Teaching Guide for **What is Science? Box Activity**

I originally participated in this activity in a teaching discussion led by Larry Wakeford, Senior Lecturer in Education and Director of Biology/Science Education, Brown University

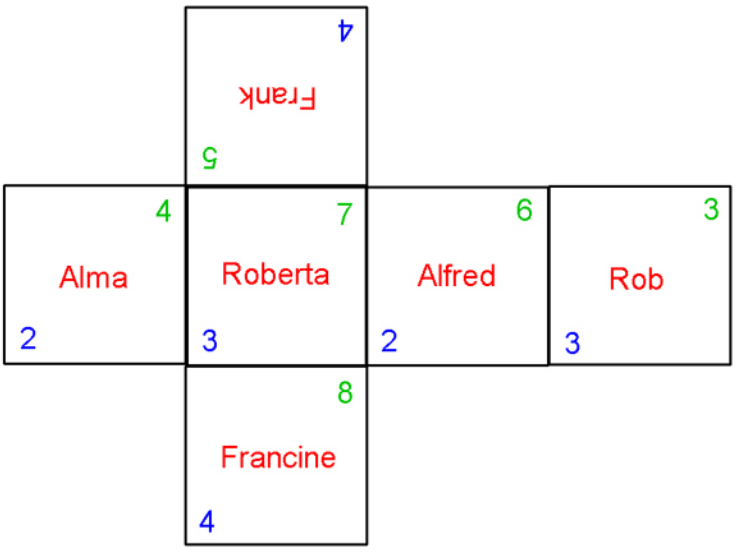
In this activity, students are presented with a box that has writing on it and are given the task of determining what is on the bottom of the box without touching the box in any way. In solving this problem, students are using the same techniques that scientists use to learn about nature.

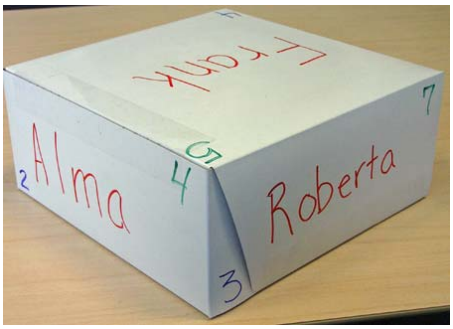
Materials: A 12x12 cake box (or any box that is one solid color and relatively cube-shaped)
Markers of difference colors
A flat mirror

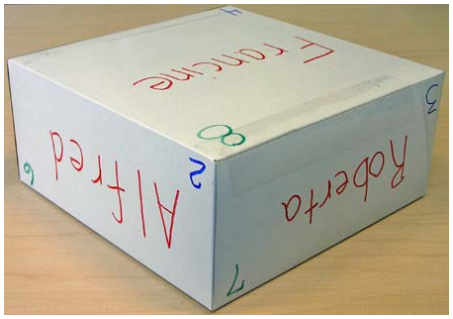
Cake boxes can usually be found or bought at local bakeries (sometimes with cakes in them!).

To prepare each box:

1. Tape the box together so that you have six smooth sides to write on.
2. Following the photos below, write on each of the six sides. Names are in red. Numbers to the upper right of the names are in green. Numbers to the lower left of the names are in blue.
3. Repeat for each group of students. All of the boxes must be identical.







In Class:

1. Place students in groups of 3-4 so that each student can only see one side and the top of the box.
2. Explain the rules: Students are not allowed to move from their chairs once they are in place and the activity begins. (Basically, you do not want them to try and see other parts of the box that are not directly facing them.)
3. Have students close/cover their eyes so they cannot see the set up.
4. Place one box in the middle of each group of students. When all the boxes are set, students may open their eyes. Alternatively, have each box in the center of the table and covered with a cloth.
5. The goal for each group is to figure out what is written on the bottom of the box.
6. (Students may write or take notes, but I generally don't suggest it to them since realizing that writing down observations is a goal of this exercise.)
7. Once students have an idea of what might be on the bottom of the box, or if they get stuck, allow them to do one "experiment." They may choose to see one of the four corners of the bottom of the box. When they have chosen the corner they would like to see, carefully lift up that corner and slide the mirror beneath so that the nearest student can see what (if anything) is written on the corner. Then remove the mirror and replace the box.
8. Since all of the boxes are the same, ask students to record what they think is written on the bottom of the box and have a group discussion (see below) about their predictions and their reasoning.
9. After the discussion, have students flip over the boxes to see whether they were right. Or not, depending on how far you want to stretch the analogy to science, see discussion below.

