountered by the Mars Explorers (represented in the online modules by two Lego™ minifigures and called Max and Mia to match the WeDo software). The curriculum then walks the students through a series of online learning modules that help them learn about a piece of technology or a new concept they'll need to build a model from Lego's™ and

Workshop 1: Liftoff

After an exciting video where Max and Mia lift off from earth and head to Mars, they suddenly realize they have six months of down time! What do they do? Get organized, try their hand at building a Lego model and get a crash course in coding in the WeDo app.

Workshop 2: Exploring Mars with a Rover

Max and Mia have landed on Mars and get their first command from Mission Control. Their mission? Build a Mars Rover and then learn to program it to go precise distances so they accurately send it out to specific locations on Mars.

Workshop 3: Creating a Safe Habitat

Crisis hits the Space Exploration module when the power suddenly begins to flicker and Max and Mia are put in emergency mode! What happened? Sandstorms! Learn how that can affect their power generation and then build and program a Lego model to monitor conditions so it doesn't happen again. As they solved that problem, they had to do many excursions on the Mars surface which required the use of an airlock system. Max and Mia explore what and airlock is and build and code a safer airlock system for their Mars habitat.

Workshop 4: Gathering Rock Samples

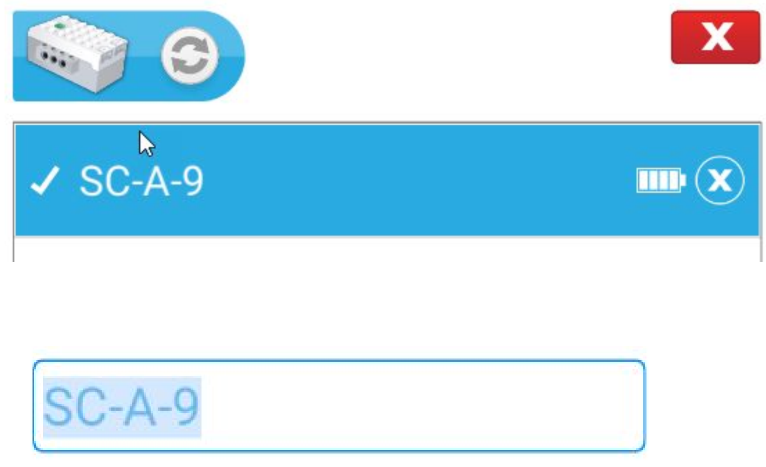
The Lego Wedo kits sport a full complement of gears to build any number of systems. In this module Milo (the Mars rover) has discovered a treasure trove of rock samples Max and Mia want to bring back to the habitat for further study. The problem? They are the bottom of a deep ravine. They learn how gears work to provide lifting power, then build a system to lift up the rocks. We use washers for our model, and both you and your students will be amazed when you see the results of this workshop.

Workshop 5: Life on Mars

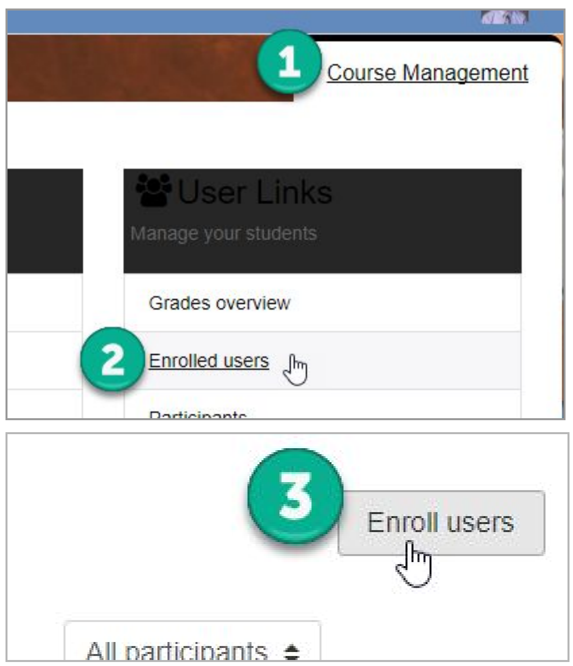
Milo returns from a mission with a microscopic life form attached! What does it look like? What does it do? Using all they have learned about Mars, engineering, and coding,students design a life form that might live on Mars. Working from a set of specs and many base models they can start from, they build a working Lego model complete with code to control it. This workshop serves as the summative assessment for the unit.

