Nature of Science Activities

Objectives

To provide (a) an introduction to the nature of science and thus frame the nature of the course, (b) an engaging activity in the style that students will experience throughout the course, and (c) a platform for a reflective conversation about why active learning strategies are effective.

Activities

Following are a variety of activities that can be used to address the Nature of Science and draw on students' natural curiosity and ability to find patterns, with little pre-existing knowledge. Each should be followed by a reflective discussion/conversation about the activity; e.g., "Why did we spend our first class period doing this?"

1. The Game of Science

"Learning the Game of Formulating and Testing Hypotheses and Theories" (The Physics Teacher, Jan. 2010, Vol. 48, Issue 1, pp. 22).
Original article: http://tpt.aapt.org/resource/1/phteah/v48/i1/p22_s1
Sample materials: http://users.ipfw.edu/maloney/game_of_science.htm

As described by Joss Ives on his Learnification blog (http://bit.ly/10pDROF) :

You give each group in your class a "list of the moves made by two novice, but reasonably intelligent players" from when they played an abstract strategy board game (think games like checkers or go but way simpler in this case). The group plays out the moves of the two novice players and tries to deduce the rules of the game. The students are able to generate hypotheses (propose rules) which can be disproven by data (moves which break the rules). Further sets of rules can be given to test the students theories (the sets of rules which have survived the hypothesis testing). The links between what they are doing and hypothesis testing and theories is discussed explicitly. This activity also leads to discussions of if it is possible to prove a hypothesis or theory and how a theory, once accepted by the classroom, is quite robust. If a future list of moves for a subsequent game ended up showing that one of the small rules was wrong, it wouldn't mean that the entire set of rules was incorrect, but instead would just mean that the set of deduced rules (the theory) would need to be slightly revised. You are also able to discuss ideas like scientific consensus, with all the groups in the room agreeing on the deduced rules and confidence in theories which withstand many tests (sets of moves lists).

Author

Various

Materials & Resources

Learnification blog (Joss Ives):
http://bit.ly/13qz5hs

Game of Science:

http://bit.ly/13p7MFk (article)
http://bit.ly/qUrdW7 (sample materials)

Cereal Boxes:

http://bit.ly/X2jUWC (article)

Classroom Context

Introductory science courses

Time Requirement

20+ minutes

About this Project

This is one of a set of materials compiled for instructors to draw upon in order to frame non-traditional modes of classroom teaching for their students. Our hope is that these materials can help reduce any student resistance to such techniques.

Compiled by Stephanie Chasteen (University of Colorado Boulder Science Education Initiative): Stephanie.Chasteen@Colorado.EDU.

Other materials available online at www.colorado.edu/sei/fac-resources

2. Learning About Science from Cereal Boxes

"Learning About Science and Spectra from Cereal Boxes" (The Physics Teacher, Oct. 2009, Vol. 47, Issue 7, pp. 450

As described by Joss Ives on his Learnification blog (http://bit.ly/10pDROF) :

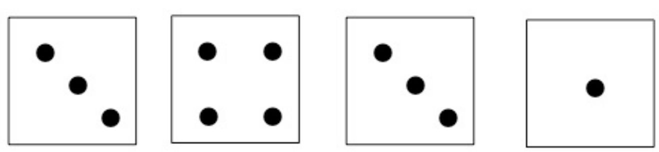
This is an activity that is very much in the same spirit as the Game of Science. They provided students with the barcodes (with UPC) for four boxes of cereal. The students then developed some hypotheses based on the UPC codes that they had. Due to the specific codes that they were supplied they were able to hypothesize that the first set of 5 numbers in the UPC represented the manufacturer. They also hypothesized that all the UPC codes started with a 0, but were able to later disprove this hypothesis when they discovered that their textbook had a UPC code which started with a 9, prompting them to revise their hypothesis to UPC codes for food start with a 0. This activity leads to the same types of discussions surrounding the process of scientific inquiry and the development of scientific knowledge that are highlighted in the above discussion of the Game of Science.

