Data Jam

OVERVIEW

Students will learn how to build a research project following the scientific method.

GRADE LEVEL

Middle and High School; can be adapted to fit younger audiences

SUBJECTS

Scientific method, Data collection, Data analysis, Teamwork, Communication, Presentation, Community Science, Community action/Stewardship

NGSS

- MS-ESS3-2
- MS-ESS3-3
- MS-ETS1-1
- HS-LS2-2
- HS-LS2-7

DURATION

4 lessons total (3 x 1.5 hours each + 1 presentation session = 7.5 hours total)

SIZE

Preferably, class size no larger than 25 students.

SETTING

Mix indoor and outdoor.

MATERIALS

- Chalkboard/whiteboard
- Students' journals
- Colored pencils (prefered)
- Plus any data collection materials specific
  to their research project.

LESSON SUMMARY

A five-part lesson where students will practice the scientific method by collecting their own data regularly over the semester, forming their own scientific questions/hypotheses, analyzing the data collected, finding trends, and graphing the results. At the end of this process, the goal is for students to come up with a creative representation of the results of their scientific project.

LEARNING OBJECTIVES

At the end of this lesson students will be able to:

- Create and execute a research project using a scientific method approach.
- Learn the components of an effective research question(s) and build their own.
- Come up with a good methodology to test their research question(s).
- Represent their data using proper graph types and including all graph elements (title, axis labels, legend, units…).
- Come up with conclusions based on their data results.
- Connect their results/research project to the bigger picture, applying what they have learned on a local and/or global scale.
- Create a call for action/raise awareness of issues learned through their projects.
- Come up with a creative way to represent their data trend using their individual skills/hobbies.

KEY CONCEPTS

Research Question(s), Hypothesis, Prediction(s), Dependent and Independent variables, Quantitative and Qualitative data, Discrete and Continuous data, Average and Standard Variation, Data Trend/Pattern

VOCABULARY

- Watershed
- Impermeable/Permeable surface
- Stormwater runoff
- *E. coli (Escherichia coli)*

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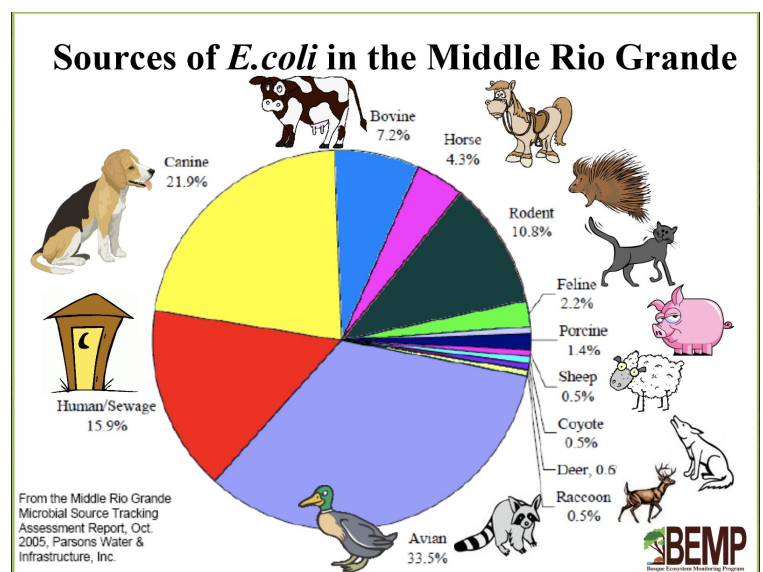
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BACKGROUND:

[If you decide to use the litter survey example as the research project for your class. This lesson can also be adapted for any other research project.]

Litter Survey Project

The southwestern United States has an arid environment where drought is common and water scarcity is an issue. With water in short supply, states such as New Mexico struggle with issues related to water quantity and quality. One major water source in New Mexico is the Rio Grande, which runs through the urbanized city of Albuquerque in Bernalillo County. In addition to being an important water source for drinking, agriculture, businesses, industry, and recreation, the Rio Grande and its associated riparian forest, the bosque, are considered key cultural components of life in Albuquerque. Thus, precipitation is a key climatic factor that shapes New Mexico's landscape as we know it. This precipitation can come as snow during the winter months or as rain (storm events) during the monsoon season in the summer months.