Preparation for Teaching the Unit

Materials

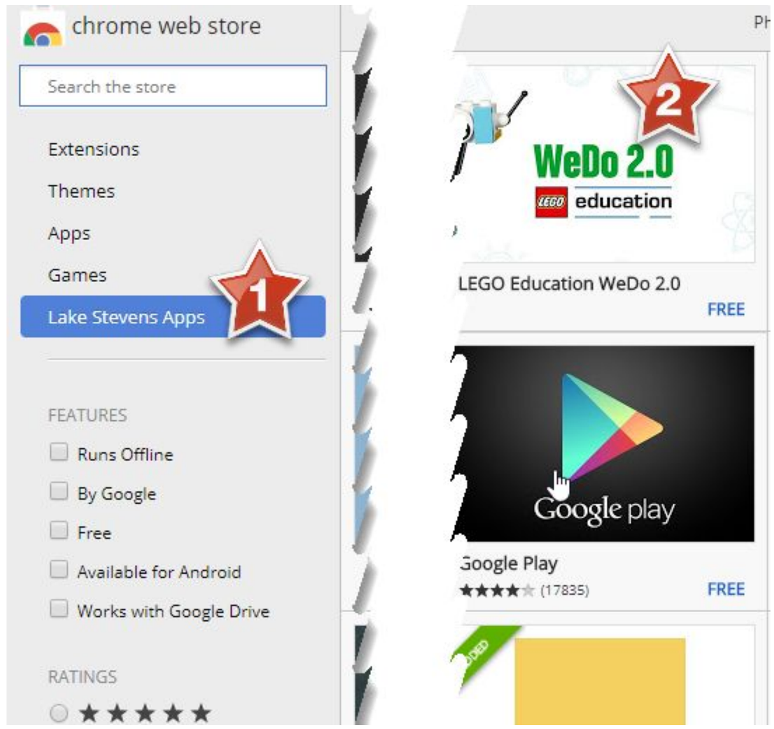
Label each of your WeDo kits with unique numbers, then label the Smart Hub in each one with that same number.	
We found it was hard for students to know which Smart Hub they were connecting to until we renamed each SmartHub to match the name of the kit they were in. You can rename each Smart Hub by first connecting to it, then **long pressing** on the name. Once the name area looks like the image to the right, just type in the new name and press **Enter**.	

<table>
<tr><td>Place about 30 washers in a ZipLock bag or container of some sort for Workshop 4.

You'll need one of these for each group.</td><td></td></tr>
<tr><td colspan="2">Online Materials</td></tr>
<tr><td colspan="2">Moodle</td></tr>
<tr><td colspan="2">If you are using Moodle to deliver the online material guides and materials:</td></tr>
<tr><td>Add all your students to the course.
Within the course, click the Course Management link at the top of the course page.
Click Enrolled users.
Click Enroll users button and start adding your students.</td><td>
</td></tr>
<tr><td colspan="2">Install the WeDo 2.0 App</td></tr>
<tr><td>Make sure all your students have installed the WeDo 2.0 app on their Chromebooks.
Open the Chrome Web Store.</td><td></td></tr>
</table>

2. Select the Lake Stevens Apps category (**RED 1**)
3. Click on the WeDo 2.0 app icon (**RED 2**).
4. Click Add to Chrome to install it.

The Lego WeDo 2.0 app is fairly large, so if the whole class is doing this at the same time, it might take several minutes for this to complete installation on all Chromebooks. A good reason to do this BEFORE the kids get their hands on a kit!



Understanding Workshops

Each workshop is organized around a challenge and follows a common flow. Each workshop will require a minimum of 3 class hours to complete, but realistically you should plan on 4 - 5 hours to maximize student's learning.

A workshop begins with a very short video to introduce students to the workshop challenge using the two main characters, Max and Mia. The video are upbeat, fast and attempt to keep students actively involved in the Mission to Mars storyline.

Knowing the challenge, students are introduced to the problem on Mars they'll be solving. These are usually short segments, and are a great place for teachers to use as a discussion starter in a session debrief or as a jumping board to other integrated lessons (i.e., a reading lesson on Mars Rovers, writing perspective on how it felt when the solar panels quit working, geography lesson on Mars surface).

