



Drought: Examining the Causes and Effects of Precipitation Shortage

Developed by Cynthia Hopkins – Corpus Christie, TX – 6th Grade Science (2023-2024)

Guiding Question

What factors contribute to the development of droughts?

Learning Objectives

Students will be able to identify the causes and explain some effects of droughts.

Standards Alignment

Performance Expectations:

- *MS-ESS2-4:* Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
- *HS-ESS2-2:* Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that cause changes to other Earth systems.
- *HS-ESS3-1:* Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Science and Engineering Practices:

- *Developing and Using Models:* Creating representations to explain water cycle and weather patterns.
- *Analyzing and Interpreting Data:* Examining climate data to understand trends and causes of drought.
- *Engaging in Argument from Evidence:* Using data to support claims about human impact on drought frequency and severity.

Disciplinary Core Ideas:

- *ESS2.C: The Roles of Water in Earth's Surface Processes:* The movement of water through the hydrologic cycle and its impact on weather and climate.
- *ESS3.B: Natural Hazards:* Understanding natural hazards, including droughts, and their impact on human society.

Crosscutting Concepts:

- *Cause and Effect:* Understanding the causative factors behind drought development.
- *Systems and System Models:* Examining Earth's systems and the interactions that lead to droughts.

Advice for Educators

The most surprising and successful moments came from the hands-on activities. Students were particularly engaged during the Observation & Discussion exercise, where they closely examined drought images and shared their observations. This activity not only enhanced their observational skills but also fostered a collaborative learning environment. The Fence Post Activity was another highlight, as it allowed students to visually and collectively analyze data, making patterns and trends more comprehensible.

Students needed more support in connecting practical activities to theoretical concepts. They often found it challenging to link their observations and data analysis to the broader causes and effects of droughts. To address this, I incorporated more guided discussions and scaffolded reflection activities, which helped bridge this gap.

For educators planning to use this unit, I recommend emphasizing the connection between activities and theoretical knowledge. Regularly check for understanding and be flexible in providing differentiated support. Encourage students to share their ideas and observations openly, fostering a collaborative and inclusive classroom atmosphere. Finally, ensure that reflective writing and discussions are integral parts of the unit, as these help solidify students' understanding and link practical experiences to theoretical concepts.

Background Information

Droughts are complex phenomena influenced by a variety of interrelated factors. Primary contributors:

- 1. Climate and Weather Patterns:**
 - **Temperature:** Higher temperatures increase evaporation rates and reduce water availability.
 - **Precipitation Deficit:** Prolonged periods of below-average precipitation are the direct cause of meteorological droughts.
 - **Wind Patterns:** Changes in wind patterns can shift weather systems, leading to reduced rainfall in certain areas.
- 2. Geographical Factors:**
 - **Topography:** Mountain ranges can block moist air masses, creating rain shadows and arid regions.
 - **Proximity to Water Bodies:** Areas far from large water bodies tend to receive less rainfall.
- 3. Soil Characteristics:**
 - **Soil Moisture Retention:** Soils with low moisture retention capacities (e.g., sandy soils) can exacerbate drought conditions.
 - **Soil Type and Vegetation:** Different soil types and vegetation cover influence the rate of evaporation and water retention.
- 4. Human Activities:**
 - **Agricultural Practices:** Over-irrigation, deforestation, and poor land management can deplete water resources.
 - **Urbanization:** Increased surface runoff and reduced natural recharge areas can lower groundwater levels.
 - **Water Usage:** Excessive withdrawal of water for industrial, agricultural, and domestic use can contribute to drought.
- 5. Climate Change:**
 - **Global Warming:** Rising global temperatures alter precipitation patterns and increase the frequency and severity of droughts.
 - **Shifts in Climate Zones:** Changing climate zones can make some areas more prone to droughts.