The sudden input of water during a storm in an otherwise dry environment creates a very specific scenario for cities like Albuquerque, where any pollution (oil, gasoline, trash, dog waste…) sitting on top of the city's pavement can get washed down to the river (lowest point of the watershed). This happens in part because pavement, an impermeable (water proof) surface, doesn't allow water to percolate through as it would through exposed soil. Without this "natural" filtration, water slides over the surface, carrying pollutants with it, until it reaches the river. This is called stormwater runoff. This runoff can cause the accumulation of a variety of pollution types/litter in certain areas of the city on its way to the river. Some examples of these pollutants/litter are plastic, glass, metal, oil/gasoline, and dog waste. When these materials decompose, they become a risk for the health of the environment and all the organisms living in it.
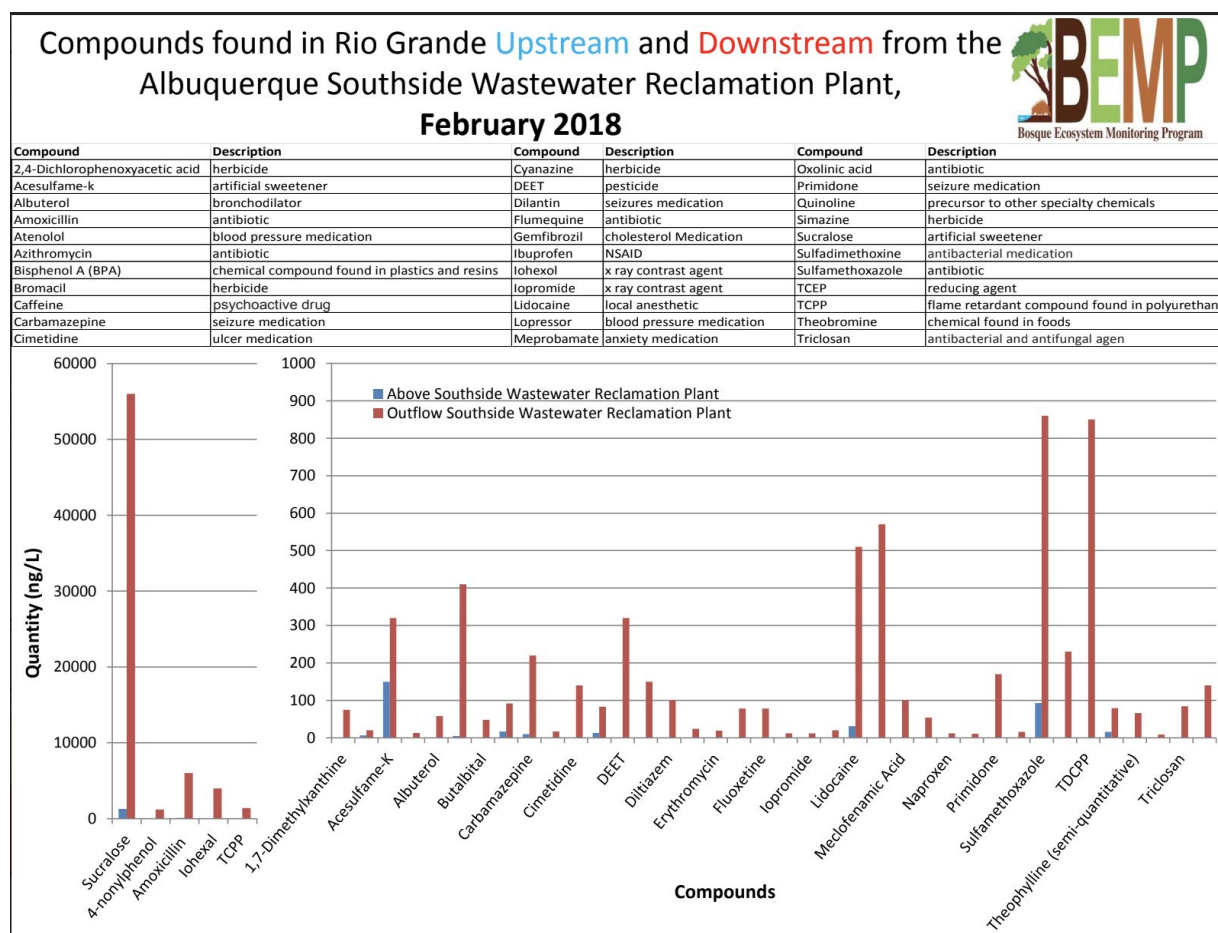
Dog waste, for example, contains a bacterium (E. coli) which can be found in the lower intestine of warm blooded animals. The cells can only survive for a short period of time outside the body, which makes them ideal indicators of fecal contamination. E. coli is naturally found in any river, but for the Middle Rio Grande, dog waste gets carried to the river through storm water and makes up to ~22% of the total E. coli in our river, making it the second biggest source (after birds) followed by human sewage (see image).