With background knowledge and clear understanding of the problem, students build a model with their Lego WeDo 2.0 kits and then learn how to use the WeDo 2.0 app to program their model to help them solve the workshop challenge.

(Moodle version only) Share their solution with a short VLog entry. (If using the web version of this program, a teacher could easily use the Recap website to easily allow students to record and share their projects).

To allow students to work at their own pace, but still keep the class together, each workshop offers extension activities. These activities challenge students to refine and extend what they've just learned or to build a similar project and program it in an effort to solve a problem.

Most modules include a badge. You can set criteria for earning a badge or just award them to students as you see fit. We highly recommend that students earn badges based on their progress in the course. This encourages them to complete every task and pay close attention to the instructions. They'll see their badges on the side block as well as in each module.

Teaching the Workshops

Workshop 1: Liftoff

Use this first workshop as a vehicle to introduce your students to every aspect of the Mission to Mars unit. Everything will be a first for them, so start slowly with lots of explanation and modeling.

Challenge

1. Work with your partner to use the Learning Modules to guide classroom work.
2. Organize the WeDo kits and build a simple model.
3. Create a WeDo 2.0 program that uses the sensors in the Chromebook (sound) and displaying data on the screen.

Introduction

The sooner you get your students actively involved in the Mission to Mars storyline, the more they'll understand what they are learning in each unit. Don't hold back. Make the first video a true launch into space, and once you've got them in their roles as Mars explorers, watch the introductory video together.

Next, explain that instead of a printed book, their book is online and it contains everything they need to know for each of the workshops. Have one student in each team sign in to your Moodle course (or open the web based version) and look at the contents of Workshop 1. Explain that they will be working through each section one by one in the order they are presented.

Students at this age probably haven't had much experience learning with a partner or working independently on projects. Use this first workshop to practice, modeling behaviors you expect them to use throughout the unit.

We found the following to be effective:

Watch the introductory video together and discuss what it might be like to travel to Mars. What obstacles might you need to overcome? What jobs or tasks would a Mars Explorer undertake? What would it be like to live and work with just one other person for a very long period of time? Take some time to get into the idea that they are now traveling to Mars, and they'll need to use their time to get ready.

Demonstrate how to use the learning modules with the entire class. Show them how to start the modules and interact with them. Explain that one of the partners will always have the learning module open and BOTH partners will read and listen closely to the instructions. The other partner will have the Lego WeDo 2.0 app open on his/her laptop and together they'll do what the learning module tells them to do. Ensuring that your students understand their reliance on each other AND on the Learning Module to guide them is paramount to success as you continue.

Workshop Assessment
Results from the Workshop One quiz are stored in the Moodle gradebook. For teachers using the web version, at this time you'll need to have students alert you when they finish their quiz and write their scores down manually.

There are two activities where students record a short video describing their project and explaining how it works. For this first unit, take some time to show them how to aim their Chromebooks at each other if they need to record the WeDo app screen or how to set up an area to show a model. Remind them that rotating the model is a good thing. You might even want to set up an area for recording complete an old rotating tray (an old Lazy Susan?) to encourage more interactive explanations. If you are using the Moodle course, as soon as kids record their videos (using the Forum activity) they'll be allowed to watch what others have done. If you are using the web version, you can set up your Recap activities to something similar. You could also have a SeeSaw journal the kids could use as well, but remember you'll only see one entry for both students. You always have to consider how to factor that in when grading.

Extension
Workshop 1 does not include a formal extension. With the emphasis in this unit on modeling behaviors and working strategies we found that students don't scatter as much at this time. Since everything is new to everyone, they have a lot to take in.

If a group does complete the workshop well before the rest of the class, you could allow them to build something on their own that a Mars Explorer team might use to occupy their time while on their way to Mars.

Workshop 2: Rovers on Mars

Introduction

Congratulations! The team has arrived on Mars and set up their Mars habitat from which they'll live and work for the next few months. Each team should watch the video to learn their challenge in this workshop.

Guiding Questions

How can we use technology to help us explore places we can't safely go ourselves?
How can we use algorithms to program a rover to go specific distances without guessing?

Challenge

1. Students will use the Lego WeDo 2.0 app to build a Mars rover. They can embellish it as they see fit!
2. Students will program the rover to move forward.
3. Students will then learn how to calculate how to move their rover specific distances and complete three missions to test their accuracy.

