Sustainability and Mining

Level: Middle School
Facilitator Guide

LESSON DETAILS

Objective: Students will investigate the extraction and use of minerals through the lens of sustainability by considering how current demand for minerals can affect future supplies.

Standards

NVACSS and NGSS

- **MS-ESS2-1:** Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.
- **MS-PS1-3:** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
- **DCI:** Natural Resources
- **SEP:** Constructing Explanations and Designing Solutions
- **CCC:** Cause and Effect

Career Readiness

- **1.2.5:** Demonstrate lifelong-learning skills by continually acquiring new industry-related information and improving professional skills.

Materials

- computer with internet access
- copies of handouts for each student
- model for each student group (shallow bin or baking pan, sand, beans, spoon, timer, 2 small cups or bowls)
- toy plants and animals, blue construction paper (optional)

Lesson Summary

Students begin by considering how a proposed mining site might affect the people living near it. They will also learn about the pillars of sustainability to consider how a new mine affects society, the economy, and the environment. Students will then use a model to understand how the mining process can affect the environment. They will then engage in research on the uses of minerals, mining processes, and the United Nations Sustainable Development Goals to more thoroughly consider the pillars of sustainability. Students will then use what they learned to prepare a presentation about how considering the pillars of sustainability can help with a decision about developing a mine at their assigned site. The lesson concludes with student groups presenting the pros and/or cons of the proposed mine, and their classmates will consider the argument to vote on whether each mine should be opened or not.

Preparation

For **Explore Mining Processes**, set up one mining site per student group. Consider if you want each site to be similar, or if there are aspects of mining you would like to highlight by having different models (e.g., different patterns of mineral locations, whether the mineral is visible at the surface, different plants and animals in the area).

If the containers you are using for this model are clear, you may want to cover the sides with construction paper so students cannot see the layers of the model. You may want to discuss techniques for determining what is underground, such as coring and **seismic profiles**.

Engage

1. Have students look at a map of Nevada and discuss what they know about natural and manmade features throughout the state. Show a series of maps as they bring up different ideas, such as:
   - **Topography** and **environments** (locations of mountains, rivers, deserts, and other natural features),
   - **Counties** (and why the state might be divided up like it is)
   - Land uses (**ownership**, **landmarks**, or other land uses),
   - How all of these factors affect where **roads and towns** have been built,
   - Where people live (**population density map**), and
   - Other factors that they bring up or ask about.

2. Assign one of these three hypothetical proposed mining sites to groups of students so they can assess it throughout this lesson:
   a. A new lithium mine near ranching land and traditional land of the Northern Paiute,
   b. A new gold mine near the Humboldt River, or
   c. A new crushed rock quarry near Reno, NV or another urban area.

3. Have students research the potential mining sites, to consider how various people and groups may be affected.
   a. Who may be concerned? Who may be in favor of the mining proposal? What might be their reasons?
   b. Brainstorm a list of possible people and groups who will be affected, including information from the **Native Land Digital map** to determine specific Indigenous nations near the proposed mining site.

4. Have students read about the "Pillars of Sustainability" on the student handout. (Additional teacher resources for background on these pillars: **An In-Depth Take**, **Sustainable Development**, **Origins of the Pillars**.)

a. Have students annotate the reading, highlighting or underlining important ideas that they might consider when thinking about opening a mine. They should also mark places in the reading that they are unsure of, or record questions they have.

b. Discuss the reading and how it generally applies to the scenario of opening a mine. Address questions they might have; record questions that will be addressed by the rest of this lesson and revisit them as they are covered by the activities and research that students complete.

5. Discuss

- *Based on what you have considered so far, would you want the mine to open at the proposed site?*
- *What else do you want to know about the potential mine site?*

Explore Mining Processes *

Adapted from* **Resource Extraction *by TeachEngineering*

1. Fill a shallow bin or baking pan halfway with sand. Add more sand to one end to make a hill.

2. Place a layer of beans on the sand, but do not make them evenly dispersed over the area (See Figure 2A). The beans can be more concentrated or more sparsely placed in different locations. This will simulate variation in the mineral-bearing formation. You may want to use different patterns and/or beans for different student groups to model how different minerals are distributed unevenly, and also that some minerals are more difficult to find.