Sources of *E.coli* in the Middle Rio Grande

Bovine 7.2%
Horse 4.3%
Canine 21.9%
Rodent 10.8%
Feline 2.2%
Porcine 1.4%
Sheep 0.5%
Coyote 0.5%
Deer, 0.6
Raccoon 0.5%
Human/Sewage 15.9%
Avian 33.5%

From the Middle Rio Grande Microbial Source Tracking Assessment Report, Oct. 2005, Parsons Water & Infrastructure, Inc.

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This is in part because Albuquerque has more than 80,000 registered dogs which can generate more than 20 tons of waste per day. Exposure of E. coli from contaminated water (or food) can make people sick. In Bernalillo County, uncollected dog waste is an issue because it can be transported by storm water into the Rio Grande. There are more than 40 dump truck loads full of dog waste picked up just in Bernalillo County Public Land every year (2015).

A variety of other materials can also impact the overall water quality of the river (see image below). From medicines that have been flushed down the toilet and make their way to the river, like antibiotics, to artificial sweeteners that the body can't process or chemical components our clothes are made up of.

Compounds found in Rio Grande Upstream and Downstream from the Albuquerque Southside Wastewater Reclamation Plant, February 2018

Compound	Description	Compound	Description	Compound	Description
2,4-Dichlorophenoxyacetic acid	herbicide	Cyanazine	herbicide	Oxolinic acid	antibiotic
Acesulfame-k	artificial sweetener	DEET	pesticide	Primidone	seizure medication
Albuterol	bronchodilator	Dilantin	seizures medication	Quinoline	precursor to other specialty chemicals
Amoxicillin	antibiotic	Flumequine	antibiotic	Simazine	herbicide
Atenolol	blood pressure medication	Gemfibrozil	cholesterol Medication	Sucralose	artificial sweetener
Azithromycin	antibiotic	Ibuprofen	NSAID	Sulfadimethoxine	antibacterial medication
Bisphenol A (BPA)	chemical compound found in plastics and resins	Iohexol	x ray contrast agent	Sulfamethoxazole	antibiotic
Bromacil	herbicide	Iopromide	x ray contrast agent	TCEP	reducing agent
Caffeine	psychoactive drug	Lidocaine	local anesthetic	TCPP	flame retardant compound found in polyurethane
Carbamazepine	seizure medication	Lopressor	blood pressure medication	Theobromine	chemical found in foods
Cimetidine	ulcer medication	Meprobamate	anxiety medication	Triclosan	antibacterial and antifungal agen

This project provides the opportunity for students to research about this problem from their homes without the need of specific tools.

Additional Resources:
https://bemp.org/education-outreach/education-resources/stormwater-science/
There's too much dog poop in the Rio Grande
https://digitalrepository.unm.edu/cgi/viewcontent.cgi?article=1147&context=arch_etds

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SESSION ONE:

Introduction & Research Question(s)

1. Start by giving a brief summary of today's session and introducing the concept of "data jam". Data Jam is *a way to creatively tell science stories to a general audience*.
   Note: Check the Asombro Institute website for more information about their Desert Data Jam.

2. Present the overall outline of their research project. This outline is the same as that of a research poster (see below) and will be the layout we will follow for the next three sessions:
   a. Session 1: Introduction & Research Question
   b. Session 2: Methods & Results
   c. Session 3: Conclusions & Creative Project
      Introduce the concept of "Creative Project". A creative project is *a way to show your data trend using words, pictures/drawings, models, videos…* Remind students to use their skills/hobbies for that portion of the project. Students will have to come up with a creative way to present their data trend/story at the end.
      Note: Check this video from the Asombro Institute to learn more about what is a creative project with examples.

