ECOS
Ecologists Educators and Schools: Partners in GK-12 Education

ECOS Inquiry Template

1. CONTRIBUTOR'S NAME: SAM STIER

2. NAME OF INQUIRY: ESTIMATION BY SAMPLING

3. GOALS AND OBJECTIVES:

a. Inquiry Questions: How can the number of trees in an area be estimated by sampling?

b. Ecological Theme(s): Sampling is a fundamental tool used by ecologists in every kind of research.

c. General Goal: To introduce students to the concept of sampling and some of its associated concepts, such as bias, randomization, and extrapolation.

d. Specific Objectives:

Academic - Students will understand the idea of sampling and be able to use it in certain circumstances, without requiring an understanding of statistics.

Experimental – Students will gather data, analyze, and assess it

Procedural – Students will use a sampling device, collect samples, record the information on data sheets, analyze and assess the data.

Social – Students will work in small teams that most work cooperatively and quickly.

Communication – Students will give short explanations in front of the rest of the class explaining their sampling methods.

e. Grade Level: 8^{th}

f. Duration/Time Required: 50 minutes

→ Prep time 2-10 hrs.
→ Implementing Exercise During Class 50 min.
→ Assessment Variable.

4. ECOLOGICAL AND SCIENCE CONTEXT:

a. Background (for Teachers): This inquiry will introduce the concept of sampling to students. Sampling is a fundamental tool used by scientists and ecologists in nearly every kind of scientific research. While complex, there are basic ideas in sampling that are easy (and fun!) to grasp, and which can form a good introductory knowledge of something scientists do every day in their work.

This inquiry is extremely simple to execute, and will require no further research or understanding than teachers already have. The only additional information teachers will have to obtain will be to put the inquiry into a local physical setting. In the example provided here, we used the number of trees in a square acre of land adjacent to the school. The same inquiry could be used on the number of grass blades in a square foot, or the number of shrubs in a quarter acre, etc. The key is to have a relatively large number of stationary objects in a known area, which you can census (count completely) but which students in 15 minutes cannot.

b. Background (to present to Students):

Introductory discussion with students:

Ok, who here can tell me how many stars there are in the universe?

Well scientists think there are approximately 70 sextillion stars in the universe [7 followed by 22 zeros or 7×10^{22} or 70 thousand million million million]; how do you think they arrived at that number? Well do you think they counted all the stars in the universe? Why not? [too many, too much time, too costly].

Because counting things is often not feasible, scientists often use a very powerful tool to answer questions like these, a tool called sampling. Sampling of one kind or another is used in almost every ecological study, so it's an important concept to grasp. Let's say you wanted to know how many individual letters there were in this book. Can anyone think of a way to estimate this without counting all the letters? [explain a way to sample]

We sample in our daily lives all the time. Let's say you come into the kitchen at home and there's a big pot of soup on the stove. To figure out how the soup tastes, you don't have to eat all the soup in the pot do you? No, you just take a teaspoon of soup out and taste it. You make an assumption that the taste in that teaspoon is *representative* of the taste of the soup overall. That's the same assumption scientists make when they use sampling to answer questions like how many starts there are in the universe, or how many deer there are in western Montana.

Sampling is just how it sounds. It means taking a small piece of something larger, in order to learn something about the larger thing. By using the tool of sampling, we can learn a lot about something even when we have limited information about it, so it's very useful.

Today, we're going to use sampling to estimate the number of trees in the outdoor classroom (OC). This is how we're going to do it: Each group is going to get a length of rope. You're going to take your rope into the OC and make a circle with it on the ground, and count the number of trees inside the enclosed circle. Just count the trees bigger than about 5 inches around [about the size of a circle if you hold your index fingers together, and your thumbs]. You're going to write this number under "sample 1" on your data sheet, and put an X on the map of approximately where you took the sample. Each group is going to do this 5 times in the OC, so you'll have 5 numbers on your data sheet and 5 x's on your map. This part is important: you must decide where you want to take your samples. It can be anywhere in the OC. But I'll give you a clue: for sampling to work, samples have to be representative of the whole. For example, if you only dip your teaspoon on the very top of the soup pot, you might only get broth, and if you dip your teaspoon only on the bottom of the pot, you might only get chunks.

When you get back, we'll talk about how to use these samples to make an estimate of the number of trees in the entire OC. Does anyone have any questions?

Ok, each group has only 15 minutes to get their 5 samples and be back in class. So if you don't have time to get all 5 samples, just get as many as you can in 15 minutes.

Discussion following outdoor exercise:

The amount of area in the OC is approximately 4,047 sq m, and the amount of area in each enclosed rope is 9 sq m. So first, get an average from your five samples. Then multiply this number by 450 (the amount of times 9 sq m goes into 4,047 sq m). Go ahead and do this, and put your estimate on your data sheet.

When you're done, one member of each group should write their samples on the board, the average, and their final estimate.

….

[Using an overhead transparency of the OC] Each group should have one member come up here and show the class where they took they're samples, and how and why they chose these areas to take their samples.

…

So we happen to know the total number of trees in the OC, because we counted them all. Melissa, the envelope please, and may we have a drumroll…the total number of trees in the OC that are 5 inches wide and bigger is…119.

…

Ok, now each group needs to make an estimate using ALL of the samples from the class. This is a total of 20 samples. So, first get an average of the 20 samples (add up the total number of trees found in the 20 samples and divide by 20), and multiply by 450 to make a new estimate of the total number of trees found in the OC. Then we'll discuss the questions as a group on the bottom of your data sheet.