Completing the Unit

Students should have the collaborative skills to work through the modules on their own. Monitor that BOTH partners are interacting with the learning modules and that BOTH partners are making decisions and contributing when programming with the WeDo 2.0 app.

Your students will run through the first parts of this unit (building the robot and getting it to move) pretty quickly. Once they get to Module 2-3, Controlling Your Rover's Movements, you'll need to monitor activity much more closely.

Before students start on Module 2-3, make sure you have printed enough copies of the Week 2: Lab Recording Sheet for each group to have one copy. If you are grading the lab sheets, it is probably best to give each student a copy. They'll each fill out their own while working with their partners.

Module 2-3: Controlling your Rover's Movements will teach students how to use an algorithmic approach to the distance problem. They will first determine how far their rover can travel in one second at power 8. Using that knowledge they'll use a bit of math knowledge to solve an equation to travel most any distance. When they start they'll discover a bug in their solution and they'll be guided to go back to their code and make some changes to increase the accuracy of their missions.

The final, big challenge is to see who can make their rover cross the room and stop with a few centimeters of the wall, then reverse and return to the starting position. To motivate students to complete their tasks in a timely manner, you should consider having an "end of module" demonstration where each team runs their rover. The team that gets the closest to the wall and back to their starting position can win the Explorer of the Week award, or something similar.

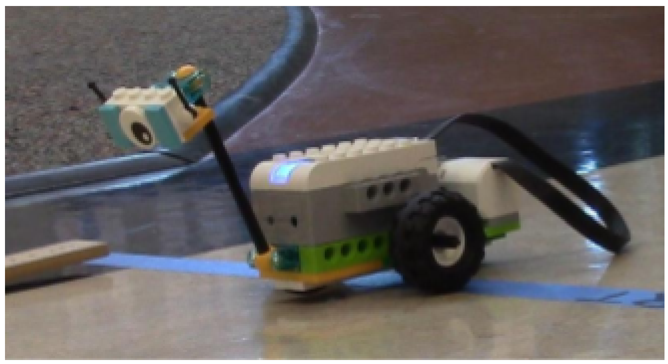
Assessment

The module includes a short quiz to test students understanding as well as the successful completion of the three challenges which will clearly demonstrate their ability to solve the problem of calculating accurate distances.

Extension

Students who complete the activity early can use Module 2-6 to learn how to make their rover go faster or slower, or climb an incline using different pulley combinations. It is a quick lesson that will provide a great introduction to Workshop 4 where students work extensively with gears.

Make sure you have printed out the Pulley Combination Recording Sheet for any students working on this extension activity.



Milo on a "Test Field."

Workshop 3: Creating Safe Habitats

Introduction

One day as Max and Mia are working in the Mars Habitat the power suddenly drops and the lights go dim. What happened? Max and Mia go outside and see that a small dust storm has swept through their solar panel array and covered them with fine dust. Their ability to produce power has dropped precipitously. As they sweep them off and bring things back to normal, they decide to build a system to warn them whenever a small storm sweeps through so they won't have this power issue again. Students will build a "Storm Detection System" using the tilt sensor and program it to sound an alarm and display a message on their computer screen whenever a wind blows.

As they leave and enter the habitat, Max and Mia must use an airlock system. After they learn how an airlock works and why it is so important, they decide to build an airlock warning system that tells them when the airlock door is open and when it is fully closed. Once again they program alarm sounds and monitor alerts to keep them safe in their habitat.

Guiding Questions

Why do people design, engineer and build things?
What can we do when we see a problem in our lives?

Completing the Workshop

Before starting this workshop locate the springs in the extra parts provided. If you are using the web-based version of the workshop, you can find the specs for the springs here. As the students get to the point in building their Storm Detection System (SDS) provide each group with one spring.

By this time students should be able to follow directions and complete the learning modules successfully on their own. You should be able to move around the room freely asking clarifying questions and answering their questions without too much interference.

Remind students continually that they need to move through the Learning Modules carefully, listening to and reading all instructions and completing every task. You'll be able to look in the Moodle gradebook to see if students are completing each lesson. If you are using the web-based version of the curriculum, you can have students call you over when they click the final button to complete each unit and check it off.

Assessment

Students complete the short quiz, which is recorded in the Moodle gradebook.

