Human Impacts on the Environment: Water Management in the Colorado River Basin

Developed by Doug Eccher – Montrose, CO – 8th Grade Science (2023-2024)

Guiding Questions

- What are the effects of human activity on freshwater resources?

Learning Objectives

- **Human Impact on the Environment:** Students will identify examples of short- and long-term environmental changes and assess the impact of environmental changes on populations and species.
- **Biodiversity:** Students will identify how biodiversity contributes to the sustainability of an ecosystem, identify the factors that affect and can threaten biodiversity, and examine ways to protect biodiversity.
- **Human Impact on Resources:** Students will identify negative and positive impacts that human activity (i.e., dams/reservoirs, crop land, pastureland, and population density) has had on Earth's resources in the Colorado River Basin.

Standards Alignment

Performance Expectations:

- MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Science & Engineering Practices:

- Analyzing and Interpreting Data
- Engaging in Argument from Evidence: Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

Disciplinary Core Ideas:

- ESS3.C: Human Impacts on Earth Systems: Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

Crosscutting Concepts:

- Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural or designed systems.
- Influence of Science, Engineering, and Technology on Society and the Natural World: All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
- Science Addresses Questions About the Natural and Material World: Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.

Colorado Academic Standards:

- **Earth Science:** Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.
- **Prepared Graduates in Science:** Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.
- **Grade Level Expectation:** Human activities have altered the biosphere, sometimes damaging it, although changes to environments can have different impacts for different living things.
- **Academic Context and Connections:** Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

Advice for Educators

- ***What were the most successful or surprising moments in the unit?***
  I was really surprised how implementing the VTS helped classroom culture. Specifically, improving collaboration and cooperation. The norms established for VTS became the norms for many of our classroom activities. It helps slow students down, listen to what others have to say, and reflect on the problem at hand. The parking lot questions generated were surprisingly insightful and provided a link to the remainder of the unit.

- ***Where did you find students needed more support?***
  Creating impactful symbology that represented the data in the clearest way possible was a struggle for many students.

- ***If you were going to teach this unit again, what changes would you make?***
  One must be willing to allocate the time needed to add this to your unit. Should I make certain assessment components of the BIO lesson summative versus formative?

- ***What other advice would you give to educators interested in using this unit in their own classroom?***
  I found it impactful to connect the global data sets for the BIO lesson to the final unit project, Summative Assessment: Effects of Human Activity on Freshwater Resources in the Colorado River Basin.

  I like the idea of global data but many of my students cognitively can relate to local data more easily.

  The emphasis on using the BIO lesson was to help students when analyzing data. I found that these skill sets helped do that:

  - *Create a classroom culture built on collaboration and cooperation*
  - *Slow down the process*
  - *Value listening to other people's observations*
  - *Reflect on what you see and hear*
  - *Clearly identify what you know and what you do not about the data set*

  This was more important than focusing on how to graph or mathematically quantify data etc. What is the data telling us and what is missing?

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Materials

- Computer and LCD Projector to display artwork and dataset
- Featured Artwork: *California - Coit Tower Mural*
- Featured Data: *Dams and Reservoirs - 1800-2010*
- 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
- Base Map Template
- Handouts:
  - Fencepost Survey Questions
  - Optional: Data Visualization Choices Worksheet
  - Design Tools Guide
  - Additional Mapped Datasets
    - Agriculture: Cropland Intensity
    - Agriculture: Pastureland Intensity
    - Population Density 2016
  - Data Sketches Student Worksheets

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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.*"

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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. 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: ***Dams and Reservoirs - 1800-2010 – WITHOUT Legend***.
3. (If this happens on the next day) Review the norms for discussion again.
4. 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. Invite More Ideas: *What more can we find*?
5. Project the **Featured Data** WITH the legend now, so that it's visible to the entire class.
6. Invite students to look again at the data visualization that now includes a legend, providing ~1 minute to silently and independently observe.
7. 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?*

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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?*

8. Thank the class for participating in the experience and for sharing their observations.
9. (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)
10. 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."*
11. 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…?*
12. 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.

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STEP 2 – Bridging Approach: Fencepost Activity

Level: Formative

Lesson Duration: 45-60 minutes

Lesson Objective(s): Students will use their individual answers as data points and reflect on how the data looks in aggregate as a class and will consider how best to represent their data/answer choices.

1. Give each student the **Design Tools Guide** handout.
2. 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. 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 Classwork or Homework: Give students the **Data Visualization Choices Worksheet** to do in class or for homework.

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STEP 3 – Data Sketches: Making Data Visual

Level: Formative

Lesson Duration: 60 minutes

Lesson Objective(s): Students will work independently and collaboratively to read and redesign a set of mapped data, layering that data in order to notice patterns and correlations.

Have students sit in groups of three. If groups require a 4th member, add Population Density map.

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. 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 dataset 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,

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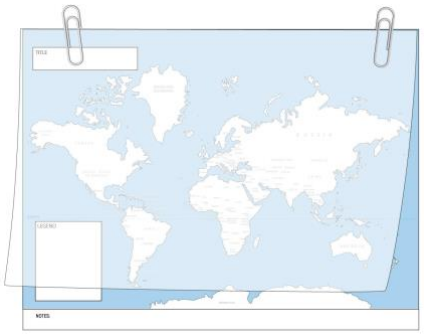
scale) from their **Design Tools Guide** for the three maps. Have students work on developing new legends for each map using scrap paper, pencils, and markers (10 minutes)

7. Ask each student to choose one of the maps. Hand out **Data Sketches Student Worksheet 1** and the **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)*

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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 **Data Sketches Student Worksheet 2**.
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. (10 minutes)

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

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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?

Assessment

Each lesson has both formative and summative assessment pieces. For the BIO lesson portion of the unit, I only provided formative feedback. The goal was to encourage students to participate in a low-risk environment and work in a collaborative and cooperative environment as they develop data analysis skills used to meet our learning objectives.

Assessment can also be individualized based on your classroom/students. You can use these general questions for ideas.

- Did student complete all activities?
- Did student participate actively in discussion?
- Did student show understanding of content?
- Did student show critical thinking?

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