Scientific Method

Center for Nanotechnology Education

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The Scientific Method

Abstract

Using cellophane “fortune telling” fish, students learn and practice the scientific method. By proposing, testing and observing, students test various hypotheses as to why the fish curl, roll up, or do nothing in their palm or on other surfaces.

Outcomes

Students will be introduced to the essential elements of critical thinking and the science method: observing a phenomenon, developing an explanation, testing that explanation, and revising as needed

Prerequisites

None. This activity may be used with groups as young as second grade.

Correlation

Science Concepts
The scientific method: observation, making and testing hypotheses
Documentation

Background Information

The scientific method is a systemic way to gain a better understanding of the world around us. Using the steps of the method, students and amateur scientists can apply the same tool used by professional researchers to answer a scientific question.

The steps of the method can be laid out as follows:

1. Chose a system to study.
    a. Make an observation (or define a "problem")
    b. Ask a question about the observation.
2. Develop a hypothesis.
    a. Consult trustworthy sources of information on the question
    b. Form a hypothesis to answer the question.
    c. Frame the question as an "if, then" statement.
3. Design an experiment.
    a. List the needed materials and procedures
    b. Consider methods to control different variables.
4. Test the hypothesis.
    a. Follow the procedure
    b. Make observations
    c. If your observations are in the form of numbers,
        i. record them in an organized way
        ii. Make a chart, graph or table of the data.
        iii. Create a document outlining how the data was obtained.
5. Make a conclusion(s).
    a. Summarize the results of the experiment.
    b. State the outcome of the experiment:
        i. did it prove or disprove the hypothesis?
        ii. Are additional test s needed to answer the question?
    c. Share what you have learned

In this application of the scientific method, students observe the motion of the cellophane fish when they place in on their hand. The Fortune Telling Fish toy consists of paper coated with sodium polyacrylate, which is a polymer that is very effective at absorbing water (it is used in disposable diapers, among other products). As they absorb water, the polyacrylate molecules change their shape somewhat. This applies a force to the underlying paper, which then deforms as well. More information about the composition of the fish is available at *chemistry.about.com/od/howthingswork/f/fortune-teller-fish.htm.*

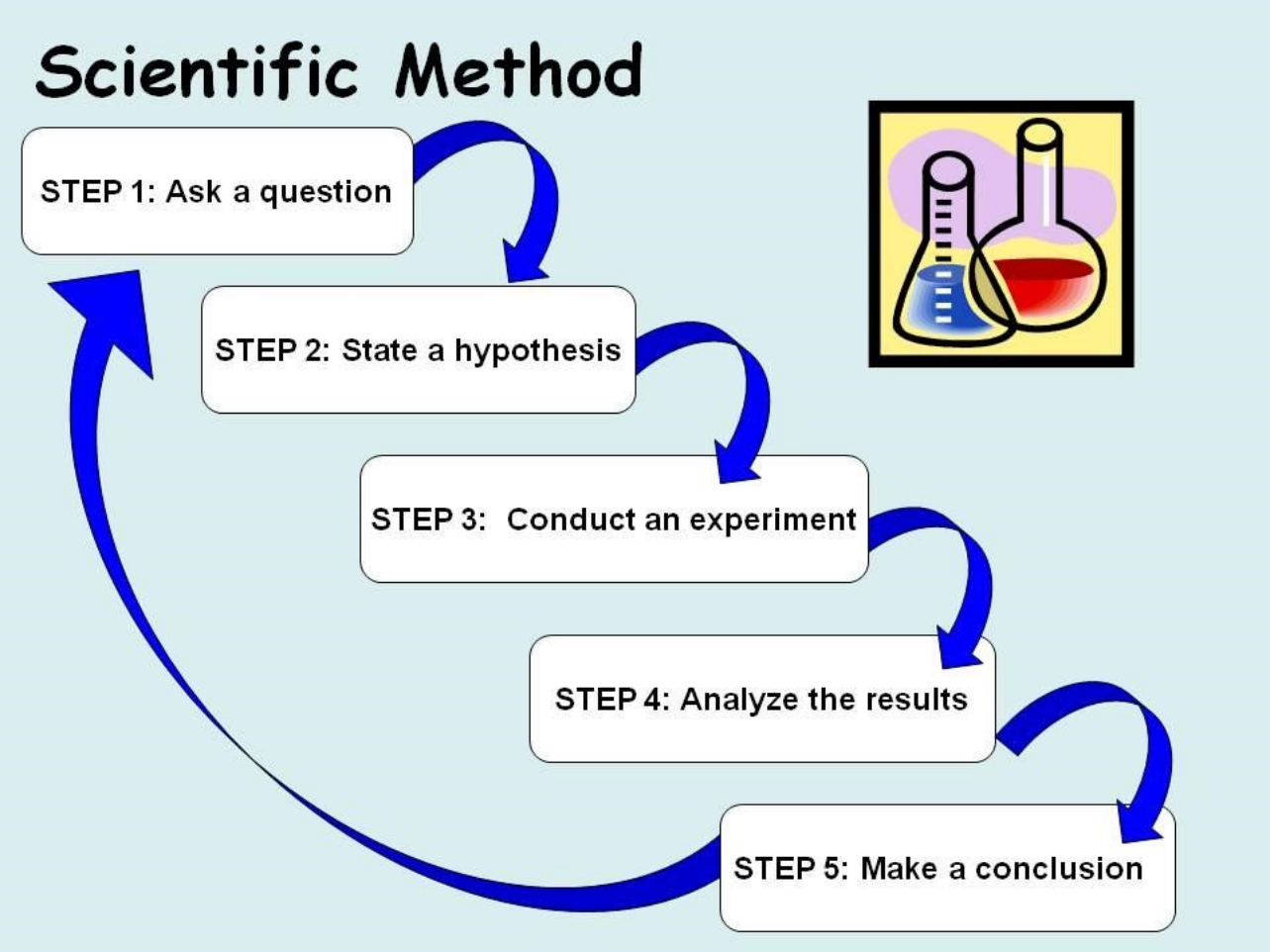
Learning Activity: Practicing the Scientific Method