Poster layout: Data Jam overview
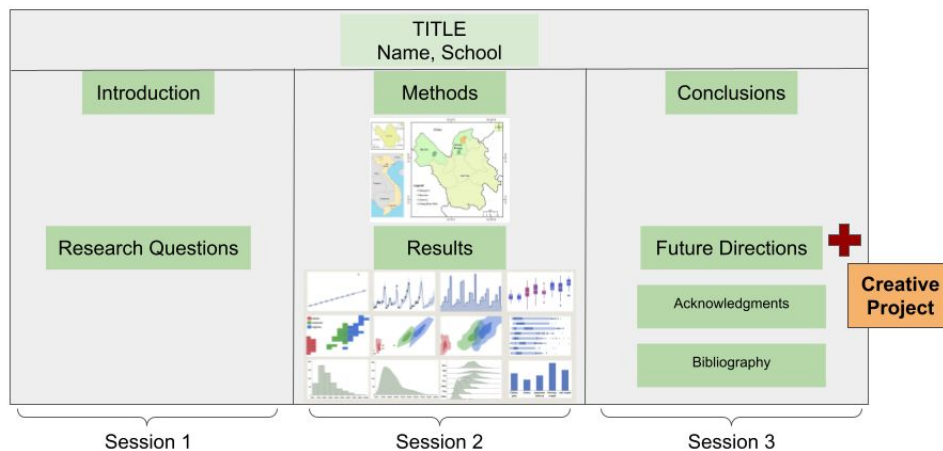
The end goal of these sessions is to create a project that can be presented at a scientific conference, like BEMP's Crawford or Luquillo-Sevilleta Symposiums.

3. Present the sections you will cover today: 1) Introduction to the specific project theme and 2) how to come up with a research question.

4. Introduce the theme you will be using as an example for this session. Start asking general questions to get students thinking about the topic.
   We will use a *litter survey* example for this document and so you could start by asking questions like:
   a. *How much waste does your city generate?*
   b. *Where does it all go?*
   c. *When litter doesn't end up in the trash what happens to it?*

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Regardless of which dataset students end up using for their final project, remind them what it's important to include in the introduction section (*use the litter survey datasheet to go over each of these points*):

- ○ **Where** - Introduce the importance of a map when describing the location. Help locate students on the map. Use land features that the students can relate to.
  The litter project example involves surveying the neighborhood by creating a circuit that students will repeat every collection day. Because of that, use this section to talk about the importance of drawing/sketching the survey route (circuit) for projects like this one.

- ○ **When** - Discuss what time of the year and how often they should collect data to obtain meaningful results. Make sure students don't select a research project that requires a long time to obtain results.

For the litter survey, if the project wants to figure out if there is any connection between litter accumulation and storm events, the data would have to be collected before, during and after the storm season.

- ○ **Who** - This section is a good place to start discussing if they are going to work as a group or individually on their research projects. If working as a group, will they all be collecting data?

- ○ **What** - Talk about the specifics of *what* is important to collect in order to obtain meaningful data.
  In the case of the litter survey, it could be important to know/note the different types of litter found (plastic, paper, glass, metal, dog poop, other animal scat and other). It could be also important to know where these were found (storm drain on the street, ditch, park…).

- ○ **How** - This section refers to the methods used to collect the data. You can introduce what the methods are here but we will go over them again during section 2.
  For the litter survey:
  - ● *Make a **map/sketch** of the circuit of the collection area.*
  - ● *Count/tally and classify all the litter.*
  - ● *Try to collect the data at the same day/time every week.*
  - ● *Take **photos** of the locations where you find litter.*
  - ● *After, collect litter using gloves, thick trash bags and any other protection needed. Do not handle needles or other sharps, etc. Take note of that on the data sheet.*

- ○ **Why** - Help students think of the importance of their project in a bigger context. *Why should we care about it?*

5. Next, introduce the concept of a **research question.** What is a research question? How do you come up with one? What makes a GOOD research question?
    Research questions are simple questions that guide the research and can be answered through data. Students should start by thinking about the data they will be collecting and then consider what it is about the data that makes them curious.
    Talk about the importance of a question that is Clear, Focus, Feasible, Concise, Complex and Arguable:
    a. Clear - no ambiguity
    b. Focus - narrow down to the point (one single problem/issue)
    c. Feasible - within the timeframe and constraints
    d. Concise - not too lengthy
    e. Complex - can't be answered with yes/no
    f. Arguable - it centers on a debate

Good research questions should generate more than "Yes" or "No" answers and instead build on facts and data rather than opinions.
Next, students work on this <u>exercise</u> to come up with their own questions:

<u>Research Question Exercise:</u>
On a piece of paper, answer the following prompts to yourself:
1. First, identify your general topic - what are you interested in researching? What is the main topic of your research? Put your answer to this question in the center of your paper.
2. Then, in the top left corner, answer: Who is impacted by this topic? What population? Are they people, plants, animals?
3. In the top right corner, then answer: What aspect of the topic are you interested in researching? The causes? The effects? The implications of it? Solutions?
4. In the bottom right corner, then ask yourself: When? Is this current? In the past? The future?
5. Moving to the bottom left corner, ask yourself: Where? Over the whole city? In your neighborhood? On a specific trail?