Materials

- Computer and LCD Projector to display artwork and dataset
- Observation & Discussion Slide Deck: [PowerPoint](#); [pdf](#)
- Featured Artwork: [Jacob Kainen, Federal Art Project \(New York City\), Drought, 1935](#)
- Featured Data: [Drought Monitor - Aug 13, 2024](#)
- Sticky notes/easel/dry erase boards for recording questions
- Long strips of cardstock paper approximately 10 inches long by 2 inches across so you can have 5 squares of 2 in. x 2 in. ([Template](#)). Dimensions and shape can be changed based on your circumstances/resources/space.
- String and clothespins or tape
- Scissors, markers, colored pencils, erasers
- Rulers
- Paper clips
- Scratch paper
- 11" x 17" vellum tracing paper
- [U.S. Base Map Template](#)
- Handouts:
 - [Fencepost Survey Questions](#)
 - Optional: [Data Visualization Choices Worksheet](#)
 - [Design Tools Guide](#)
 - [Data Sketches Grading Rubric](#)
 - Additional Mapped Datasets
 - [Freshwater Withdrawals: U.S. - 2010](#)
 - [Temperature Maximum Ranking: U.S. – 2023](#)
 - [Precipitation Ranking: U.S. - 2023](#)
 - [Data Sketches Student Worksheets](#)
- Additional Materials
 - [Water Cycle Dice Game](#)
 - [Water Cycle Board Game](#)
 - [Water on Earth Spreadsheet](#)

STEP 1 – Observation and Discussion

Part 1 – Art

1. Share norms for the discussion and briefly introduce the process to the students.
2. Project the **Featured Artwork** so that it's visible to the entire class.
3. Invite students to observe the image silently for 1-2 min.
4. Have students journal or write down initial ideas during this time.
5. Tell students: *“Let’s take a moment to look at this picture together.”*
6. Invite as many students as possible to share their ideas about what the image shows, using the following prompts/facilitation sequence (10-15 minutes)
 - a. Invite Student Ideas: *What’s going on in this image?*
 - b. Gesture: As each student is speaking, use your hand, mouse, or pointer to gesture to parts of the image that they are referencing so that the whole class can see.
 - c. Paraphrase: Repeat the student’s observations using different language, taking advantage of opportunities to introduce appropriate vocabulary and without validating/invalidating their ideas.
 - d. Ask for Evidence: *What do you see that makes you say _____ ?*
 - e. Invite More Ideas: *What more can we find?*
7. Thank the class for participating in the experience and for sharing their observations.
8. (Optional) Have students share in pairs any additional thoughts or observations (5 minutes): *“Now that we have all looked together, I know there are still more ideas. Turn to a person sitting next to you and share more or share something you didn’t share with the larger group.”*

Part 2 – Data

1. Tell students that now you are going to use the same approach and observe a mapped dataset. **It is important you do these observation sessions back-to-back. The observation and discussion with the art image may be more accessible to many students and encourages those that do not usually speak up or that are uncomfortable with science/data to participate. The art image may be more engaging and personally relevant, getting the students primed in the approach of observing and talking.*
2. Optional: Share digital copies of the selected data-only visualization so that students can view on their own devices during the silent observation time. Have the students put these devices away and focus on the projected image after the observation time.
3. Project the **Featured Data** WITHOUT the legend. Ask for 1 minute of silent observation time and 2-3 minutes of journaling time. Use the map: ***Drought Monitor - Aug 13, 2024-WITHOUT Legend***
4. (If this happens on the next day) Review the norms for discussion again.

