Biodiversity Counts!

In this activity, students will learn about biodiversity: how we measure it and why it matters!

Project Area: Environmental Science

Skill Level: Intermediate—Advanced

Learner Outcomes:
-Define biodiversity
-Be able to count and calculate diversity metrics
-Understand why biodiversity is important

TN Science Curriculum Standard GLEs:

S1. Embedded Inquiry 0607.Inq.1-5, 0707.Inq.1-5, 0807.Inq.1-5

S5. Biodiversity & Change 0807.5.1, 0807.5.5

TNCore Math:
7.NS. 2-3
7.EE.1-4

Science Skills: Develop hypothesis, observe, collect data, interpret
Math Skills: Solve real world problems using numerical and algebraic equations; apply multiple operations on rational numbers (add, subtract, multiple, divide)
Life Skills: Observing, Reasoning

Tags: Biodiversity, communities

Time Needed:
Set up: 5 minutes
In class: 30 minutes

Materials:
-Small items that can be sorted by color, size, shape etc. (e.g. animal counters, lego blocks, beads, cards with pictures of animals etc.), approximately 20 per group of students
-Chalk board or large writing pad for recording observations

Set up

This activity can be done with either natural communities (e.g. insects collected from a pond or field, plant specimens collected from a field - see EXTENSIONS for more ideas), or can be done with an artificial community consisting of at least 4 different things (e.g. beads, animal figures, legos, cards with pictures of the animals - anything that can be sorted by a characteristic).

Students will work in small groups, 4 or 5 groups in a class. Before class, create 4-5 "communities" of approximately 20 individuals. Make some more diverse (equal representation of all types) and some that are less diverse (mostly one type of thing). Here's

Community	Pillbug	Monarch butterfly	Lady beetle	Honey bee	Stink bug
1 (more richness, more evenness)	4	4	3	5	4
2 (less richness, more evenness)	6	0	7	0	7
3 (more richness, less evenness)	15	1	2	1	1
4 (less richness and less evenness)	0	15	0	4	1

an example set up with insects:

Introducing the Activity

Ask your students: What do you think biodiversity means?

Possible answers : Diversity of life on earth, all the different species in a community, all the genetic differences in a population or community

Show your students pictures of various biomes. First show a tundra (arctic) biome and a rainforest. **ASK: Where do you think we find the most biodiversity?** (Answer: rainforest). **Ask your students why they think that is.** (Answers: warmer temperatures means greater plant productivity which can support a bigger food web, warmer temperatures mean nutrients are recycled quickly, lots of different niches and habitats, etc. If you think of a food pyramid, the rainforest has a broader base.)

Now show pictures of two temperate biomes: a grassland and a temperate deciduous forest. **ASK: Which has a greater biodiversity?** This should be difficult to answer, because it is hard to tell from simply looking at them.

Explain that because we cannot always tell what the diversity of an area is, we need ways to quantify and describe biodiversity. In this lesson, they will learn how to do just that.

Have your students work in 4-5 small groups for this activity. Give each group an artificial community (see set up) or have them collect a natural community (see extensions). They should be sitting so that they can see all the other groups' communities. As you work through this activity, record the answers for all groups on a large chart.

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Part 1. Calculating biodiversity

Predict: Ask your students to look at the different communities. **Have them make two predictions:**

1. **Which community has the highest diversity?**
2. **Which community has the lowest diversity?**

Investigate: Explain that one way we can quantify diversity is by counting **richness**: This is the number of types of species in your community. Have them count the number of species and record the observations. (In the example dataset, richness = 5, because there are 5 different species present).

Now explain that diversity takes into account both richness and **evenness**: This is relative abundance of each species (or how they are distributed). The highest evenness is when every species has equal representation in the community. Have them rate each community as **high**, **medium** or **low** evenness.

Have them look at the richness and evenness scores, and determine the **diversity** of each community.

For younger students: Have them score each community as low, medium or high.

For older students: Have them calculate diversity using **Simpsons diversity index**[1].

$$D = 1 - \frac{\sum_{i=1}^{S} n_i(n_i - 1)}{N(N-1)}$$

D= Simpsons Index of Diversity
Σ = summation
S= number of species
n_i= number of individuals within the i^{th} species
N= total number of individuals within the sample

Species	Number of individuals
Pillbug	1
Monarch butterfly	9
Lady beetle	2
Honey bee	4
Stink bug	5

Example dataset and calculation:

First, calculate the numerator (top):
= (1 (1-1) + 9(9-1) + 2(2-1) + 4(4-1) + 5(5-1))
= 1(0)+9(8)+2(1)+4(3)+5(4)
= 0 + 72 + 2 + 12 + 20 **= 106**

Then, calculate the denominator (bottom):
N = 1 + 9 + 2 + 4 + 5 = 21
N(N-1) = 21(20) = **420**

Then, put it all together:
D = 1 - (106 / 420)
D = 1 - (0.25) **= 0.75**

This means that if you randomly pick two species you have a 75% chance of those two individuals being different species. We can say the diversity is HIGH (the closer to 1, the higher the diversity.) **Have your students record the diversity on their datasheets.**

Revisit the hypothesis: Were their original predictions correct? Who had the most diverse and who had the least diverse community?