They also did further activities with matching the barcodes to the UPC codes. In the post-activity discussion several groups called the UPC/barcode the product's thumbprint and the instructors drew a parallel to spectra being unique identifiers for elements: "a way to recognize each using nothing but a set of lines in specific patterns." Although this activity can be used to teach about the nature of science, in the authors' implementation it also served to set up a unit on spectra.

3. The Farmer and The Seeds

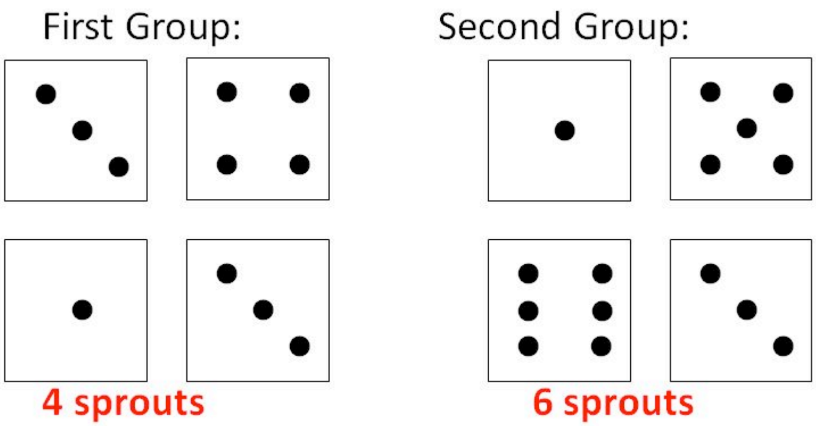
Author: Dewey Dykstra, "Piaget beyond 'Piaget' for physics learning" workshop, in American Association of Physics Teachers National Summer Meeting (2006). Some activity wording from Noah Finkelstein, Physics, University of Colorado Boulder.

A "seed" is defined as a square with some dots on it, as shown below.



Four different kinds of seeds

A farmer always plans 4 seeds in a group. He then observes the number of sprouts the group produces. The farmer would like to know the number of dots on the seeds affects the number of sprouts that it produces. That is, he would like to know the underlying structure of his seeds by examining the sprouts (an obvious connection to the nature of science).



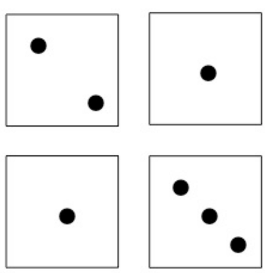
Have students work in groups to answer these questions:

What is the pattern? What do you think is the relationship between the number of dots on the four seeds, and the number of sprouts they produce? In your group, come up with as many "theories" as you can to explain the possible pattern.

How would you know? What evidence would you need to collect in order to determine if any of your theories were right?

Students will come up with a variety of creative hypotheses about how the number of sprouts relates to the number of dots, e.g., # sprouts = highest # of dots, total even # of dots, etc. Have them share their theories with the whole class.

Then, show them the following group of seeds and ask what their model would predict:



Group 3:
How many sprouts?

Tell them that this grouping produced **7 sprouts.** Discuss using the following questions:

- How should we make use of the comparison between each of these predictions and the outcome the farmer actually observed?
- Where did these schemes we have been discussing come from? (Note: This question is not about the elements of the schemes, but the decisions as to what elements to use and how to use them. They came from our heads.)
- How do we know if we have figured out all the possible schemes?

- If we have made many different tests of the seed groupings and have found a scheme that has worked on all of them so far, how do we know if will work on the next new test?

Summary:

- Scientists "make up" theories to explain the evidence they see.
- These theories are constrained by experiment.
- We can't always open up the seed and look inside. Have to make inferences from indirect evidence.
- A theory with a plausible mechanism is more convincing than a rote algorithm.
- The more different cases our theory works on, the more we believe it.
- But it could always be wrong…