Students use the built in recording tools in Moodle to record a short, 1 minute video clip explaining why they built their Storm Detection System and how it works. (Web-based classrooms can use SeeSaw or Recap to this activity)

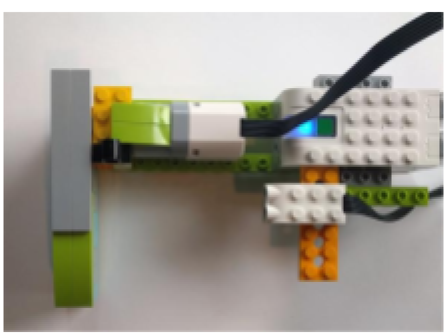
Students use the built in recording tools in Moodle to record a short, 1 minute video clip explaining why they built their Airlock Warning System and how it works. (Web-based classrooms can use SeeSaw or Recap to this activity)

Extension

The more students can work with sensors and program them to react to external stimuli the better they'll understand them. The Workshop Three extension encourages students to build and program another model in the WeDo 2.0 app that uses sensors. It would be fine to allow them to build a model of their own choosing and attach a sensor to it and program it. However, we found in our initial tests that students often don't have the building knowledge to build much more than very basic models (boxes, a beam with motor, etc.). If students learn to use existing models and then adapt them or redesign them into their own design, they'll end up with a much more sophisticated and rich design.

We asked ourselves often as we designed this unit if this was cheating? Shouldn't students be required to start everything from scratch and figure it out on their own? As we continually wrestled with this question we realized that in real life engineers don't start from scratch. That is just too inefficient and expensive to work in that matter. If an engineer is told to design and bridge she will start by researching and examining many different bridges already in existent that offer solutions close to what her problem requires. Then she'll redesign the parts that need it and come up with her own solution. To imagine that an engineer must figure everything out with no prior models to work from is to imagine a life of exhaustion. Helping our students understand that a great deal of solving their immediate problem is researching and building on what others have done before it essential to developing good engineering and design skills.

So, in this extension, ask students looking for a bigger challenge to pick a model from the list provided and 'mod' it into a new product that might accomplish something more or more efficiently.



Airlock Alarm Model

Storm Detection System (SDS)

Workshop 4: Gathering Rock Samples

Introduction
Max and Mia have been busy sending their rover out to look for good rock samples that might show signs of life on Mars. One day they find a promising load, but they are at the bottom of a steep ravine… and their rover is high above. Time to build a crane to lift the cargo up to the surface. They'll learn to use gear systems to lift heavier and heavier loads.

Guiding Questions
How can we use simple machines to allow a motor to generate higher speeds or higher torque?
How do we calculate how much weight a geared system can lift?

Completing the Workshop
Students will use the washers provided in your kits for this workshop. Have a bag of 30 washers ready to give each group once they've completed their first crane design. We recommend using a washer that weighs as close to 1 ounce as you can get to make it easy for students to calculate the total weight they are lifting. This washer comes the closest and can be purchased online (and this company was great to work with and excited to be doing something to help kids learn!).

This is one of the best workshops for students to work independently. If they have been careful and paying attention in past workshops, they'll be able to follow along easily with the learning modules in Workshop 4. We did find that the concepts in this module can be a bit abstract for many learners. As one or two groups are finishing a gearing module you might want to gather the whole class around and have the group demonstrate. Take time to ask lots of questions from the class as they watch and get them to predict. If the drive shaft has a small gear and the load has a big gear, will it raise it fast or slow? Why or why not? They need to really think about what is happening as they are working with the gears.

To understand how gears can be a building block to understanding many other concepts, you might want to read this essay by Seymour Papert on how gears were such a powerful learning tool for him as a child. Seymour Papert went on to become a professor at MIT where he developed the LOGO programming language that helped ignite the education technology movement. I'm always thankful for gears and the way they provided the catalyst for much of the foundational thinking of how we are using technology in this unit!

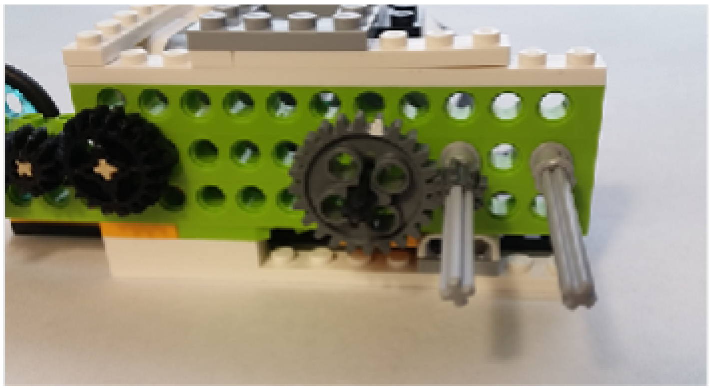
Assessment
Students complete a short quiz, which is recorded in the Moodle gradebook.