In this activity, students use a simple toy to develop their observation and scientific thinking skills. The goal of the activity is to engage students in observing a phenomenon, developing an explanation, testing the explanation. and revising as needed. This is an experiment that will prompt students to ask "Why does it do that." As multiple ideas are proposed, they can each be tested by applying the process of the Scientific Method. As mentioned above, the Fortune Telling Fish is paper with a very thin layer of sodium polyacrylate in the shape of an 8.9 cm (3.5 inch) long fish. The polyacrylate will absorb small amounts of moisture. The side of the fish that is exposed to the moisture will expand while the other side will not, causing the curling motion of the fish. As the polymer dries, the fish will once again lay flat on the table.

Discuss the scientific method and how it relates to discovering and learning new information. Then as students observe the fish and how it moves, they will begin to develop hypotheses. Record these hypotheses and solicit ways in which they can be tested, then have students carry out these tests. Remind older students that proper documentation is critical, and have them record their observations. The students will eventually arrive at the answer: the Fortune Telling Fish works by absorption of water from people's hands. Also, students need to be careful to test only one variable at a time – this is the process of design of experiments.

Allow students to examine the claims made about the fish on the package. On the back of the package is a chart which explains that the fish supposedly reveals the holder's mood, based on how the fish behaves in the holder's hand. Ask the class if this can be justified, based on their findings.

Activity Flow Chart



Graphic from: science-fair-coach.com.

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Materials

- "Fortune Telling Fish" toy x Laboratory gloves (preferably disposable nitrile light duty gloves).
- Paper towels
- Water

Procedure

1. After all students have received a Fortune Telling Fish toy, remove the fish from the envelope and lay it on the table in front of you. Observe the fish and note details of its appearance,
2. Place the fish in the open palm of your hand. Observe the action of the fish as it rests in your hand, and describe what you see to your fellow students.
3. Return the fish to your desk and make further observations.
4. Considering your observations, create a hypothesis that might explain how you observed the fish to move. Share this with your instructor, who will compile a list of potential hypotheses.
5. The class will discuss and consider which hypothesis to test.
6. Design a simple experiment that can test the hypothesis.
7. Carry out your experiment. Make observations and record what you see.
8. Consider your observations, and write a short summary that explains how these observations do or do not support your original hypothesis.
9. If your hypothesis was not verified, go back to step 4 and generate a new hypothesis, along with a way to test it. Repeat steps 5 through 8.

Discussion Questions

1. Why does the fish move in my hand?

2. Does the fish move while sitting on other surfaces?

3. What seems to change how the fish moves?

4. Why does the fish appear to move differently for different people?

Current and Future Applications

The scientific method is fundamental to sound research and reasoning at any level. Thus, the applications of the method are broad, and may be used by your students in their daily life any time they are attempting to learn more about how something in nature behaves.

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Alignment of Scientific Method Module to the Next Generation Science Standards

The Next Generation Science Standards (NGSS) were published in April 2013. They consist of statements that convey the performance expectations for students. Each performance expectation is a single statement that is built from three parts: science and engineering practices (Practices), disciplinary core ideas (DCI) and crosscutting concepts.

Since the Scientific Method Module was created prior to the release of these standards one would expect that it aligns most readily to the individual statements that articulate the practices or crosscutting concepts. The background material, reading, and the slides from the module address the aspects of the NGSS shown in Table 1.

TABLE 1. ALIGNED PRACTICES, DISCIPLINARY CORE IDEAS, AND CROSSCUTTING CONCEPTS
No alignments

Alignment of Scientific Method Module to the Common Core State Standards for English Language Arts/Literacy and Mathematics

The Common Core State Standards (CCSS) were published in June 2010. They articulate student skills for English language arts/literacy and mathematics. The content of the module addresses the concepts and skills shown in Table 3.

For English language arts/literacy, the CCSS is organized around College and Career Anchor Standards (CCR) that articulate the over-arching skills that students need to be prepared for college and career. There are grade level versions of each Anchor Standard, as well as versions for science and social studies classrooms (literacy standards). Alignments in Table 3 were made to the Anchor Standards, unless a more specific version of the standard was a closer fit to the skills in the module.

Table 3. Aligned Common Core Standards for English Language Arts & Literacy
RST.11–12.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. *Partial in teacher and student materials*

For mathematics, Table 4 shows alignments to standards found in the 8th through 12th grade levels.

TABLE 4. ALIGNED COMMON CORE STANDARDS FOR MATHEMATICS
No alignments