[1]Simpson, Edward H. (1949). Measurement of diversity. Nature, 163, 688

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Part 2: Disaster Strikes!

Introduce: ASK: Why do you think biodiversity is important?

Possible answers: Aesthetics (looks nice), recreation (e.g. bird watching, fishing, hunting), source of new products (e.g. pharmaceuticals), resists invading species or diseases, important for other organisms in the food web, other ecosystem services (e.g. clean water, air, soil, clean up pollutants).

Predict: When disaster strikes (like disease or natural disasters) which communities do you think will be more affected?

Investigate: Pick a species and explain that they have a very important function in the community. e.g. flowers depends on honey bees to pollinate. These flowering plants can't reproduce without the help of honey bees.

Tell your students there's been a terrible disaster (e.g. hurricane, disease, hunters) which has killed off almost all the honey bees. Go around the classroom and randomly remove 2 honey bees from each group. (If they only have one honey bee, remove that one).

ASK: Do you have any bees left in your community?

-Students with more diverse communities should still have some bees, the less diverse communities may have no bees.

ASK: What do you think will happen to the flowering plants in your area?

-Possible answers: If several bees are left, likely has little or no effect. If no bees are present, then the flowers won't get pollinated and that plant species might die off.

Get your students to recalculate the richness, evenness and diversity of their new communities, just as they did for part 1. If short on time, then just re-calculate richness. Record the data and share the with the class.

Revisit your hypothesis: Which communities were more affected by the disaster? (Answer: Least diverse)

Disscuss & Apply:

What happened to the diversity in the more diverse communities? Answer: richness/diversity stayed about the same.

What will be the effect of the disaster on the plants in these more diverse communities? Answer: still bees there to spread seeds, probably little effect on the plants

What happened to the diversity in the least diverse communities? Answer: richness/diversity was lower

What will be the effect of the disaster on the blueberry plants in the least diverse communities? Answer: bees are gone (or reduced), so flowers won't get pollinated and won't be able to reproduce.

What else might have happened as a result of this loss of biodiversity? Possible answers: no honey is made, so bears and other animals might lose a food source, birds that eat bees also lose a food source

What are some ways humans cause losses in biodiversity? Possible answers: habitat destruction due to civilization or climate change, spread diseases, spread invasive species, forest fires, pollution, over hunting, over fishing etc.

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Extension and Variations:

1. Use a natural community. Instead of using toys, get your students outside to sample their own community! Try to pick at least two sites, one which is impacted by human activity (e.g. urban area) and one that is more natural. From a creek, use a bucket to collect sediments and collect the larvae that live there. On land, use a hula hoop to designate an area in a field or forest, and collect different plants or insects that live there. Students can use a key to identify the organisms. For example, use the activities in the "life beneath your feet" module on soil biology to collect organisms and preserve them in isopropanol. Then carry out the diversity exercises here.

2. Small samples (Activity 3 in student handout). Since scientists usually can't count ALL the species in a given area, they must use small subsamples to estimate biodiversity. In this activity, students randomly pull 5 and then 10 individuals from their community, then recalculate richness and/or diversity as for part 1. They should find that for less biodiverse communities, a small sample is fairly accurate, but for more biodiverse communities, they need a larger sample to estimate richness or diversity.

> **Was small sample more accurate for more diverse or less diverse communities?** (Answer: less diverse)
>
> **How do you know if you have a big enough sample to estimate biodiversity?** (Possible answers: if you have the same richness in your small and large sample, then it's probably pretty accurate; keep sampling more and more until the richness doesn't change anymore.)

3. Biodiversity as a function of scale. Biodiversity can depend on the size of the area you are measuring. Typically, we expect higher richness if we take a larger area into account. If your students are working in small groups, tell them each group is a different patch of forest. Now ask them to predict if the biodiversity would be higher or lower for the entire forest (i.e. the whole class). Then, pool all the communities and have your students calculate richness and/or diversity.

Resources

Project Learning Tree: "Exploring Environmental Issues: Biodiversity" is available at www.plt.org

Duncan, S.I., Lenhart, S.L. and K.K. Sturner. 2014. Measuring biodiversity with probability. The Mathematics Teacher. *In press*

Acknowledgements

This work is funded in part by UTExtension. A portion of this work was conducted at the National Institute for Mathematical and Biological Synthesis, an Institute sponsored by the National Science Foundation, the U.S. Department of Homeland Security, and the U.S. Department of Agriculture through NSF Award #EF-0832858, with additional support from The University of Tennessee, Knoxville.