Iowa Science Teachers Journal

Volume 24 | Number 2 Article 4

1987

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EXERCISES ON THE NATURE OF SCIENCE: INDIRECT OBSERVATION

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An earlier *ISTJ* article (Stout, 1986) presented several methods for demonstrating the importance of observation in scientific inquiry. The blue bottle demonstration described there illustrates the use of indirect observations in science. The demonstration described here carries the concept of indirect observation further. It can stand alone, or be integrated with the blue bottle demonstration for a more complete discussion of the nature of science.

Very few scientific investigations would be possible without indirect observations. In a study of Charles' Law for example, one does not see directly the gas expand with increasing temperature. However, a balloon might be observed to expand, or the levels of liquid in a U tube observed to change as the temperature is changed. Both of these observations are indirect indications that the volume of the gas has changed with the changing temperature. Similarly a doctor usually can not "see" directly the disease a patient has. A number of indirect observations are made instead: symptoms, temperature, blood pressure, appearance of the ears and throat, blood tests, etc. From this indirect evidence, each a piece of the puzzle, the doctor is able to diagnose the disease.

Actually all of us are experienced in indirect observations. Consider the parent or teacher who can tell what a child/class is doing when his or her back is turned, or who realizes that it is *too* quiet. And who of us hasn't rattled, lifted or listened to a packaged gift in order to guess what was inside. We learn this technique early. In a recent issue of *Sesame Street Magazine* (Carter, 1985), Grover tried to deduce the identity of a birthday present, saying, "I, Grover, will try to guess what it is. This cute present is not heavy at all, so I don't think that it is a piano."

The Brown Box Exercise*

To stimulate indirect observation and deduction I use a series of boxes, all wrapped in brown paper, with various objects inside. The objective is to determine what is inside each box by the size, shape and weight of the box, the sounds the contents make and other clues. Most people do very well at identifying the contents, or at least making reasonable guesses. Several of the boxes I use are described in Table 1.

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*It has been brought to the author's attention that this exercise is similar to one presented in a textbook nearly twenty-five years ago. See ***Investigating Chemical Systems, Chemical Bond Approach Project,*** McGraw-Hill, Inc., New York, 1963, p. 8.

Table 1
BROWN BOXES AND THEIR CONTENTS

CONTENTS	COMMENTS
Styrofoam "peanuts" (packing material)	Fairly easy. Many youth guess a breakfast cereal.
Water in a metal bottle	How do you know it's water and not honey? Is the bottle made of plastic, metal or glass?
Baby toy that rattles and squeeks. ("Box" is a brown cloth bag)	Can determine size, shape and hardness by feel. Most youth correctly guess "Bigbird."
Two wrenches	Metallic clank
Can of tennis balls	Tennis balls or soup can?
12 dowels 1.57×20 cm (Box is $10 \times 17 \times 30$ cm)	How long are the dowels?
Two toy cars taped back to back in a cylindrical box	The cars always roll down the tube but tumble if the tube is rolled.
Bell suspended in the center of a box	Jingle, cow or church bell? How could you tell if the box were soundproof?

Initially I hand out the boxes and ask what the contents are. Usually a student will provide an answer. Typically I then ask a few questions designed to get the students to focus on why they chose that answer. One such exchange went something like this.

I gave a student a light weight box which he promptly shook.

"Sugar Crisp."

"What makes you think so?"

"It sounds like Sugar Crisp when I shake it."

"How do you know that it is Sugar Crisp and not Fruit Loops?"

"OK, it's a sugar-coated breakfast cereal."

And so on. (The box in question actually contains Styrofoam "peanuts," a packing material which sounds very much like breakfast cereal. Invariably someone will guess the correct contents.) The intent is to get the students to focus on exactly what information they have, and what can be concluded from it. After one or two such exchanges, the students begin to make more critical observations on their own and will often provide their evidence for a given conclusion.

In this exercise students are, subconsciously perhaps, applying the scientific method. Usually they enter the process by experimentation (shaking and listening), then propose a hypothesis, test and refine it. After the first few boxes have been passed around and their contents identified, I point out the method being used implicitly and alter the exercise to expose the use of the scientific method. In terms of the scientific method, I introduce a hypothesis and ask how we can test it, rather than performing the test first and then trying to interpret it. In terms of this demonstration, I tell a class what the box might contain and ask how we can tell if it does. For example, "This box contains either a soup can or a can of tennis balls. How can we tell which?" or "This box contains twelve ⅝ inch dowels of the same length. How can we tell how long they are?" In each case the answer may be deduced by simple manipulation of the box and listening. Once the class has proposed an appropriate method for answering the question, I give them the box, to apply their method and answer the question.

If the two deomonstrations are being done together, this is a good place to return to the blue bottle exercise (Stout, 1986) using a series of leading questions to elicit the appropriate observations and conclusions. A constructive conclusion to this indirect observation exercise is a discussion of indirect observation methods commonly used in science. There are numerous examples from all areas of science. In geology, for example, a study of the rock formations and fossil record of an area can indicate past climatic conditions. You and your students will be able to provide many other examples.

Acknowledgement

I would like to thank Karen Murphy, in whose classes this and several other demonstrations have been tested, and Dr. Wilbert Hutton who informed me of the prior history of this exercise.

References

Carter, Jackie. 1985. *Sesame Street Magazine* Oct.: 26.

Stout, Roland P. 1986-87. Exercises on the Nature of Science: The Necessity of Observation. *Iowa Science Teachers Journal* 23(3):2.