Here's a visual and example to help show what that might look like:

Who is impacted by this topic? What population? Animals? People? The city of ABQ? Children

What aspect of this topic are you interested in researching? The causes? Effects? Solutions? Caused illness

What is the main topic of your research? Led poisoning

Ask yourself where? Over the whole city? Your neighborhood? Flint, Michigan

Ask yourself when? Is this current? In the past? Future? Over the last 3 years

Has lead poisoning in Flint, Michigan over the last 3 years caused illness in children?

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Now that you have all these key components gathered, it's time to pull them all together! A great trick is to take the center answer, then work backwards with your answers. For example, your sentence would read like this:

- Has _(center answer)_ in _(Bottom Left)_ over/in the _(Bottom Right)_ caused/been caused/been impacted by, etc. _(Top Right)_ in _(Top Left)_?
- While your data might be about something else, here's another research example: Has lead poisoning in Flint, Michigan over the last 3 years caused illness in children?

Students work on this exercise individually, then discussing it with their partner and finally sharing it with the whole class following the "Think-Pair-Share" model.

Finish the session by reminding students of the importance of their research project: "Why should we care?". This discussion can be as simple as reminding students of the importance of learning about the surrounding ecosystem, know how it's doing so we can make hypotheses of its future health, and figure out ways to help improve it.

For a better learning experience and so students can take out the most of each of these lessons, we recommend them working on their projects in blocks after each of these sessions. So, before the next session students should have started their project by outlining their introduction and writing a few potential research question(s). They can also start thinking about how they will collect the data for it.

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SESSION TWO:

Methods & Results

1. Open the session by asking students what they learned during the last session and reviewing the main concepts. Use the litter survey example to do that and point out that even though <u>we won't be using this example for today's session</u>, they still should keep in mind how today's material relates/connects/applies to the litter project specifically. We will come back to it in our last session.
2. Then, start by introducing today's focus: Methodology & Results. Tell students they will actually do a little experiment from beginning to end as a way to go over the research process and all the steps that it involves.
3. Briefly remind them of the sections we covered in our last session (Introduction and Research Question). Quickly review how to come up with a good research question using the exercise from the last session. Ask students to provide you with some of the research questions they came up with for their project and use them as a way to give feedback - what did they get right? What are they missing?
4. Move on to today's goal: we will develop and go over a research project beginning to end but we will focus on the methods and results sections. We will study our **happiness levels**!
5. Give some background information about the research topic: "Some research says that interacting with living things affects happiness levels" ([Relationship between happiness and the interaction with nature and other living things like pets](#); [Relationship between happiness and the interaction with other humans](#); [TED Talk about the relationship between social connections and happiness](#)) . You can even ask/discuss with students how they feel when they interact with a car (inanimate object) in comparison to when they interact with their friend/pet/plant (animate object). Today we will study this!
6. Start by coming up with a research question for the project. Remind them of what makes a good research question (Clear, Focus, Feasible, Concise, Complex and Arguable). Give them a few minutes to come up with one or two, then share it with their class mate and finally with the whole class ("Think-Pair-Share" approach). Select one for today's research project.
7. Next, introduce the concepts of **hypothesis** and **predictions**. *A hypothesis is the answer to your research question*. This hypothesis should be based on background research. *A prediction is the outcome you would observe if your hypothesis were correct*. Ask students what they think the outcome of this project would be if they had to guess using the background knowledge you just provided. Give them a few minutes to repeat the "Think-Pair-Share" exercise with the predictions.
   <u>Potential Examples:</u>
   - *Research Question:* "[How] does happiness levels in the classroom change when (before vs. after) interacting with a living object?"
   - *Hypothesis:* Interacting with living objects makes people (in the classroom) happier.
   - *Prediction:* If people (in the classroom) interact with living objects, then we should see an increase in their happiness levels.

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- *Dependent variable:* The variable that scientists are often most interested in learning about. It often depends on one or more other variables. Usually located on the y-axis of a graph. For example, for our happiness project that variable would be happiness level.
- *Independent variable:* These variables are often not changed by other variables. We often look to see if these variables affect the dependent variable. Usually located on the x-axis of a graph. For our project that would be the effect or change (time before-after interacting with a living object)

8. After, introduce the different **types of graphs** they could use to represent their data based on the type of data collected.

