***The Cube Exercise and the Methods of Science***

***Source***: National Academy of Sciences (1998). *Teaching about evolution ad the nature of science*. National Academy Press: Washington DC, p. 66-73.

***Goal***: To reflect upon two common methods of science—descriptive and experimental—by practicing these methods through analogy.

***Target audience***: Mid-level geoscience majors in a lab setting wherein students can work in 6 small groups of 3 to 4 per group.

Instructor Preparation

* Use a color printer to print six cubes for folding.
* Before assembling the six cubes, cover a significant portion of the cube face labeled *Francene* with a small rectangle of opaque card stock cut to half or less of the size of the cube face. On each cube, tape the opaque card onto part of the face labeled *Francene* but cover different information on each cube. When you are finished, make sure that if one person looked at all the *Francene* cube faces, all the information on the face could be pieced together but that *only one cube face* exposes the first “e” in the name *Francene*.
* Assemble the cubes by cutting them out and taping them together. Then *gently* tape a piece of opaque card stock (e.g., plain 3x5 notecards) onto the faces labeled *Francene*. Students will remove this card later so it only needs to be barely tacked in place.

Descriptive Scientific Methods

* ***Action***: Ask students to break into six small groups and tell them that they my not touch the cube you are about to distribute. Give each group a cube with the “Francene” side facing down and gently taped to a 3x5 card so no one will be tempted to sneak a peek. Tell students that their goal is to figure out EXACTLY what is printed on the bottom of the cube. In order to do this, they will need to gather information from the other five exposed sides of the cube. Can they find trends or patterns on those exposed faces that provide them with clues to hypothesize what is on the unexposed face? Give them 5 minutes to find the patterns and ask them to predict what is on the bottom of the cube by drawing an “explanatory model” of the cube face on a piece of paper.
* ***Debrief***: Indicate that this activity of making observations and thinking about trends and patterns reflects the descriptive or observational methods of science. Careful empirical observation (define empirical) using efficient causal or empirical reasoning allows researchers to note trends and patterns, create working mental models based on these patterns, and use these models as a predictive tool. Sciences such as paleoecology, paleontology, geology, and astronomy use predominantly descriptive/observational methods, largely because these sciences cannot manipulate their most important variable, time. As a result, direct experimentation to test these explanatory ideas or hypotheses is generally not possible. Descriptive/observational methods also dominate many of the social sciences and history because their two most important variables, time (e.g., history) cannot be manipulated and individual humans (e.g., psychology) cannot be cloned. Point out that observational methods are equally valid investigative approaches to experimental methods and are used by all empirical disciplines but especially those in which direct experimentation is not possible.
* ***Action***: Ask students to share their explanatory model with each other, preferably on a black or white board where all the models can be seen simultaneously.
* ***Debrief***: Tell the students that their explanatory model/prediction is essentially a hypothesis. In descriptive/observational science, multiple lines of evidence are brought together to support and refine hypotheses.
* ***Action***: Ask students to compare the results of all six models and synthesize all findings into a “review” that describes the explanatory model with the most empirical support. Ask a student to draw this “consensus” model on the board.
* ***Debrief***: In effect, by pooling and reviewing their findings, they would be taking the first steps to building a descriptive theory. Make the point that this robust process of refining models depends upon multiple lines of well-constrained evidence provided by the contributions of researchers globally. As evidence mounts over time, descriptive hypotheses can and are elevated to descriptive theories. Examples include the theory of plate tectonics, or Darwin’s theory of natural selection.

Experimental Scientific Methods

* ***Action***: Ask students to design an experiment to test their descriptive hypothesis. The obvious response is to remove the 3x5 card from the bottom of the cube. Tell them to do so carefully. Ask them whether they need to refine each of their models on the board. If so, tell them to draw the cube face on the board again next to their first predication.
* ***Debrief***: Make the point that with new evidence, models or hypotheses are “tweaked”. The Popperian notion of falsification is not necessarily practiced at this stage of inquiry. In general, when a new line of evidence that appears somewhat contradictory is presented, it is scrutinized, tested, and if it appears to hold, the existing hypothesis is “tweaked” to fit the new evidence or another modified hypothesis is presented. Indicate that with regard to experimental scientific methods, this exercise demonstrates the reproducibility of science and emphasizes the reliance on cooperation and the sharing of accurate and precise results that are critical to the scientific enterprise. Everyone essentially performed a similar “experiment”—e.g., exposing the hidden cube face—but the results were not all identical because each group was privy to a different part of the cube face.
* ***Action***: Ask the students whether the consensus version of the model they had predicted prior to experimentation needs to be reviewed and revised. At this point, the one group who has the cube with the first “e” in *Francene* exposed will want to show the other groups their results (e.g., Francene with an “e”). Let them do so.
* ***Debrief***: This exercise works well if most students have spell *Francene* the common American way as *Francine*. At this point, you can and should launch into a discussion about assumptions and how they can deeply affect a researcher’s vision. Humans make assumptions based on their biases and this exercise is an example of cultural bias, but it makes the point the biases can blind researchers to lines of inquiry beyond their scientific or cultural experiences.