Lesson Title: Experimenting with Experiments

Grades: 5-8

Time Allotment: Two 45-minute class periods

Overview: Using segments from the PBS program: ***The Human Spark,*** students learn how to design and critique experiments with living subjects. In the Introductory Activity, students explore the steps involved in designing and conducting an experiment and view a video segment of an experiment with rhesus monkeys. Students discuss the steps involved in the experiment, the ways in which the researchers controlled for variables and how the experiment could be modified. In the Learning Activity, students explore several experiments conducted with human children and chimps and compare the methodology used in each. In the Culminating Activity, students design and conduct their own experiments, present their findings to the class, and share their reflections on the process.

Objectives:
Students will be able to:
- Describe the steps involved in conducting an experiment.
- Critique other experiments.
- Discuss how researchers control for variation in an experiment.
- Explain the difference between controlled, dependent and independent variables.
- Design, conduct and discuss their own experiments.

LEARNING STANDARDS:
New York State Standards:
www.nylearns.org/standards/standard_tree.asp?StandardID=6
Standard Area: Math, Science & Technology/Standard MST1: Analysis, Inquiry & Design
Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

- **Key Idea** MST1.SI2: **Scientific Inquiry:** Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.
  Intermediate:
  - **Performance Indicator** MST1.I.SI2A: Students use conventional techniques and those of their own design to make further observations and refine their explanations, guided by a need for more information.
    Major Understandings: 2.1a:Demonstrate appropriate safety techniques; 2.1b: Conduct an experiment designed by others; 2.1c: Design and conduct an experiment to test a hypothesis; 2.1d: Use appropriate tools and conventional

techniques to solve problems about the natural world, including: measuring, observing, describing, classifying, sequencing

- **Performance Indicator** MST1.I.SI2B: Students develop, present, and defend formal research proposals for testing their own explanations of common phenomena, including ways of obtaining needed observations and ways of conducting simple controlled experiments.
  ***Major Understandings*:** 2.2a Include appropriate safety procedures; 2.2b Design scientific investigations (e.g., observing, describing, and comparing; collecting samples; seeking more information, conducting a controlled experiment; discovering new objects or phenomena; making models); 2.2c: Design a simple controlled experiment; 2.2d: Identify independent variables (manipulated), dependent variables (responding), and constants in a simple controlled experiment; 2.2e: Choose appropriate sample size and number of trials.
- **Performance Indicator** MST1.I.SI2C: Students carry out their research proposals, recording observations and measurements (e.g., lab notes, audiotape, computer disk, videotape) to help assess the explanation.
  Major Understandings: 2.3a Use appropriate safety procedures; 2.3b Conduct a scientific investigation; 2.3c Collect quantitative and qualitative data.

STANDARDS
National Science Education Standards
http://www.nap.edu/openbook.php?record_id=4962

Grades 5-8:
Content Standard A: Science as Inquiry
Fundamental concepts and principles that underlie this standard include:

- **Abilities Necessary To Do Scientific Inquiry**
  - **Identify Questions That Can Be Answered Through Scientific Investigations.** Students should develop the ability to refine and refocus broad and ill-defined questions. An important aspect of this ability consists of students' ability to clarify questions and inquiries and direct them toward objects and phenomena that can be described, explained, or predicted by scientific investigations. Students should develop the ability to identify their questions with scientific ideas, concepts, and quantitative relationships that guide investigation.
  - **Design And Conduct A Scientific Investigation.** Students should develop general abilities, such as systematic observation, making accurate measurements, and identifying and controlling variables. They should also develop the ability to clarify their ideas that are influencing and guiding the inquiry, and to understand how those ideas compare with current scientific knowledge. Students can learn to formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations, and critique explanations and procedures.