5. Invite as many students as possible to share their ideas about the visual patterns they see in the data visualization, using the following facilitation sequence and prompts (~5 minutes)
 - a. Invite Student Ideas: *What's going on in this image?*
 - b. Gesture: As each student is speaking, use your hand, mouse, or pointer to gesture to parts of the visualization that they are referencing so that the whole class can see.
 - c. Paraphrase: Repeat the student's observations using different language, taking advantage of opportunities to introduce appropriate vocabulary related to the phenomenon, visualization, and/or data (e.g., scale, hemisphere, latitude/longitude, trend, variability) and without validating/invalidating their ideas.
 - d. Ask for Evidence: *What do you see that makes you say _____ ?*
 - e. Probe for more: *What do you think [visual feature you observed] might mean?*
6. Project the **Featured Data** WITH the title & legend now, so that it's visible to the entire class.
7. Invite students to look again at the data visualization that now includes a legend, providing ~1 minute to silently and independently observe.
8. Invite as many students as possible to share their ideas about the visual patterns they see in the data visualization, using the following facilitation sequence and prompts (~5 minutes)
 - a. Invite Student Ideas: *Now that you see this addition, how has your thinking changed?*
 - b. Gesture: As each student is speaking, use your hand, mouse, or pointer to gesture to parts of the visualization that they are referencing so that the whole class can see.
 - c. Paraphrase: Repeat the student's observations using different language, taking advantage of opportunities to introduce appropriate vocabulary related to the phenomenon, visualization, and/or data (e.g., scale, hemisphere, latitude/longitude, trend, variability) and without validating/invalidating their ideas.
 - d. Ask for Evidence: *What do you see that makes you say _____ ?*
 - e. Probe for more: *What do you think [visual feature you observed] might mean?*
 - f. Invite More Ideas: *What more can we find?*
 - g. If students are having difficulty providing new observations, try asking:
 - i. *What do you wonder?*
 - ii. *What jumps out at you? What do you see first?*
 - iii. *Does anything in this visualization seem unusual or unexpected to you?*
 - iv. *What's interesting to you? What is familiar to you?*
 - v. *If you could talk to the scientists who made this, is there anything you'd want to ask them?*
9. Thank the class for participating in the experience and for sharing their observations.
10. (Optional) Have students share in pairs any additional thoughts or observations. Ask them to think about additional questions they have which you will record in the next section (~5 minutes)

11. Tell students: *“Now that we have all looked together, I know there are still more ideas. Turn to a person sitting next to you and share more or share something you didn’t share with the larger group. Think about additional questions you might have. We will discuss these questions next as a class.”*
12. Develop a list of questions that were generated and ask for more questions. It is at this point that you, the teacher, can interject questions that would facilitate the investigation/learning of content if the students have not yet brought it up. Ask: *What are you curious about? What questions do we have? I’m curious why the patterns are...?*
13. Create a digital (e.g., Google Docs) parking lot with a question list or use sticky notes and tell students you will revisit these questions later in the program. Another option is for the teacher to aggregate the questions into 5-10 questions for a Driving Question Board that can be displayed in the classroom during this unit.

STEP 2 – Bridging Approach: Fencepost Activity

1. Give each student the **Design Tools Guide** handout.
2. Provide context about data collection/sources and symbology. Tell students: *“Data like we just saw in the Mapped Data exercise comes from a variety of sources – individuals can collect data at a local level or one point in time and then combine those observations/data to show data over time or over a larger spatial area. We can also collect data with satellites which provide large areas of remotely sensed observations and can even provide global pictures of data/science phenomena. People use symbols to convey information in a simple and effective way. Symbols are an important part of maps and can represent a range of different types of data. Symbols are described in a legend – a box or other place on the map where there is a key that says what each color of symbol means. Let’s look at different ways we can represent data.”*
3. Review the **Design Tools Guide** with students - ask the students to reflect on the previous activity comparing maps about which design tools were used/chosen and why.
4. Give each student a strip of paper that is divided into 5 numbered squares (You can use the **Template** provided).
5. Hand out the **Fencepost Survey Questions**.
6. Read through each question and discuss with the class which design tool would be best, and then determine which color, symbol, shading, etc. would work for that question. This could also be done initially in pairs and then discussed/decided on as a whole class. Tell the students that they can’t use each design tool more than once in the survey. ****Note: This can be a little time-consuming, but it’s a great way to give students a chance to think carefully about design tools, and to take ownership over the data.****
7. Have the students answer the questions on their strip using the colors/symbols that correspond to their answer choice. Instruct the students to work their way through the questionnaire and respond to the first question in the first block and so on. For some questions, students can color, draw or collage with images from the magazines. For other questions, a written word or phrase is ideal.
8. After all students have finished their responses, line all the students’ work side by side as a “fence post” (tape them on a wall or attach to a string) so that you can see trends across the class. Alternatively, you can spread them out onto a table so the strips can be moved around.
9. Invite the students to silently observe the ‘fence posts’ for 1 minute.
10. Invite discussion or written responses on the following:
 - a. What patterns do you notice?
 - b. What do the patterns tell us about our collected data?
 - c. Do you think the patterns would be different in other locations/with other ages/more people?
11. Optional: Have students complete the **Data Visualization Choices Worksheet** in class or as homework.