Figure 2A: Determine the mineral distribution within the model. exposed. Note that the left end of this model is higher (a hill).

Figure 2B: Figure 2B: The final model, with some mineral This model might lead students to think that the mineral is evenly distributed under the sand. Credit: L. Mossa, AGI

3. Cover the beans with another layer of sand, allowing the beans near the top of the hill to be partially exposed (See Figure 2B), which can allow for the “discovery” of the mineral “vein.”

4. Arrange toy plants and animals on one area of the model as a terrestrial habitat. You may also want to place blue paper in at least one spot to indicate an aquatic ecosystem or water source.

5. Have students work in groups to plan how to most efficiently extract the mineral from their mine site. Provide a spoon or other tool for "excavation."

6. Provide materials for their dig. Give each student group:

   a. A timer. They will each work as an "extractor" in 30-second intervals to extract their mineral pieces (beans). Each 30-second interval will represent one workday.

   b. A bowl or container to represent the "extracted pile" where students will place mineral pieces they remove with their fingers.

   c. Another bowl or container to represent the waste pile where materials (minerals and sand) are placed when removed with a tool.

7. On each workday, they have two tasks:

   a. To extract as much mineral as they can. They can collect mineral pieces using only their forefinger and thumb, and they can only pick up one piece of mineral at a time. An additional "extractor" can be added when there are 10 or more mineral pieces visible. They will need to keep track of how many mineral pieces they extract each workday and place it into the "extracted pile".

   b. To dig, as needed, to locate more of the mineral. Mineral extraction should stop during digging. Any mineral that gets dug out with their tool has to go into the "waste pile" with the sand they remove from the mine site, it cannot go into the extracted pile. (This will hopefully prevent them from digging too quickly.) They should keep track of how many seconds they dig each day and how many seconds they spend extracting mineral pieces.

8. As they work through their workdays, they should consider things like:

   - *Should they work around the organisms that live there or relocate them?*
   - *Should they work around the body of water or "empty it" to mine under it?*
   - *When should they stop?*
   - *Is there a point where they are no longer collecting enough resources to make mining profitable?*
   - *How much waste is removed as the mineral was extracted?*

9. After students have decided to stop mining (or gotten to the end of the model), they should make a double bar graph showing how much mineral they collected and the time they spent digging each workday.

10. Discuss their results:

    - *Compare the data from each group. Are there any trends in the data? Does the amount of time spent digging correlate with the number of mineral pieces you were able to extract?*
    - *Why wasn't the mineral found evenly throughout the site?*
    - *To what extent did you consider the environment as you mined? How did this affect (or might this have affected) how much mineral you were able to extract (and, therefore, the profit made from it)?*
    - *Consider the amount of material in the "waste pile." What potential impacts could the waste materials have on the surrounding environment, especially the terrestrial habitats and water sources in your model?*

Explore Sustainability

1. Based on their work so far, have students generate a list of pros (benefits) and cons (concerns or negative impacts) about opening a new mine.

2. Provide students a copy of the student that shows the United Nations 17 Sustainable Development Goals (SDGs).

    a. Based on the titles of each goal, have students circle goals they think are related to opening a new mine (both pros and cons). You may want them to use different colored pencils to indicate which SDGs are related to pros versus cons. You may also want them to relate the SDGs to the pillars of sustainability they learned about in the **Engage**.

    b. Provide some **background** on the SDGs and why they were developed.

    c. Have students visit the **SDG website** to learn about the Targets and Indicators that are part of each goal.

3. Have students read an **introduction to the SDGs** as they relate to the earth sciences. Additionally, provide students with a copy of the Mining and the Sustainable Development Goals handout.

4. Have each group select two or more of the 17 sustainable development goals that they think may be important in making arguments about whether or not the new mines should be built to extract the currently untouched mineral deposit.