Students record a video of their crane lifting a payload. They should explain how the gears help the crane lift the load and if possible be able to tell the audience the potential weight their crane can lift.

Extension
In this extension students go on to build more and more powerful cranes by using compound gearing, and if they can get all the way through they'll build a crane with a worm gear which makes the little motor in the WeDo 2.0 kit capable of herculean lifts. It will astound everyone in

the room. If only one group gets this far, be sure to gather the class together and watch the crane lift a huge load. Have the students do their best to explain how it all works to their classmates.

As students work on the extension activities, you'll need to find a way to provide more weight for them. If you have enough extra washers you can keep providing them. If not, have the students borrow from each other. The interaction between groups keeps the buzz alive in the room.



The crane fully built out.

Workshop 5: Life on Mars

Introduction

The greatest test of student understanding of technology is to provide them with what we call the "white screen test." That's where they start with nothing more than an idea and they have to use all that they've learned to create a model and program it -- completely on their own.

This unit starts with an introductory video that inspires them to make a model of the life form they've found on their rover after one of his missions. If they can do this, all the citizens of earth will be able to learn from them.

They are then introduced to the task and set off to build and program their interpretation of life on Mars.

Guiding Questions

What might life on Mars look like?
What mechanisms move a model without wheels? How can I design and build them with Legos?
How can I use sensors to mimic a living organism sense? How can I program it work in a lifelike manner?

Completing the Workshop

In our pilot classroom we found that students needed background work to help prepare them for this module.

- Students didn't have much of an idea of what a microscopic life form looked like. We recommend that you have each team do some quick research on this and share one picture they have found with the class.
- Students really didn't have any idea of how to build a model that moved, especially with a mechanism other than just wheels. We added a link to a page of WeDo models that they could use to base their creature on, making modifications and necessary changes to to create their final model.

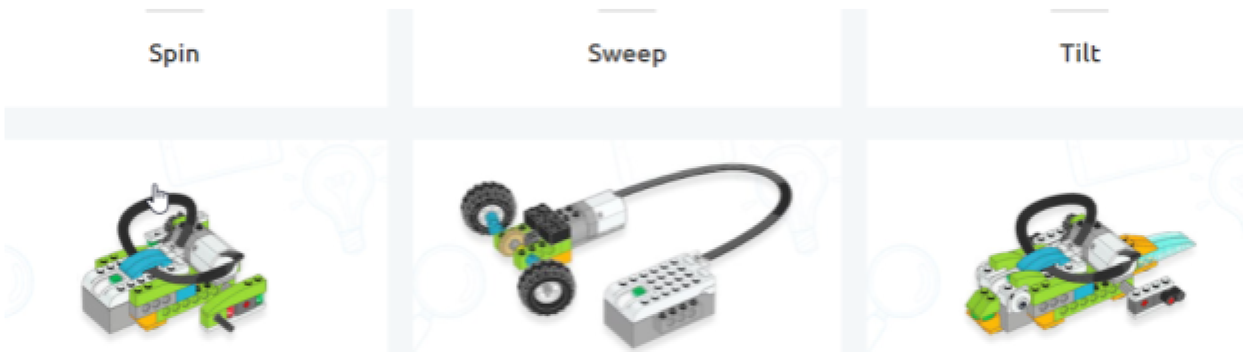
After students have researched microscopic life forms (on earth and other planets) and at least looked at possible ways to move a model without wheels, they should sketch out what their lifeform should look like. Asking them to answer some basic questions as they sketch would help:

- How does the lifeform breathe?
- How does the lifeform eat? What does it eat?
- What does the lifeform live in (i.e., ice?, water?, dust?, crevices of rocks?).
- How does the mobility solution you chose help them move in their environment?
- What sense would be most useful to the lifeform in its environment? Which Lego sensor best simulates that? The Distance Sensor or the Tilt Sensor?