Optional Extensions

Water in Motion

Have students play the **Water Cycle Dice Game** or the **Water Cycle Board Game**.

Graph in Water

1. Refer students to the data table on the **Water on Earth Spreadsheet**.
2. Have students work in pairs to create a graph depicting water on Earth.

Drought

Links:

- [What is drought? \(UNL National Drought Mitigation Center\)](#)
 - [How does drought affect our lives? \(UNL National Drought Mitigation Center\)](#)
 - [Why is America running out of water? \(National Geographic\)](#)
 - [Can we protect ourselves from drought? \(UNL National Drought Mitigation Center\)](#)
1. Provide the above links to students. Have them research what a drought is, how it affects our lives, and how communities protect against it.
 2. Have students work in pairs to create a poster on the importance of water (using Canva, Google Slides, or paper/color pencils).
 3. Have students present their posters to their classmates.

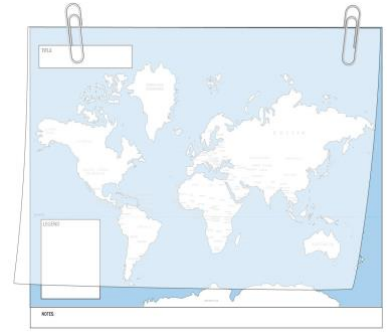
STEP 3 – Data Sketches: Making Data Visual

Have students sit in groups of three or four.

Part 1 – Plan & Sketch

1. Give each student a printed copy of the original mapped data (with legend) from the Observation and Discussion with Data session along with the **Design Tools Guide** handout.
Note: By now the students should be familiar with both the original map and the design tools. It is important to keep referring to the design tools so students become familiar with using them.
2. Explain: “Remember how we looked at the different mapped data representations and how we used the Design Tools to come up with our own symbols to answer the questions in the Fencepost Activity? Today we are going to discuss mapped data further and practice using these tools ourselves by creating our very own map legends with symbols, colors, marks...”
3. First, let’s remind ourselves about our map from earlier in this lesson. Invite discussion about the following questions regarding the printed map you have handed out (10 minutes):
 - What design tools were used to draw the data on this map?
 - What is included in the legend?
 - Why do you think they chose this particular design tool for this set of data?
 - While some tools are better for representing sets of data, there is no right or wrong tool. Are there different design tools we could use to represent this data? *Look through the handout and discuss what some good choices might be for this topic.*
4. Give each group 2-3 **Additional Mapped Datasets** related to the topic so that each student has a different map to work with. You can have students choose or you can assign datasets to different students based on ability or interest. If your groups are smaller than 4, not every group will have every map represented, which is fine. Just make sure that someone from each group is assigned to the original **Featured Data**.
5. Invite students to silently observe their maps for a few minutes and have them spend a little time making sure they understand what the data is trying to show. (5 min.)
6. Ask the students to decide within their group how they might represent the data in each of the three maps in a different way than it is currently while using three distinct design tools (i.e., color, symbols, scale) from their **Design Tools Guide** for the three maps. Have students work on developing new legends for each map using scrap paper, pencils, and markers (10 minutes)
7. Ask each student to choose one of the maps. Hand out the **Data Sketches Student Worksheet 1** and the **U.S. Base Map Template**.

