A bird in the cage is worth two in a bush

Enhance your activities to engage students in science practices

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The *Next Generation Science Standards* (*NGSS*) present a new and exciting vision for science education in the United States (NGSS Lead States 2013) and represent what we have come to understand about how students learn science (NRC 2012). As states, districts, schools, and teachers begin to adapt their instruction to align with this new vision, the labs, demos, and activities that we have done for years become important material for this process. At the Teacher Institute, a professional development provider at the Exploratorium, a museum of science, art, and human perception, we too have worked to best understand how our classroom-tested activities needed to be modified to align to the *NGSS*. In this article, we share one activity that we have modified to engage students in the science and engineering practices.

Over three decades, the staff and participants of the Teacher Institute have created over 1,000 unique student-centered activities, all of which use low-cost, readily available materials and are designed to be accessible for use regardless of classroom budget. Many of these activities are modeled after exhibits on the museum floor and are referred to as Science Snacks. Collections of Science Snacks have been widely disseminated through published teacher activity books. Over 150 of these activities are available for free on the museum website (see Science Snacks in Resources). These activities were developed to provide student-centered, inquiry-based avenues that use physical representations of science to learn content described in prior national and state science standards (NRC 2007).

In this article, we explore how Science Snacks can provide an opportunity for students to engage in the *NGSS* practice of Planning and Carrying Out an Investigation. Scientists plan and carry out investigations to work through competing ideas and to gather evidence about how a process works. For example, a neuroscientist may design an investigation to understand whether a particular visual illusion is due to the physiology of the eye or activity in the brain. There may be a number of possible reasons why humans experience the visual-perception phenomenon, but until we have evidence to support those ideas, we do not know which is the most robust explanation for what humans perceive.

Bird in a Cage activity

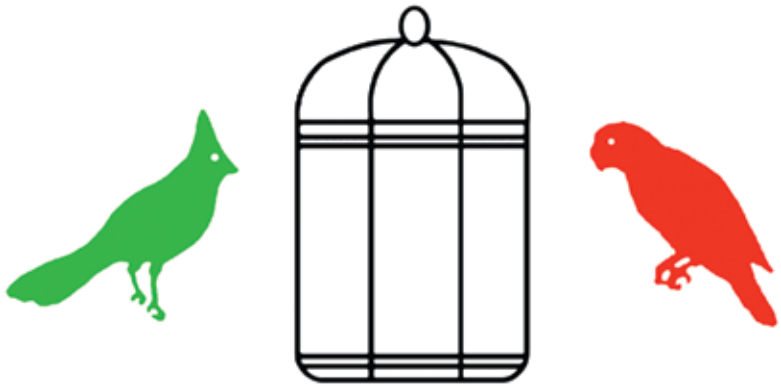
Bird in a Cage (Figure 1) is one example of a Science Snack that elicits a number of varied observations and ideas about how we see. This Science Snack is a classroom version of an Exploratorium exhibit that provides students with an opportunity to explore a phenomenon referred to as an *afterimage*—a lingering image in the visual system that can persist even after you look away. The learning objective for this activity is that students will plan and carry out an investigation to provide evidence for how the eye perceives different colors. In this activity, students stare at one of the colored birds for 30 seconds and then shift their gaze to the empty cage (Figure 1). Once students shift their gaze, they see an afterimage of a bird that is a different color

than the original bird. If students do the activity a second time and stare at the other bird, they notice that again the afterimage is a different color than the original bird and also distinct from the first afterimage they saw. Similarly, students may have different observations about how long the afterimage lasts and if it moves or stays in the cage. In the next section, we describe how to use this activity and the variety of observations about the afterimages as a way to engage students in planning and carrying out an investigation to explore their system of visual perception.

Start the activity by instructing students to stare at one of the birds in the picture. Do not give them any instructions about what part of the bird or which of the birds to look at; minimal directions will ensure some variation in student observations. Ask students to share what they observe and write their observations on the board or on chart paper. Use this as an opportunity to solicit different ideas, encouraging students who saw something different to share. Once you have a variety of observations on the board, ask students to lump similar observations together, and note how those groups are different (e.g., differently colored afterimages, bird moved out of the cage, bird stayed in the cage). Students will naturally begin to think about how they may have approached the activity during this discussion. Pair off students based on competing observations.

With their partners, students will discuss their observations and any differences in their procedures in their initial encounter with the bird. Students will tend to consider which bird they looked at, what part of the bird they looked at, and for how long they stared at the bird (did they get distracted and look away before you told them to?). From here, partners should come up with a more standard procedure for staring at the bird and then shifting their gaze to the cage. For example, students could agree to stare only at the green bird and then collect data on what color afterimage was observed. Another example would be for students to stare at only one part of the bird, its eye or its tail, and observe the movement of the afterimage. After repeating the experiment using the new collaborative procedure, students can compare observations to determine if there was a difference from their initial experiment and try to determine how that particular difference resulted in dif-

FIGURE 1: Bird in a Cage



CONTENT AREA

Life science

GRADE LEVEL

6-8

BIG IDEA/UNIT

Vision and color perception

ESSENTIAL PRE-EXISTING KNOWLEDGE

Humans have receptors in our eyes that detect light

TIME REQUIRED

1 hour

COST

Minimal (you likely have everything you need)

fering observations of the afterimage. Once students have a specific procedure that repeatedly yields the same result, they should write it down on a whiteboard or another mechanism you use for quickly sharing student work.

