Grade level: 2nd
Lesson length: 60 minutes

Exploring Insect Adaptations

Lesson Topic: Form and function of insect spines
LESSON MATERIALS:

- Spider Hexbug (HEXBUG® is a registered trademark of Innovation First Labs, Inc. *www.hexbug.com*)
- Spider Hexbug with spines (cut pieces of a paperclip and glue them onto the legs of the Hexbug with superglue)
- Wire mesh cut into a 16” square with duct tape along the edges
- Map of the world
- Books
- Activity handouts
- Pencil, markers or crayons
- Ruler
- Live Madagascar Hissing Cockroaches
- Insect research video

Link: http://crablab.gatech.edu/pages/publications/BB_movies_for_spanga_et_al.html

NGSS CONNECTIONS:

Standard 2-LS4 Biological Evolution: Unity and Diversity

- Performance Expectation: 2-LS4-1 Make observations of plants and animals and compare the diversity of life in different habitats.
- Disciplinary Core Idea: LS4.D: Biodiversity and Humans
- Science and Engineering Practices: Asking Questions and Defining Problems and Planning and Carrying Out Investigations

Standard K-2-ETS1 Engineering Design

- Performance Expectation: K-2-ETS1-3 Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

SAFETY:
Students and adults who handle insects should wash their hands and apply a hand sanitizer that contains at least 62% alcohol. Students should take precaution when handling the Hexbug with spines as the edges of the cut paperclips can be sharp. Instruct students to not touch the spines on the models.

STAGE ONE: DESIRED RESULTS

BIG IDEA:

Form and Function of Insects
Biomimicry/ Bioinspiration

CORE KNOWLEDGE

- Microhabitats are the smallest part of the environment that supports a distinct flora and fauna, such as a fallen log in a forest, clump of grass or space between rocks
- Spines help insects walk over uneven terrain
- One way to communicate scientific results is by using graphs

ESSENTIAL VOCABULARY

- Bar graph
- Cockroach
- Insect
- Madagascar
- Microhabitat

MISCONCEPTIONS

- All conditions of a given habitat like a forest, desert, and prairie are the same.
- Spines on an insect are for fighting, looking pretty or scary, or lack function.

SCIENCE PROCESS SKILLS

- Qualitative observations
- Communicate findings in charts

HABITS OF MIND

- Values and Attitudes

  Curiosity

  By fostering student curiosity, teachers can help students uncover ways to find answers to questions about how the world works.
- Communication

  Discourse in science calls for the ability to communicate ideas and share information with fidelity and clarity, and to read and listen with understanding.

APPLICATIONS OF LEARNING

- Communicating – Express and interpret information and ideas
- Making connections – Recognize and apply connections of important information and ideas within and among learning areas

STAGE TWO: DETERMINE ACCEPTABLE EVIDENCE

Evidence

- Students will collect data on the “Do spines help insects walk?” graph after each trial.
- Students will complete the “exit slip” at the end of the experiment

Reflection

- Students will compare how far the insects can walk with or without spines and discuss how spines might help insects navigate uneven terrain.

STAGE THREE: LEARNING PLAN

Part 1: Initial Insect Observations and Discussion (15 min)

Question to be investigated: Is an insect able to move across uneven terrain better with or without spines on its legs?

1. Begin lesson by asking students, “Today we are going to learn about insects, what do we already know about insects?” Record student prior knowledge in group discussion.
2. Introduce a live Madagascar Hissing Cockroach to the students.
3. While students view the cockroach ask students to make observations and ask questions about them. One suggestion is to pass the cockroach in a circle and have each set of partners make 2 observations and raise 2 questions about the live cockroach.
4. Ask students, “Where do you think these cockroaches live?” “What does the word “habitat” mean?” and “What is their habitat?” (They are from Madagascar and live in forests).
5. Show students a picture of the world. Point to where your classroom in located, and then point to Madagascar.
6. Ask students, “Do you think a cockroach lives throughout the entire forest, or just in a small part of the forest?” “How do cockroaches move around?” Does anyone know what the word “Micro” means? Micro = small. Explain to students that cockroaches live in small spaces within the forest called a microhabitat (or small habitat). Microhabitats are the smallest part of the environment that supports a distinct flora and fauna, such as a fallen log in a forest, clump of grass or space between rocks. The microhabitat for this cockroach is usually in a rotting log on the forest floor.
7. Check with students to see if they notice the small mites on the cockroach. If not, point them out. Ask students, “What is the microhabitat of these mites?” (The cockroach is the microhabitat of the mite).
8. Show students that some places on the cockroach contain different amounts of food (mites eat bits of moist food on the legs and saliva of the cockroach) and there are different physical conditions (some places on the cockroach are wetter or warmer than others). Stress to students that mites can live their entire life on just one roach!