8. Have students paperclip a sheet of tracing paper over the map template and follow the prompts on Worksheet 1 (*please show an example of what they are being asked to do*). This worksheet will guide them through beginning their map. *The map template provided to be used as a guide under the tracing paper is important because it forces each student to create a map that is on the same scale as the others so that these maps can be easily layered together in the second part of this exercise. The order of steps on the worksheet is important to follow because it allows the student to create the legend prior to getting involved in the task of drawing. You, as the teacher, can walk through each step one at a time, if needed, or have the students follow the instructions independently. (10 minutes)*



9. “Sketch” - the final task of this worksheet asks for the student to use their new legend as a guide to sketching out their mapped data in a new way. Students are also asked to note important features. *Students may begin by tracing the outline of the countries and, although it is not necessary and sometimes time-consuming, it is a way that they can begin to process the map spatially. For that reason, the timing of this component is variable and left up to the teacher. Students should have a minimum of 20 minutes to respond or the teacher may choose to break here and allow the students to complete their mapped “work of art” at home overnight and wrap up the next day with Part 2. (20 minutes – 2 hours)*



Part 2 – Analyze & Discuss

1. Looking at the maps they have sketched, ask students to write a one or two sentence summary of what their sketched data represents and then complete the **Data Sketches Reflection Worksheet**.
2. Have the students share their answers with their group. (5 min.)
3. Group work Round 1 - Patterns, Correlations, Hypotheses: The group works together to layer two maps at a time and look carefully at the paired maps, noting any patterns and correlations they can find and hypothesizing about what the correlations mean and giving each other feedback. (15 minutes)

Suggested sentence starters:

- *We notice that there is a correlation between ____ and ____ ...*
 - *There seems to be a pattern in...*
 - *One possible hypothesis that could explain this correlation / pattern is... This makes sense because...*
 - *This could tell us about... by...*
4. Have students report out as a group to the rest of the class about possible patterns, correlations, hypotheses. (10 minutes)

Wrap Up/Synthesis

1. Group work Round 2 - Evaluating Design Choices. Students discuss the design tools they used and evaluate how well those choices worked in terms of helping their analysis of the data.

Suggested sentence starters:

- *One design tool we used was... It helped us notice...*
- *When we used.... as a design tool, it made it more difficult to notice...*
- *Using as a design tool was interesting because...*
- *If we could do it again, we would do... differently. This is because...*

Have students use a dry erase board to write down their ideas for evaluating their design choices. (10 minutes)

2. Have students report out as a group to the rest of the class about their design choices. (5 minutes)

STEP 4 – Guided Discussion

1. Revisit the questions generated (parking lot/sticky notes) in Step 1.
2. Review if the answers were found during the rest of the activities or if more sleuthing and research needs to be done. This can also be a great jumping off point for other related lessons and activities related to your content.
3. Discuss with the class the following questions:
 - a. What questions did we answer?
 - b. What questions remain?
 - c. How can we find the answers to the remaining questions?
 - d. What skills/tools have we learned that can help us answer them?
 - e. What research can we do? What additional data do we need?
4. Lead a discussion with the following questions.
 - a. What are the causes of droughts?
 - b. What are the effects of droughts?
 - c. What additional data do we need?
 - d. What additional research do we need to do?

Assessment (Optional)

Have students write a claim, evidence, and reasoning in response to the guiding question: Why should communities prepare for drought?

	0	1	2	3
Claim	Nothing turned in / Blank	Claim is scientifically correct and complete or Correct multiple choice option chosen		
Evidence		Does not provide evidence, or only provides inappropriate evidence (evidence that does not support claim).	Provides appropriate but insufficient evidence to support claim or also includes some inappropriate evidence.	Provides appropriate and sufficient evidence to support claim.
Reasoning: Completeness		Does not provide reasoning, or only provides reasoning that does not link evidence to claim.	Some attempt is made to relate evidence to underlying principles, but there are missing pieces.	All of the ideas necessary to link the evidence to the claim are included.
Reasoning: Accuracy		The links between the evidence and the claim are based on incorrect ideas.	The evidence is tied to the claim by scientific principles established in the class, but there are also "extra" ideas that are incorrect.	The evidence is tied to the claim by scientific principles established in the class, AND there are NO "extra" ideas that are incorrect.