- **Use Appropriate Tools And Techniques To Gather, Analyze, And Interpret Data.** The use of tools and techniques, including mathematics, will be guided by the question asked and the investigations students design. The use of computers for the collection, summary, and display of evidence is part of this standard. Students should be able to access, gather, store, retrieve, and organize data, using hardware and software designed for these purposes.
- **Develop Descriptions, Explanations, Predictions, And Models Using Evidence.** Students should base their explanation on what they observed, and as they develop cognitive skills, they should be able to differentiate explanation from description—providing causes for effects and establishing relationships based on evidence and logical argument. This standard requires a subject matter knowledge base so the students can effectively conduct investigations, because developing explanations establishes connections between the content of science and the contexts within which students develop new knowledge.
- **Think Critically And Logically To Make The Relationships Between Evidence And Explanations.** Thinking critically about evidence includes deciding what evidence should be used and accounting for anomalous data. Specifically, students should be able to review data from a simple experiment, summarize the data, and form a logical argument about the cause-and-effect relationships in the experiment. Students should begin to state some explanations in terms of the relationship between two or more variables.
- **Recognize And Analyze Alternative Explanations And Predictions.** Students should develop the ability to listen to and respect the explanations proposed by other students. They should remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations.
- **Communicate Scientific Procedures And Explanations.** With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations.
- **Use Mathematics In All Aspects Of Scientific Inquiry.** Mathematics is essential to asking and answering questions about the natural world. Mathematics can be used to ask questions; to gather, organize, and present data; and to structure convincing explanations.

- **Understandings About Scientific Inquiry**
  - Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations.
  - Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new

technologies to improve the collection of data. All of these results can lead to new investigations.

Media Resources

***The Human Spark*, selected segments**

- Monkey See, Monkey Take
  A look at an experiment where monkeys take food from humans when the humans are not looking.

- Humans vs. Chimps
  A look at experiments which compare the abilities and reactions of human children and chimps.

Websites:

For use by students in this lesson:

- **Neuroscience for Kids/ The Senses**
  http://faculty.washington.edu/chudler/chsense.html
  This section of the University of Washington's website includes descriptions of different experiments involving the 5 senses, which students could use in the Culminating Activity.

- **Science Experiments for Kids**
  http://www.sciencekids.co.nz/experiments.html
  This website provides a variety of ideas for experiments. Students could conduct the "taste without smell" or "dominant side" experiments in the Culminating Activity.

Related Resources:

- **Cool-Science-Projects.com**
  http://www.cool-science-projects.com/
  This website provides a variety of information about experiments which could be used in this lesson, including the following:
  - ***Independent and Dependent Variables***
    http://www.cool-science-projects.com/independent-and-dependent-variables.html
    This page defines the terms "dependent," "independent" and "controlled" variables.
  - ***Science Fair Experiment***
    http://www.cool-science-projects.com/Science-Fair-Experiment.html
    This page outlines the experimental process in a clear and concise manner.

- **Thinking Like a Monkey**
  http://www.smithsonianmag.com/science-nature/monkey-200801.html?c=y&page=1
  This article on Smithsonian.com provides more details about the research presented in the Introductory Activity, highlighting Professor Laurie Santos' experiments with monkeys.

Materials
For the class:
- Computers with internet access
- Computer, projection screen and speakers (for class viewing of online/downloaded video segments)
- 1 copy of the "Human vs. Chimps Discussion Guide" (download here)

Before the Lesson
Prior to teaching this lesson, you will need to:

Print out one copy of the "Human vs. Chimps Discussion Guide."

Preview all of the video segments and websites used in the lesson.

Download the video clips used in the lesson to your classroom computer(s) or prepare to watch them using your classroom's Internet connection.

Bookmark all websites which you plan to use in the lesson on each computer in your classroom. Using a social bookmarking tool such as del.icio.us or diigo (or an online bookmarking utility such as portaportal) will allow you to organize all the links in a central location.

Introductory Activity

1. Let students know that today's lesson is about designing, conducting and evaluating experiments. Ask students to brainstorm what steps are involved in an experiment?
   Possible answers:
   *1) Come up with a **question** to explore.*
   *2) Make a **hypothesis or prediction** about the results of the experiment.*
   *3) Determine the **methods** involved in conducting the experiment.*
   *4) Acquire necessary **helpers and materials**.*
   *5) **Test** the materials and the experimental design, as needed, before conducting the experiment.*
   *6) **Recruit subjects and reserve a venue**, if needed.*
   *7) **Conduct** the experiment.*
   *8) **Record findings**.*

9) ***Analyze the results/data****.*
*10)****Present findings****.*

2. Ask students to describe some experiments they have conducted. Ask students to discuss difficulties they encountered in the process, as well as some of the positive highlights of their experiments.

