SN EDUCATOR GUIDE December 10, 2016

Animal Math

Activity: How good is your number sense?

Class time: 2–3 class periods, depending on the depth of the experimental design and analysis

Day 1: Teacher-led experimental activity and student experimental design

Days 2–3: Experiment and analysis of data

Purpose: After an initial mini-experiment run by the teacher, students will divide up into groups. With Blackline Master 4 as a guide, they will design their own experiment to study the strength of students' sense of quantities. There will be a focus on isolating variables and selecting sample size.

Notes to the teacher: You may choose to have your students analyze their data with statistics or leave out statistical analysis. Rice University provides information on specific types of statistical analysis that might be useful for those with some background understanding of statistics.

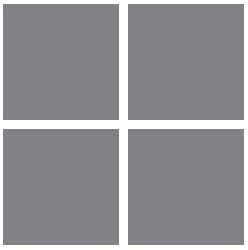
Materials:

- Access to the internet to use links provided
- Paper and pencil or laptop for record keeping
- Large-format paper (6 per group) and markers
- Other objects for testing, as determined by students

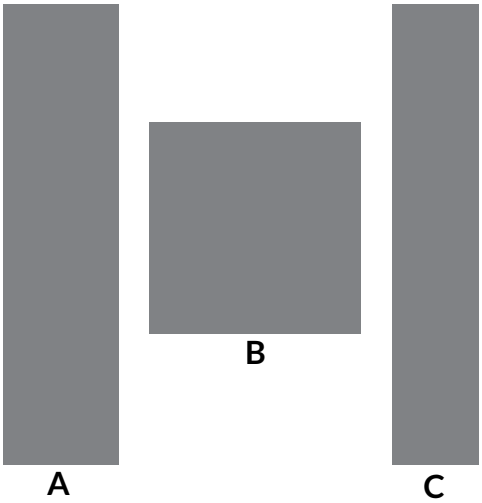
Directions:

1. Tell students that you are going to give them a very simple experiment. Show a student the image of four squares. Remove this original figure and immediately show the same student the set of three options. Ask, "Which of the three choices is the same (surface area) as the original?" and tabulate the students' response (A, B or C). Allow only one second for a student to respond.

Original figure



Students may choose A, B or C



Repeat with at least 10 students and display the data:

Student	Selected "A"	Selected "B"	Selected "C"
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

2. Ask students to explain your experiment. What is it testing [*whether the subject can identify two equal surface areas*]? How was the test set up [*the subject examines one image, then looks at a series of choices and has to determine which has the same surface are*]? What are the strengths of the design? [*It is simple. The test is given to multiple test subjects. The response time is kept constant.*] What are some weaknesses of the design? Are there confounding variables? [*Each subject only looks at one set of images. It's unclear whether the right number of students in the class were tested in order to form any conclusions based on the results. Students being tested may be different ages, genders, etc.*] How many and which students were tested? Ask whether students think the same images in a different order would result in different responses from their subjects and why. Use this discussion to help students begin thinking about how they can design their own experiment. This experiment tests a continuous quality; have students design an experiment to instead study their peers' sense of numbers.
3. Have students form groups and select a possible question related to number sense that they would like to test. Students should refer to Page 23 for the example in the figure labeled "Reckoning with Weber's law." Would they like to compare the number sense of different categories of people (such as different age groups, math levels or genders)?
4. Give students time to create the visuals they will need to test the mathematical idea they selected. They'll need to decide on their experimental testing procedure. For example, how long will they give each subject to answer a particular question?
5. Have teams share their visuals and explain how each visual tests their specific variable. Other students should listen for any confounding variables, such as those described in the article. Based on this discussion, students may need to refine some of their visuals.
6. Teams need to plan the number of subjects that will be tested. For example, if there are 25 students in the class, should 10 be tested or is that too many/not enough? You can find various sample size calculators online, such as this one, but be sure students are aware of the challenges of statistical analysis.

7. Once a sample size is selected, how will students determine who to include in their experiments? Explain how to create a simple random sample using a number generator such as the one offered on Random.org.
8. Give students time to plan how they will record their data for each subject. For example:
9. Once teams determine the subjects they will test, they have to think about how they will gather the infor-

Subject ID	Selection from Q1	Selection from Q2	Selection from Q3

mation from their subjects. Can your class pair up with another class for a short time to collect data?

10. As time allows, you might want students to script what they will say to each person who is willing to participate. [*"I'm doing a science experiment, and I'd love it if you would participate. I'm going to show you an image and ask you a question. Is that OK?" Show the first image, then show the next set of choices and ask, "which is the same?"*]
11. Give teams time to set up their data table, determine who will administer the group's test, and how the team will collect the data (work as a group or split up to test more people at the same time).
12. Once students have collected their data, it's time to analyze it. On a very simple level, they may be able to determine the percent of respondents who answer the questions correctly, or students should do statistical analyses most appropriate to their test. Unless time and class level permit long-hand calculations, students should use a free online statistical calculators, such as this one from GraphPad Software. You may also download the free Past software designed for scientific data analysis.
13. Give students the opportunity to share and compare their findings.

SN IN HIGH SCHOOLS December 10, 2016

Animal Math

Design your experiment: How good is your numerical acuity?

Directions: Answer question No. 1 after your teacher's mini-experiment. Use this mini-experiment and the questions below to design your own experiment to study the strength of students' sense of quantities. Your teacher will define the timetable for the design process, experimental testing and data analysis.

Plan your experiment:

1. Watch your teacher do a simple experiment. Analyze what you see:
   a. What is being tested?

   b. How was the test set up?

   c. What are the strengths of the experimental design?

   d. What are some weaknesses of the design? Are there any confounding variables?

   e. Do you think the order of the images presented in the set would make a difference in the results?

2. Form a design group. Who's in your group:

3. What discrete quantitative sense do you want to test? Use clues from the article "Animal math" to generate ideas (refer to Page 23 for the example in the figure labeled "Reckoning with Weber's law"). Would you like to compare the sense of quantities of different categories of people (such as different age groups, math levels or genders) or would you like to study the ability of one group of individuals?

4. Create the visuals you will need to test your mathematical idea based on the example your teacher provided. State your hypothesis based on your idea. Determine the exact testing procedure you will use for each test subject and write this down. Who is administering the test? What script will the test administrator use? Think about minimizing confounding variables.

5. How many subjects will you test? You can use a sample size calculator to help you determine the number of people you should test based on the population of people you are able to test (as defined by your teacher).

6. Once a sample size is selected, how will you determine which subjects to include in your experiment? Use a random number generator such as the one offered on Random.org to create a simple random sample.

7. How will you record your data for each subject? Create a data table.

Implement:

8. Collect your data in the time allotted. Make sure you stick strictly to your procedural protocol.

Analyze your data:

9. What do you want to know about the data you collected?

10. Check with your teacher to determine how to analyze your data. If you're using a particular statistical test, your teacher will provide the online resource necessary to perform your analysis.

11. Summarize your results here. Do your findings support your hypothesis with statistical significance? Explain.

12. What errors do you think existed in your experiment? How could you modify your experiment in the future to remove those potential errors? What other questions might you want to test in the future?

13. Share and compare your findings with other groups. If the test that you developed used similar variables as another group, did you have similar results? If not, discuss why.