Using their sketches and answers to persistent questions, students build and program their lifeform.

Assessment
Students demonstrate their understanding in this lesson by recording a video of their lifeform. As they record, they should answer:

1. In what environment does the lifeform live?
2. How does the solution you've chosen to make it move help him in that environment?
3. How does the sensor you've chosen to use help the lifeform survive in its environment?



Examples of alternative methods of moving a model.

Standards Correlation

Next Generation Science Standards	
4-PS4-2	Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.
4-LS1-2	Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.
LS1.D	Information Processing Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions. (4-LS1-2)
4-LS1-2	Use a model to test interactions concerning the functioning of a natural system.
1-PS4-1	Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.
1-PS4-2	Make observations to construct an evidence-based account that objects in darkness can be seen only when illuminated.
1-PS4-3	Plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam of light.
1-PS4-4	Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.
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.
ELA/Literacy (Common Core)	
RI.5.1	Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. (3-5-ETS1-2)

RI.5.1	Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (3-5-ETS1-2)
RI.5.9	Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.
RI.4.7	Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.
RI.4.10	By the end of year, read and comprehend informational texts, including history/social studies, science, and technical texts, in the grades 4-5 text complexity band proficiently, with scaffolding as needed at the high end of the range.
RI.4.1	Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.
RI.4.4	Determine the meaning of general academic and domain-specific words or phrases in a text relevant to a grade 4 topic or subject area.
SL.4.5	Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes.
SL.4.6	Differentiate between contexts that call for formal English (e.g., presenting ideas) and situations where informal discourse is appropriate (e.g., small-group discussion); use formal English when appropriate to task and situation.
Math (Common Core)	
4.MD.A.1	Solve problems involving measurement and conversion of measurements.
.4.NF.C.6	Understand decimal notation for fractions, and compare decimal fractions.
4.OA.C.5	Generate and analyze patterns.
.OA.A.1	Use the four operations with whole numbers to solve problems.
4.OA.C.5	Generate a number or shape pattern that follows a given rule. Identify apparent features of the pattern that were not explicit in the rule itself.
Practices	1. Make sense of problems and persevere in solving them. 2. Reason abstractly and quantitatively. 3. Construct viable arguments and critique the reasoning of others. 4. Model with mathematics. 5. Use appropriate tools strategically.

	6. Attend to precision. 7. Look for and make use of structure. 8. Look for and express regularity in repeated reasoning.
Washington State Computer Science Standards	
1B-A-2-1	Apply collaboration strategies to support problem solving within the design cycle of a program.
1B-A-5-3	Create a plan as part of the iterative design process, both independently and with diverse collaborative teams (e.g., storyboard, flowchart, pseudo-code, story map).
1B-A-5-4	Construct programs, in order to solve a problem or for creative expression, that include sequencing, events, loops, conditionals, parallelism, and variables, using a block-based visual programming language or text-based language, both independently and collaboratively (e.g., pair programming).
1B-A-5-5	Use mathematical operations to change a value stored in a variable
1B-A-3-6	Decompose (break down) a larger problem into smaller sub-problems, independently or in a collaborative group.
1B-A-3-7	Construct and execute an algorithm (set of step-by-step instructions) that includes sequencing, loops, and conditionals to accomplish a task, both independently and collaboratively, with or without a computing device.
1B-A-6-8	Analyze and debug (fix) an algorithm that includes sequencing, events, loops, conditionals, parallelism, and variables.
1B-C-7-9	Model how a computer system works. [Clarification: Only includes basic elements of a computer system, such as input, output, processor, sensors, and storage.]
1B-C-6-11	dentify, using accurate terminology, simple hardware and software problems that may occur during use, and apply strategies for solving problems (e.g., reboot device, check for power, check network availability, close and reopen app).
1B-D-5-12	Create a computational artifact to model the attributes and behaviors associated with a concept (e.g., solar system, life cycle of a plant).
1B-I-1-17	Seek out and compare diverse perspectives, synchronously or asynchronously, to improve a project.
1B-N-4-21	Model how a device on a network sends a message from one device (sender) to another (receiver) while following specific rules.

Print Resources

The following resources are used throughout the course. Click the links to open these up in either Google Docs or as a PDF file.

Workshop 2		
Milo Moves: Lab Recording Sheet		
Workshop 2 Challenge Recording Sheet Pulley Combination Recording Sheet		