> How close is your group's estimate to the true number? Why do you think your estimate is higher/lower?

[Here you can bring in the presentations made by each group about how they chose their sampling locations. In many cases, students will seek out the object being estimated, in this case trees, and primarily sample areas where these objects exist. They will tend not to sample areas where these objects don't exist. As a result, they will tend to end up with an overestimate of the number of such objects in the area.]

> Is your group estimate closer or farther from the class estimate of the total number of trees in the OC? Why do you think your group estimate is closer/farther than the class estimate from the true number of trees in the OC?

[This discussion will work in cases where at least some group sample more or less randomly. Generally in such cases, the class estimate will tend to be better than individual group estimates, because of the greater number of samples taken. As sample size increases, biases in either direction tend to even out, and the true number (in this case trees) is approached by the estimate.]

> What do you think we could do to get a more accurate estimate of the true number of trees in the OC?

[Here you are looking for students to suggest randomizing their sampling locations, and getting more samples.]

> In order for sampling to provide a reasonably accurate estimate, an important assumption is made about each sample. What is this assumption? [remember about tasting soup] What can we do when choosing our sample locations to best meet this assumption?

[Another opportunity to discuss randomization.]

Mathematical parameters used in this example of the inquiry:

Outdoor Classroom = 1 Acre = 43,560 sq ft; 4046.86 sq m
A square with each side 208.71 ft (63.61 m)

3m x 3m x 3m x 3m = 12 m long rope can contain about 9 sq m of area
4047 sq m/9 sq m = 450

So multiply the sample average by 450 to scale up to 1 acre.

5. MOTIVATION AND INCENTIVE FOR LEARNING:

Outdoor component is fun for students. Giving students a tool to answer seemingly impossible questions (like the number of individual letters in a large book) can also be fun. You can include prizes for the group whose estimate is closest to the true number. You can also emphasize the relevance of sampling to students by giving every day examples in which they use sampling, such as tasting soup, checking the weather outside, and being tested in school about a subject they learned.

6. VOCABULARY:

Census: to count completely.
Sample: an incomplete count used to estimate a complete count.
Bias: a predisposition to make choice non-randomly.
Randomization: any process used to eliminate or reduce bias.

7. SAFETY INFORMATION:

CHILDREN WILL BE SAMPLING OUTSIDE IN A LIMITED AMOUNT OF TIME, SO CAUTION MUST BE ADVISED.

8. MATERIALS LIST (including any handouts or transparency masters):

STRING FOR SAMPLING
DATA SHEET
MAP
PENCIL
CLIPBOARD

9. METHODS/PROCEDURE FOR STUDENTS:

a. Pre-investigation work: None.

b. Investigation work:

1) What evidence (data, samples) do students collect?

It is extremely flexible. Anything can be used if it can be censused by the teacher and exists in an enclosed space.

2) How do students present the evidence (data)? On data sheets, on the blackboard, and orally

3) What conclusions are drawn from the evidence students collect?

An estimate of the number of certain objects in a defined space.

4) Include examples of data sheets.

Using Sampling to Estimate the Number of Trees in the OC

Data Sheet

Group Number _______
Group names:

Sample #1: ______

Sample #2: ______

Sample #3: ______

Sample #4: ______

Sample #5: ______

Average based on above 5 samples (add up the total and divide by 5): ______

Your group's estimate of the number of trees in the OC (multiply the average above by 450):

______

The class's estimate of the number of trees in the OC (get an average of the 20 class samples and multiply by 450): ______

How close is your group's estimate to the true number of trees in the OC? Why do you think your estimate is higher/lower?

Is your group estimate closer or farther from the class estimate of the total number of trees in the OC? Why do you think your group estimate is closer/farther than the class estimate from the true number of trees in the OC?

What do you think we could do to get a more accurate estimate of the true number of trees in the OC?

In order for sampling to provide a reasonably accurate estimate, an important assumption is made about each sample. What is this assumption? [remember about tasting soup] What can we do when choosing our sample locations to best meet this assumption?

10. ASSESSMENT:

Did students seem to understand the relevance of sampling? The procedures of sampling? The meaning of their results? Did students enjoy the activity?

11. EXTENSION IDEAS:

IN MORE ADVANCED CLASSES, THE NOTION OF VARIABILITY CAN BE DISCUSSED, AND BASIC STATISTICS USED (SUCH AS CONFIDENCE INTERVALS).

12. SCALABILITY

IN MORE ADVANCED OR UPPER-LEVEL CLASSES, VARIANCE AND STATISTICS CAN FORM PART OF THE DISCUSSION. FOR LOWER-LEVEL CLASSES, THIS EXERCISE MAY STILL WORK WELL WITH STUDENTS DOWN TO PERHAPS THE 5TH GRADE LEVEL.

13. REFERENCES: NONE. HOWEVER, YOU CAN FIND OTHER EXAMPLES ON THE INTERNET WHERE SAMPLING IS USED, FOR INSTANCE TO COUNT THE NUMBER OF STARS IN THE UNIVERSE.

14. LIST OF EXPERTS AND CONSULTANTS

NOT APPLICABLE.

15. EVALUATION/REFLECTION BY FELLOWS AND TEACHERS OF HOW IT WENT:

WE CONDUCTED THIS EXERCISE WITH SEVERAL 8TH GRADE CLASSES, AND IT SEEMED TO GO EXTREMELY WELL. THE EXERCISE IS EASY TO UNDERSTAND AND EXECUTE, AND HAS TREMENDOUS RELEVANCE, WHICH IS A NICE COMBINATION OF FEATURES.