    First, differentiate between **continuous** and **discrete** data:
    - **Discrete** data is information that can only take certain values, for example, shoe size. A kid can have a shoe size of 3 or 3.5 but cannot have a shoe size of 3.72.
    - **Continuous** data is data that can take any value, for example, weight, temperature, length...

    Also, if they need to collect **quantitative** or **qualitative** data:
    - **Quantitative** - Data expressed in numbers (ex. Temperature measurement).
    - **Qualitative** - Data expressed in words (ex. survey).

    Then, introduce the main graph types:
    - *Pie chart* - used to compare the parts of a whole.
    - *Bar graph* - used to compare facts or quantities in different categories or groups.
    - *Line graph* - used to present data that changes continuously over time.
    - *Other* - Scatter plot, pictogram, bubble chart…

    Based on that help them choose the right graph for the data they will be collecting for this class study. Don't forget to go over the important elements in a graph: Title, axis label, legend, data points (color/symbol coded), scale…

9. Next, go back to the research question for this class study and ask the students how they think we should test it (methods). This is another opportunity to use the "Think-Pair-Share" exercise with the students as a way to think about possible ways to test the question.

    Methodology proposed:
    1. *Grounding exercise* - Explain that this is to make sure that everybody starts the exercise in a similar (mental) space because otherwise somebody could feel very awake/active and while another person could feel sleepy instead and that would affect the results. We are **standardizing** the data! There are other ways to do that with statistics but we won't get into that in these lessons.
    2. *Pre-test questionnaire* - At this point ask students to use their journals to write the date, time, name of the exercise, a comments section so they can write down which living object they will be interacting with and any other important information. Go over each of the questions with them (these will be the same for the pre and post test so we can compare the results):

        This is a five question test adapted from *Oxford Happiness Questionnaire* that will be rated using a 1-5 likert scale (strongly disagree to strongly agree):

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		1	2	3	4	5	
1.	I feel happy	Strongly Disagree	○ ○ ○ ○ ○				Strongly Agree
2.	I laugh easily		○ ○ ○ ○ ○				
3.	Life is good		○ ○ ○ ○ ○				
4.	I find beauty in things		○ ○ ○ ○ ○				
5.	I feel mentally alert		○ ○ ○ ○ ○				

Note: You might want to keep the results anonymous so students can feel comfortable and be as honest as possible.
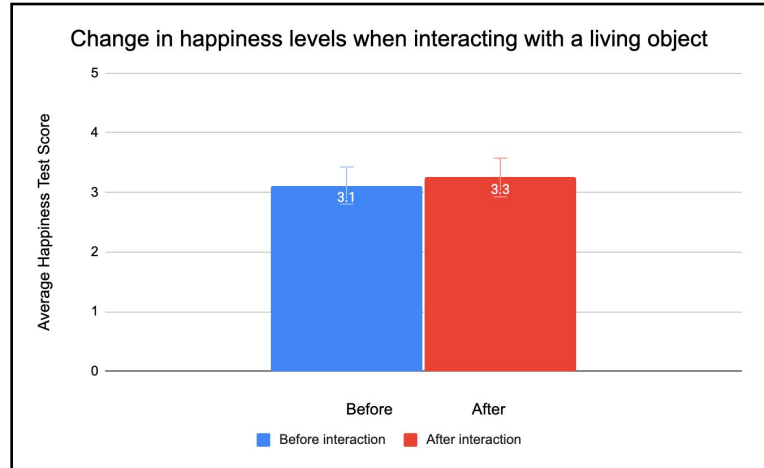
3. *Find a living object* - After, students will have to find a living object to interact with. If they are at home this can be anything from a house plant to a family member or a pet. If they are at school, students can interact with their classmates or you. You might have to set up some ground rules so students stay on task.

4. *Interaction* - Give students ~5 minutes to interact with it. Remind them to write down in their journal what they interacted with and how (play, talk, pet… - all this information might be helpful if you want to take this project to another level).

5. *Grounding exercise* - This time this exercise is a way to notice any shifts in your emotions compared to before the interaction, if any.

6. *Post-test questionnaire* - Repeat the questionnaire after the interaction.

7. *Enter all the data* - Once everybody is done, enter all the results on a spreadsheet (or any other platform) so you can share them with the class.

Lead the whole exercise so everybody can do the exercise at the same time together.

10. Use the results from the classroom as a frame to go over some basic statistics to **analyze the data**. Start by explaining how to calculate the average or mean and why it's important. *The mean (average) is the central or most common number.* This statistic can give you an idea of the tendency of your data. First, give students some time to calculate the mean/average of their individual scores for the scenario before and after the interaction. Then, ask them to calculate and represent the mean for the whole class (like the example below).