As students share their procedures and findings with the class, you can help students highlight variables and controls embedded in their investigations. At this point, students should have come up with a variety of methods to investigate the different observations of the bird in the cage. Any of these observations can serve as the focus of further student investigation; however, we suggest that you first focus students on planning an investigation to collect evidence on the color of afterimages. You can ask students to look at the different procedures and decide on a procedure that they all can use to investigate the color of afterimages other than the original red and green birds. One way to do this is to have each group of students write a procedure for collecting data on the color of the afterimage that corresponds to different initial colors and then compare their procedure with another group. It is helpful to have a variety of materials students can use in their investigations, including different colors of construction paper, markers, or other ways to represent different colors. As students compare their procedure with another group, they should push each other to identify the different variables and controls in their suggested investigation. Gradually, each of the different groups can meet with each other and, in the process, come up with a consensus procedure for the class. Once the class has agreed upon a procedure, they should proceed to collect the data. After students have completed their investigations, the data should be shared with the class. You can then facilitate the class to organize the data in a way that makes sense for students.

An important note about color blindness: If one or more of your students has some level of color-vision deficiency, they will still be able to detect an afterimage. Depending on the type and degree of color-vision deficiency, this can add another level of variation to the student observations that can be further explored to better understand the phenomenon of how we see. It is possible that color-blind students are not aware of their color-vision deficiency, and this activity could reveal an individual difference from their classmates. In addition to sensitivity around the discovery of this difference, it could be useful to have color blindness tests available for them to do further explorations. Many of these tests are available for free online.

A single activity will likely not fully attend to a given performance expectation; it does, however, lay the essential groundwork for students to build toward it. For the Bird in a Cage activity described in this article, we link the learning objectives to the Performance Expectation MS-LS1-3 (see *NGSS* box, p. 69). Although students will not be ready to demonstrate this performance expectation at the completion of this single activity, they will have some of the initial pieces and be ready to explore the phenomena further. At the end of this activity, students will have an understanding of how investigations are designed to generate evidence and that staring at different colors produces differently colored afterimages. These concepts will prime them to pose investigable questions about the structure and function of the eye and its specialized receptors, as well as how information is processed and stored by the brain.

By engaging in other activities or Snacks, students can pull together the pieces they need to make sense of how we see. For example, by participating in the Afterimage Snack, students will be able to determine by the shape of the afterimage that certain receptors in the eye become unresponsive after staring. The Colored Shadows Snack draws students into what happens when colors of light are added or subtracted, leading students to understand that the human brain perceives white only when certain colors are added together. In the Peripheral Vision Snack, students are able to discover at which angles in their line of sight they are able to determine shape, color, motion, and text. These activities will provide students with more information about the function of the photoreceptor cells in the eye. By the end of this series of activities grounded

Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013)

- The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities.
- The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectations listed below.

Standard

MS-LS1-3: From Molecules to Organisms: Structures and Processes
www.nextgenscience.org/pe/ms-ls1-3-molecules-organisms-structures-and-processes

Performance Expectation

MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

DIMENSIONS	CLASSROOM CONNECTIONS
Science and Engineering Practice	
Planning and Carrying Out an Investigation	Students discuss their procedure with other students to understand how it impacted their observation and why it was different from the procedures of other students. Students build on this experience to design a consensus procedure for collecting data on different afterimages and their colors.
Disciplinary Core Idea	
LS1.D Information Processing • Each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behavior or memories.	Students learn that lingering afterimages can result due to the way signals for sense receptors in their eyes are processed by their brains. By exploring the colors of initial objects and their afterimages, students can determine that the eye has different cells that work together with the brain to see color.
Crosscutting Concept	
Patterns Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.	In this activity, students look for patterns in the color of different afterimages to begin to understand how the eye and brain perceive color.

in the science practices, students should be able to develop an argument for how the photoreceptors in the retina work together with cells in the brain to help us see and process what we see, which is the focus of the performance expectation (see *NGSS* box).

Modifying other inquiry activities

The Bird in a Cage activity was chosen as a candidate activity to adapt for alignment to the *NGSS* because it typically generates multiple and varied observations. These activities are important resources for engaging students in the practice of Planning and Carrying Out an Investigation because students are able to design experiments and collect data to support or refute the ideas presented. If you have other activities that simi-

larly elicit a variety of competing ideas amongst your students, you might consider using those activities to engage students in this practice. We have developed a planning tool in our professional development program that can lead you through the process of adapting that activity with your colleagues. This process will support you in identifying (1) the variety of ideas that might surface with the activity, (2) which materials and resources students can use to plan and carry out their investigation, and (3) what students will know at the completion of that activity. ●

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NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states*. Washington, DC: The National Academies Press. *www.nextgenscience.org/next-generation-science-standards*.

RESOURCES

Afterimage Snack—*http://bit.ly/29fStGy*

Colored Shadows Snack—*http://bit.ly/29krvAi*

Exploratorium Teacher Institute—*http://bit.ly/29ufTNO*

NGSS planning tool—*http://bit.ly/29hWUAS*

Peripheral Vision Snack—*http://bit.ly/29g64In*

Science Snacks—*http://bit.ly/1R7Jp9I*

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