Part 2: The Investigation (20 min)

Generate and Share Predictions

Encourage students to make observations about cockroach legs. Be sure to point out the spines on the legs. Help students to visualize by imagining they were climbing on a rope ladder. Ask students, “Would it be easier to climb with your hands pushed together or

apart? Why?" Based on their responses, gage student's readiness to form a hypothesis. If they do not understand, ask them to picture themselves climbing up a ladder. Ask, "Would it be easier to climb the ladder with my hands tied together and my feet tied together or would it be easier to have them separated?" You could also have students model this with their body. Then say, "If it's easier to climb with your hands apart, let's make a prediction about which Hexbug will be able to get across the mesh screen better, the one with spines or without spines? Why?"

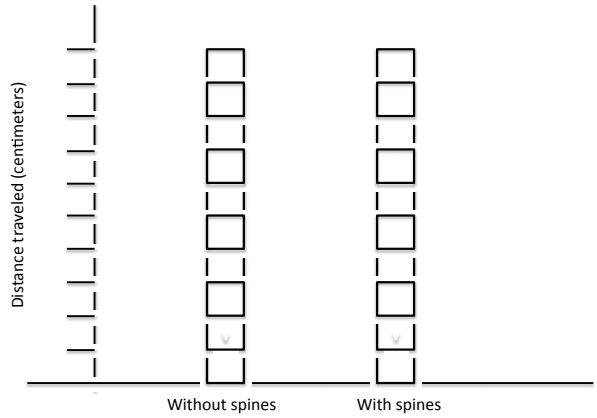
Procedure:

1. Elevate the piece of wire mesh across two textbooks on either end.
2. Tell students that the wire mesh simulates our uneven ground
3. Pull out the Hexbug without spines.
4. Say, "Let's see if this bug can get across the wire mesh! Do you think it will be able to cross?"
5. Turn the Hexbug "on" (legs should be moving) then place it on the wire mesh (the bug will get stuck).
6. Measure how far the Hexbug without spines went with a ruler.
7. Record the results.
8. Ask students, "What can we add to the robot to help it get across?"
9. Pull out the Hexbug with spines glued on.
10. Ask students, "Do you think this Hexbug will be able to get across? If it does get across what will that tell us?"
11. Turn the Hexbug "on" (legs should be moving) then place it on the wire mesh. The Hexbug with spines should be able to cross the wire mesh.
12. Measure in centimeters how far the Hexbug with spines traveled on the mesh using the ruler.
13. Record results.
14. Repeat the investigation two times for each Hexbug.

Part 3: Gather Data and Create a Graph (10 min)

Record results in a bar graph (see example below). Instruct students to label the *y*-axis 0– 0 by writing the number on the line provided and color in the number of boxes to correspond to the distance traveled. For example, if the Hexbug walked 1 cm without spines, students should color in 1 box. Do this for the 3 trials and have students pick a color of a crayon for "Yes Spines" and a different color to represent "No Spines."

Do Spines Help Insects Walk?



Part 4: Analysis (15 min)
Review results of data presented in the bar graph students created. Ask students, "What does that tell us about the spines?"

Have students complete the exit slip.

Discussion Points:

- Insects are able to help solve the problem of walking over uneven ground by having spines on their legs. Do humans ever have trouble getting across uneven ground? Have students come up with ideas. Examples from student groups include playing soccer or football.
- What did we learn from these insects today? (Spines help walk on uneven terrain). Studying the way animals solve their locomotion problems can result in people learning from them and helping solve our own problems.

Part 5: Video, Reflection and Final Insect Interactions (5 minutes)

- Have students watch the video comparing the robots and animals with spines and without spines (provided by email). Discuss the similarities and differences between their investigation and the scientific research experiment in the video.
- If there is time, allow students to hold the cockroaches again.

References:

- http://livingwithinsects.wordpress.com/2011/01/31/spineless-invertebrates/

- Spagna, J.C., D.I. Goldman, P. Lin, D.E. Koditschek, and R.J. Full. 2007. Distributed mechanical feedback in arthropods and robots simplifies control of rapid running on challenging terrain. *Bioinspiration and Biomimetics* 2: 9–18.

Additional Information:

Cockroach care: Madagascar hissing cockroaches are easy to keep as classroom pets! Approximately 10–15 cockroaches can live in a container as big as a shoebox. For easy student viewing, purchase a terrarium with clear sides and a well-fitting lid. Place toilet paper rolls and egg cartons in the terrarium for plenty of spaces for the cockroaches to hide. They love to eat fresh fruits and vegetables such as apple cores, lettuce, mangos, and bananas. Also place a couple of pieces of dry dog food inside for protein supplementation. One to two times a week spray the cage walls with water. The cockroaches may drink from the water droplets. Clean the cage as needed by removing old pieces of fruit and completely toss out all disposable materials and wipe down the cage about one to two times a month.