3. Explain that today's lesson focuses on observing, designing and conducting experiments with living subjects (humans or animals).

4. Let students know that you will now be showing a video segment from the PBS program ***The Human Spark***. This segment features an experiment with rhesus monkeys conducted by Yale Professor Laurie Santos and her students. Ask students to observe the steps involved in conducting this experiment.

5. Play Monkey See, Monkey Take. After showing the segment, ask students to list the steps involved in conducting the experiment.
   Possible answers:
   a) *Researchers A, B and C stand facing a monkey. Researcher A tempts a monkey by showing it two grapes.*
   b) *The researcher hands the grapes to Researchers B & C (one grape to each researcher), who are both wearing short-sleeved white t-shirts and dark pants, with their hair in a ponytail.*
   c) *When directed by Researcher A, Researchers B & C each place one grape on a skewer which is attached to a flat surface (paper, cardboard, Styrofoam or similar material.)*
   d) *When directed by Researcher A, Researchers B & A place the grape skewers on the ground and then one researcher turns around, facing away from the monkey.*
   e) *The researchers then stand still until the monkey has stolen a grape from one of the researchers. Researcher A films the event.*
   f) *One of the researchers says "good" after the monkey has made its selection to indicate that the researchers can move from their testing positions.*

6. Ask students to explain what the goal was of this experiment and what the researchers discovered. (*Possible answer: The goal was to examine monkeys' understanding of human perceptions and mental states. They discovered that monkeys were good at thinking about where eyes are pointed, but only in the restricted context of stealing food. The experiment indicates that monkeys have a "glimmer of awareness of others' minds."*)

7. Ask students to describe what gave Laurie Santos the idea to conduct this experiment. (*In previous experiments, monkeys had stolen food from her and her colleagues when they weren't looking.*)

8. Ask students to describe some of the ways that the researchers' controlled for factors that might cause monkeys to approach one researcher rather than the other. *(Researchers dressed in similar attire- white short-sleeved t-shirts, dark pants and ponytails. The researchers were both women, similar in height and wore eyeglasses. A third researcher called out the commands, so that each researcher did her action at the same time. Researchers stood the same distance away from the monkey. Researchers used the same sized grapes, skewers and paper/cardboard. Researchers A & B took turns turning around and switched positions.)*

9. Discuss the experiment with the students and solicit their feedback about the experiment. Discuss the importance of controlling for external factors in order to reduce the variables that might impact the results. Discuss the following terms and challenge students to identify each type of variable in the Laurie Santos' experiment.
   - **Independent Variables-** changes in the experiment that are controlled by the experimenter (for example, having one researcher face away while the other faces the grape).
   - **Dependent Variables-** changes that occur as a result of the independent variable (for example, the monkey steals the grape when the researcher turns away).
   - **Controlled Variables-** Anything else that could impact the results of the experiment (for example, the clothing of the researchers, the distance of the researchers from the grape and from the monkey, etc.) These variables are held constant during an experiment.

10. Brainstorm ideas on how researchers could modify the experiment to gain more insight into the monkeys' reactions. *(Possible ideas:*
    - *One researcher could turn her back to the monkey and then as the monkey approaches, turn back around to face the monkey.*
    - *Instead of turning completely around, one of the researchers could just turn her head and face her eyes away from the monkey.*
    - *One researcher could turn her body around, but keep her eyes focused on the monkey.*
    - *The researchers could sit down.*
    - *One researcher could close her eyes, as if sleeping, while the other researcher could keep her eyes open.*
    - *Both researchers could turn away at the same time.*
    - *One researcher could be positioned closer to the monkey than the other.*
    - *Have both researchers turn their backs and observe the monkey's reaction.*
    - *The researchers could conduct the experiment in the presence of multiple monkeys and just have one researcher turn her back.)*

Learning Activity

1. Introduce the next segment by letting students know that they will now be watching experiments conducted with children and chimps. Ask students to observe the similarities and differences between each experiment conducted for children and its corresponding experiment conducted for chimps.