Educational Goals:

I do this activity with almost no prior explanation or discussion of what science is and how it is done. I just let the students go at it. You can preface this with discussion of "metacognition" and ask the students to pay attention to why they are doing what they are doing, but my experience has been that the students are too involved in solving the problem to focus on this extra task at least while they are actively working on the problem.

The main goal of this activity is to demonstrate how science is done and how we do science all the time simply by solving problems that life throws at us. There are many relationships between the process of science and this activity:

In this Activity…	**In Science…**
Students immediately make two big assumptions: 1. That there is something written on the bottom of the box, and 2. That they can use the patterns in front of them to figure out what that is.	It turns out that the world is a (relatively) logical and predictable place – patterns abound in nature and scientists use these patterns to learn about the world.

Students can only see a part of the clues to solving the problem.	Scientists have specialties that allow them to see only certain parts of the problem.
Students must collaborate with other students in order to see all parts of the problem.	Scientists do not work alone; they must collaborate with others.
Students must communicate with each other and share their information in order to be able to solve the problem.	Scientists must be able to communicate and share information with each other.
Groups that are more successful in solving the problem typically write and take notes on what they see.	Scientists do not solve problems just by thinking about them; they need to write and sketch and compare information.
Once students have all the "data" they will begin seeing patterns.	Patterns are important in science because science is founded on the idea that nature is (to some extent) predictable. Once scientists have data, they will start looking for patterns or things that are similar/different.
Different students will see different patterns.	Because different scientists have different backgrounds, experiences, and specialties, they will not all see the same patterns at once.
Students will begin to share the patterns that they are seeing with their other group members.	Again, scientists need to share their interpretations and work together to solve a problem.
Students will devise hypotheses for what might be written on the bottom of the box.	Scientists generate hypotheses to explain their data and predict the solution.
As various hypotheses are proposed, students will work together to see whether a given hypothesis is able to explain all of their current observations.	Scientists also test their hypotheses against current data to see whether the hypothesis is able to explain what they already know.
Students may settle on one or two hypotheses that may predict what is written on the bottom of the box. In order to test their hypothesis/es, students will decide upon one corner of the box to perform their experiment on. Ideally, the data they gain from seeing this corner of the box will allow them to validate one of their models.	Scientists perform experiments all the time in order to validate their working hypotheses.
Students may see what they expected during their experiment.	Sometimes a the new data from a scientist's experiment supports the hypothesis.
Students may see something unexpected during their experiment. Students will then refine their hypothesis to include this new data.	Sometimes the results from the experiment do not support the hypothesis. In this case, scientists need to incorporate this new data by revising their hypothesis (after all, you can't argue with nature).

Students may see nothing at all on the corner during their experiment.	Sometimes the experiment does not provide more information or is not designed well enough to actually yield any more data. Of course, obtaining no data is a result in itself, and two of the four corners are expected to be blank.
Students may want to do another experiment. (I generally do not allow this.)	Scientists have to be careful with the experiments they choose to do because they are limited by time and money and nature just like everyone else.

Throughout the discussion of this activity, we talk about the above similarities between this activity, science, and everyday life experiences. I emphasize that humans are natural scientists; we are born asking questions, making observations, comparing and contrasting objects, and figuring out how the world works around us. Everyone is a scientist and "does science" all the time!

For example, if you woke up this morning, turned the key in your car and the car didn't start, you have been presented with a scientific question: Why didn't your car start? You will make a number of observations – did you hear the ignition turn over? Is the gas gauge low? You might perform an experiment – tightening the connections to the car battery. And eventually you will figure it out (or contact another person with more knowledge to ask for help). If you can solve that problem, you are a scientist!

Throughout this discussion, **I do not let the students look on the bottom of the box**. They will beg to see it, they will reach for it, etc. but I make them wait. We talk about whether scientists are ever able to "see the bottom of the box" when they are exploring the world and what types of advances might allow that to happen. We talk about whether the process of science is ever truly complete. We talk about how it feels to not know what is on the bottom of the box, to not know if their theory is correct or not. But, generally, I do eventually let them see what is on the bottom of the box (because they would mob me if I didn't). I did have one group of teachers who actually accepted that I wasn't going to show them the bottom of a box during a workshop. We were so shocked that, on the last day, we had a cake made with the correct answer on it to celebrate their patience and trust in science!