11. Ask students to graph their data using platforms like excel / CODAP or by hand. Make sure to discuss the type of graph they might want to use to represent their data and why. Review some of the previously mentioned aspects of their data to help with that:
    ○ *Are we representing **continuous** or **discrete** data?*
    ○ *Do we have **quantitative** or **qualitative** data?*

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11. After, go over the results. *What is the trend you see in your data? We understand trend as the overall pattern/tendency of the data.* It is used to see if there is a relationship between the variables: upward/increase/positive, downward /decrease /negative or no trend/correlation. Students use the "Think-Pair-Share" approach to discuss their data trend.

Change in happiness levels when interacting with a living object

Average Happiness Test Score — Before: 3.1, After: 3.3

Before interaction / After interaction

12. Finish by going back to the research question to conclude the main points based on the graph trend.

13. The happiness research project is done now so they should feel more comfortable building a research project from beginning to end! Make sure to finish this session by going over the methods and results sections for their research project specifically, <u>not</u> the happiness test example.

In preparation for the next session, encourage them to apply what they have learned today to their project and write the methodology using their own words. Go over the results one more time: the importance of identifying the variables, using the right graph… End by encouraging them to start playing with their data.

14. End this session by stepping back and reminding the students why it's important to create projects like this one: *to learn about the surrounding ecosystem, know how it's doing and figure out ways to help improve it.*

If you have a specific deadline for the finalization of the project, remind students what needs to happen before the next (and last) session before the project presentations:
   ○ Finish writing the research question(s)
   ○ Write the methodology
   ○ Play with the data to create a graph and find the trend - what does that mean (conclusions)?
   ○ Start thinking about the Creative Project (focus of the next session)

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SESSION THREE:

Conclusions & Creative Project

1. Open the session by reviewing the material covered over the last session. Use this as a chance to check in with the students where they are at with their projects and if they need any clarifications before moving any further.
2. Next, introduce today's focus: Conclusions & the Creative Project. Remind them what a creative project is. A creative project is *a way to show your data trend using words, pictures/drawings, models, videos…* Remind students to use their skills/hobbies for that portion of the project.
3. After, go over the conclusions section of their research project and point out the importance of connecting the dataset to the big picture. For example, in the case of the litter survey example, *how might litter numbers/quantity be connected to natural events like storms or even strong winds? How can litter impact the ecosystem?* Discuss this and other aspects that might be connected/impacted by their project with the whole group.
4. Then, go over each of the different sections of the **conclusions** using the litter survey (in winter season) as example:

   A. Rephrase the research question:

   Research question: How has the last precipitation events (and consequent snow/snowfall) over the past three months impacted the amount of garbage accumulated on the San Antonio arroyo in Albuquerque?
   Rephrasing: Snowfall (and consequent snowmelt) during winter months in the Albuquerque area can cause the accumulation of litter in waterway areas like the San Antonio arroyo.

   B. Summarize the findings:

   Runoff from snowmelt caused an X% increase in plastic litter around the San Antonio arroyo area in Albuquerque during the winter and early spring months (Jan-March 2021). The amounts of other types of litters did not change during the length of our research.

   C. Suggest key takeaway(s):

   The increase of plastic litter in the arroyo negatively impacts the overall pollution in the city.

   D. Fit the project into the **big picture** (so what?) and make a call for **action**!

   This increase in plastic pollution could ultimately affect the organisms living in that area including humans. Albuquerque habitants should reduce their individual plastic consumption (by using reusable materials, buying in bulk…) as a way to reduce the amount of plastic litter that ends up on the streets and arroyo areas in the first place. Also, there should be a more extensive study about plastic pollution in the area, in particular after snowfall, to know the real impact of plastic pollution on the ecosystem as a whole and the organisms living in it.

   Raise awareness about the topic: Put pictures of places in the city full of trash on site/location where we want to raise awareness next to informative panels.