2. Play Humans vs. Chimps. After showing the video, ask the students to list the four different experiments highlighted in the video. *(Hidden object under moving cup; object-dropping/ social skills experiments; hidden object under cup with pointing; light vs. heavy boxes.)*

3. Discuss each experiment, highlighting the similarities and differences between each human experiment and its corresponding chimp experiment. (Refer to the "Humans vs. Chimps Discussion Guide," as needed.)

4. Discuss the findings of the experiments.
   - **Hidden object under moving cup:** In the video segment, the chimp selected correctly every time, while the featured child made some mistakes. However, according to the narration in this segment, when looking at the results of many trials with different subjects, the results of chimps and human children are similar at this task.
   - **Object-dropping experiment:** This experiment examines the social skills of children and chimpanzees and found that both children and chimpanzees pick up an object that is out of a researcher's reach and hand it to the researcher (without being asked to do so).
   - **Hidden object with pointing:** This experiment explores whether human children and/or chimps are able to interpret a pointing gesture as a way to help the subject to correctly complete a task. The experiment shows that, although humans perform well at this task, chimps do not. Chimps do not appear to realize that when that the researcher is trying to help the chimp by pointing to a cup.
   - **Light vs. Heavy:** This experiment explores human children and chimpanzees' understanding of the concept of heavy and light. The experiment examines whether humans and chimps can use information gained by observing someone else moving an object to make a decision about which object would be easiest for them to move. The human children are able to successfully choose the lighter object, while the chimps are not.

5. Lead a discussion about the **methodology** used in the featured experiments. Include the following in the discussion:
   - Discuss the importance of having a large enough **sample size** to draw accurate conclusions.

- Ask students to think about how they could **modify the design** of the experiments to provide the researchers with more information. *Possible modifications:*
  - *Hidden object under moving cup: Experiment with moving the cups different numbers of times and see how that impacts the results—for example, shifting the positions once, twice, three times, four times, etc.*
  - *Light-heavy experiment: Have one child at a time observe the boxes being brought in to see if children might respond differently.*
  - *Object-dropping experiment: Have two subjects at a time participate and observe how that influences the results.*
  - *Hidden object with pointing experiment:*
    - *Have the researcher keep her finger touching the glass by the cup with the hidden object (in a fixed position) and see if that constant pointing effects where the chimp looks.*
    - *Have two chimps perform the task at the same time.*

Culminating Activity

1. Review the different experiments that you have discussed already. Let students know they will be designing and conducting their own experiments with human subjects.

2. Ask students to brainstorm questions they would like to investigate.
   Possible ideas:
   - *Do people prefer one brand of food, beverage over another?*
   - *Do people prefer one type of chair/ desk, etc. over another?*
   - *Does covering up one's sight or smell impact someone's taste?*

3. Divide students into small groups. Ask each group to select a question to investigate and to design an experiment to explore that question. Ask the groups to share their ideas with you. Provide them with feedback on their designs.

4. Ask the groups to conduct their experiments, using other students, friends or family members as subjects. Ask students to record their findings, by writing up the information, videotaping and/or audio recording the session.
   - *Possible experiments:*
     - **Beverage Brand Comparison-** Pour one product (for example- Coke) in one cup and another brand (for example, Pepsi) in another cup. Bring in a subject one at a time and ask the subject to taste one beverage, then the other and to indicate his/her preference. Make sure to vary the order in which each brand is presented. For example, for half of the trials give the Coke first and in half the trials give the Pepsi first. (You could also use 3 brands- 2 known brands and a generic store brand)

- **Taste test with nose plugging**- Peel apples and pears and slice them into cubes. Blindfold the subjects and ask them to taste the food with and without their noses plugged.
- **Chair selection-** Select two chairs. Ask students one at a time to come into a room and sit down. Observe which chair each student selects. *Variations:* Have one "comfortable" and one less comfortable chair. Let the student know that someone else (another student, your teacher, the principal, etc.) will be joining both of you—Observe which chair he/she chooses. Observe whether the choices vary based on who else the student thinks will be coming into the room.
- **Toy/Game selection-** Invite a student in a room. Have several games available to play with. See which one he/she chooses.

5. After students have conducted their experiments, ask them to summarize their findings and present them to the class. Ask students to reflect upon the design of their experiments and to think about how they could modify them (for example, increasing sample size, changing the items used, varying the environment in which the experiment took place, etc.).