Material costs associated with this lesson plan include approximately $25 per Hexbug "spider" as well as $15 for a classroom terrarium. Hexbugs and terrariums are readily available at in store or online retailers. NOTE: Even though the Hexbug is called a spider, it does not have eight legs! It actually has six legs like an insect.

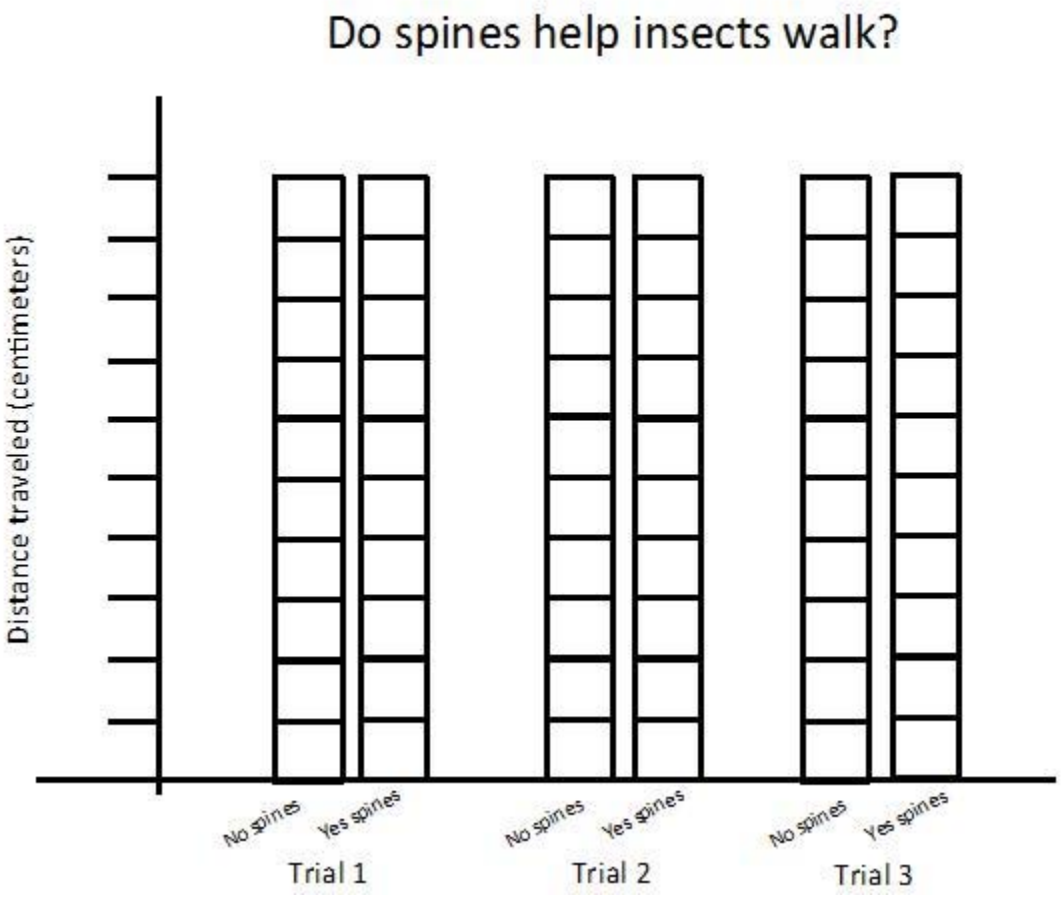
Alternative models:
One may also use the Hexbug "crab" as a less expensive substitute for the Hexbug "spider." The crab costs approximately $15 per Hexbug "crab." The crab has eight legs so it does not mimic an insect per se, which would be an important distinction to point out to students. That could be an opportunity to discuss how models might not exactly replicate desired conditions, but are still very useful to understand various phenomena in our world.

Assessment:

Exit Slip Question:

Sketch and label the Hexbeg that traveled the farthest/navigated uneven terrain the best in your investigation. Why do you think this happened?

Graph Template:


Do spines help insects walk?
Distance traveled (centimeters)
No spines
Yes spines
No spines
Yes spines
No spines
Yes spines
Trial 1
Trial 2
Trial 3

Investigation Rubric: Do spines help insects walk on uneven terrain?

Student Name: _____

CATEGORY		
Observations	Student contributes at least one question or observation to the group discussion.	Student does not contribute a question or observation to the group.
Variables	Student identified and defined which variables were going to be changed (independent variables).	Student did not identify or define which variables were going to be changed (independent variables).
Recording data	Student completes the graph for all three trials and uses a different color or pattern for the trials with spines and trials without spines.	Student does not complete the graph for all three trials or does not designate a separate color or pattern for each variable.
Conclusion	Student engages in group discussion and communicates ideas and observations.	Student does not engage in group discussion or communicates ideas or observations.

Rubric Made Using RubiStar (*http://rubistar.4teachers.org*)