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Design, evaluate, and redefine a solution to the problem: Invent an object to make carrying plastic a more manageable task. Students should think of the pros and cons of their designs.
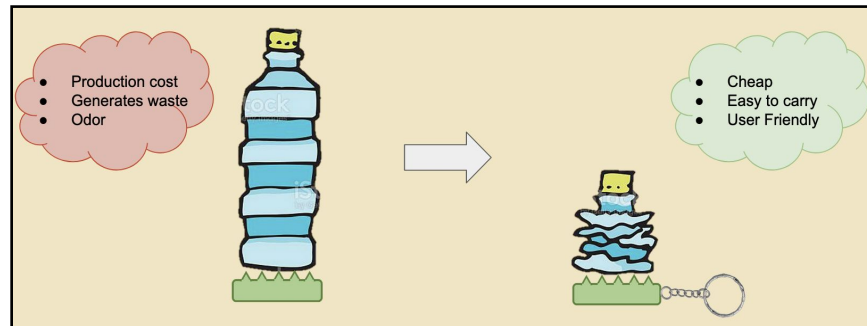
5. Remind students of the importance of applying what they have learned to a local and global scale. You can continue to use the litter example to talk about this:
   - *How can you apply what you learned with your project to our **local** ecosystem?*
   - *How can you apply what you learned with your project to a **global** scale?*
6. Next, use the underlined happiness experiment so students can practice coming up with a conclusions outline using the steps provided above. Remind them the research question and data trend (even if the trend is not specifically the one they got in their class group). Students should use this time to write down in their journal each of the different subsections within the conclusion. Students share with their peers what they came up with. You can use the "think-pair-share" exercise or just share as a class.
7. Then introduce the **creative project** piece to your students and remind them of what it is (we introduced the concept in session 1). Go over the main steps to create this creative piece:
   1. Find the **data trend**
   2. Identify one hobbie/**skill** to use when representing the data trend
   3. Use the right **scale** (Very important! Make sure to repeat and emphasize this point to students)
   4. Include a **key** to explain the symbols and/or scale
      Note: You can use this video from the Asombro Institute to walk your students through the process of what is a creative project with examples.
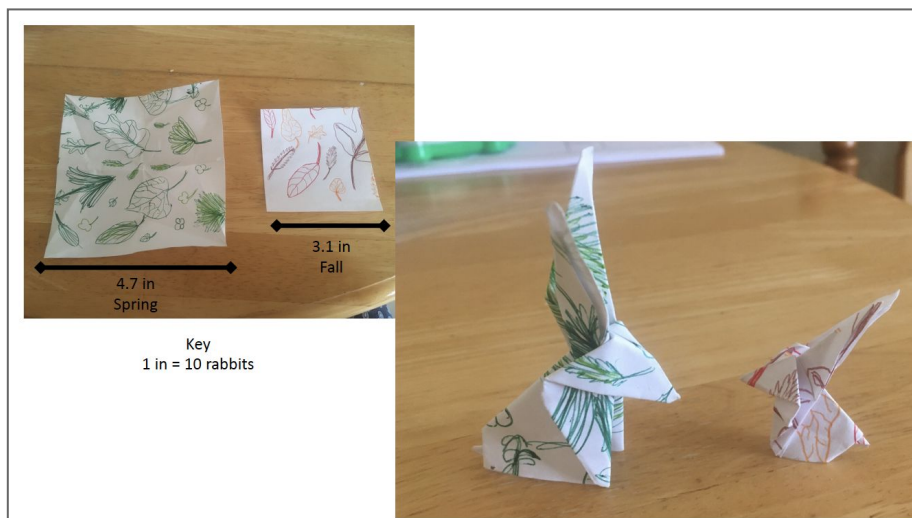
Jackrabbit Creative Project created by Kelly Steinberg from the Asombro Institute

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8. Students use the happiness experiment again to practice coming up with some ideas on how to represent the data trend in a creative way. Then they share what they came up with. There might not be much time for students to physically create a piece so instead ask them to think and outline/draw a few ideas of how they would go about it.
9. End the session by reminding them that they will be presenting their projects during the last session. Go over what they need to work on before then:
    ○ Work on the creative project
    ○ Prepare a presentation that includes:
        ■ Background/Introduction (session 1)
        ■ Research Question (session 1)
        ■ Methods (session 2)
        ■ Results (session 2)
        ■ Conclusions & Future Directions (session 3)
        ■ Creative Project (session 3)

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Bosque Ecosystem Monitoring Program

DATA JAM

SESSION FOUR:

Project Presentations

During this session the students present their research projects.

A NOTE ON SAFETY:
Safety protocols will have to be evaluated independently depending on the topic of their research project. Students working on the litter survey project should collect the litter at the end of the survey using gloves, thick trash bags, avoiding needles or other sharps, etc.

ASSESSMENT:
Written and/or oral presentation of their research project and creative piece.

EXTENSION:
Try to connect their project to things related to their local ecosystem. For example, in the case of the litter survey, the results could be connected to climate events happening in their area, like storms.

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