5. After brainstorming and discussing their initial pros and cons and the SDGs, ask students to expand or modify their original list.

Explain Mining Impacts

1. Students will use information sources from websites to learn more about a mineral resource to be mined at their assigned site. The websites should cover the mining process for the specific resource, environmental impacts of mineral-specific mines, and how humans use the mineral/rock resource. Here are some online sources that you can use as background, or to get students started (consider the reading level of sources before providing them to students):

    a. Lithium Mines and uses: **Lithium Mines in the U.S. (overview of Lithium use)**, **Mining Lithium in Argentina**, **The influence of exploration activities of a potential lithium mine to the environment in Western Serbia.**

    b. Gold Mines and uses: **How Gold is Mined**, **Environmental Impacts of Gold Mining**, **Uses of gold**

    c. Crushed Rock Quarry and uses: **The Complete Guide to Crushed Stone and Gravel**, **The environmental impact of extraction**, **Crushed Stone (uses)**

Elaborate

1. Have students develop a presentation to share their summaries of pros and cons as they relate to the SDGs with their classmates. Determine the presentation format students should use, or if they are allowed to choose their own.

2. Provide students with the planning sheet on the student handout to ensure they include all necessary information in the presentation. This could be adapted as a rubric for assessing student work.

    a. If multiple groups were assigned the same site, consider having one summarize the pros and the other the cons.

    b. Alternatively, you can have groups focus on specific aspects of the rubric.

    c. Making these modifications may mean that students do not have to consider all the questions on the planning sheet or all the steps on the rubric. Be sure to communicate with each group if there are parts of these handouts that they can skip.

Evaluate

1. Have each group present their pro/con summaries based on what they have learned about their assigned mine site, the specific resource of interest there (lithium, gold, or crushed rock), and the SDGs.

2. Encourage student discussion. The teacher can raise additional points and pose questions, such as:

    ▸ *What additional information would you need to form an opinion on whether the mine should be opened?*

- *Who might be concerned about the mine opening? Who would probably be in favor of the mine opening?*
- *What constraints on the mining operation might be put in place to address the concerns some people might have?*
- *Under what conditions should the mine not be allowed?*

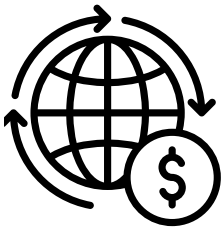
3. Have students share the pros, cons, and the constraints that they suggest to be put into place were the mine to be opened.

4. Based on what they have learned about each other's proposed mine sites, have students vote on whether each should be opened or not. Invite volunteers to explain why they voted the way they did.

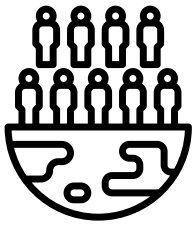
HANDOUTS

Pillars of Sustainability

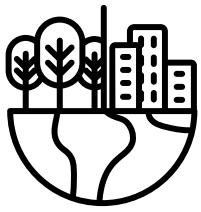
Sustainability is about meeting our needs today while considering how future generations will also be able to meet their needs. There are many factors that contribute to sustainability, which are often called pillars. Let's consider three commonly used pillars: economy, society, and environment. When they work together, each pillar plays a key role in helping humans use resources, innovate, and accomplish other goals in a way that is fair and balanced. By understanding how these pillars work together, we can create a better future for everyone.



The economic pillar focuses on having a strong economy that helps people have a good standard of living while taking care of the planet and its people. A sustainable economy creates jobs, encourages new ideas, and uses resources wisely. This can mean investing in green technologies, supporting local businesses, and making sure people produce and consume goods and services in responsible ways. By including sustainability in our economic plans, we can make sure that everyone benefits from the use of resources.



The social pillar is all about fairness, community well-being, and respecting different cultures. A sustainable society ensures that everyone has access to important things like education, healthcare, and safe places to live. It encourages all community members to participate and feel valued. This pillar also reminds us to honor cultural heritage and include diverse viewpoints in decision-making. By promoting social justice and inclusion, we can create strong and united communities that can handle challenges together.

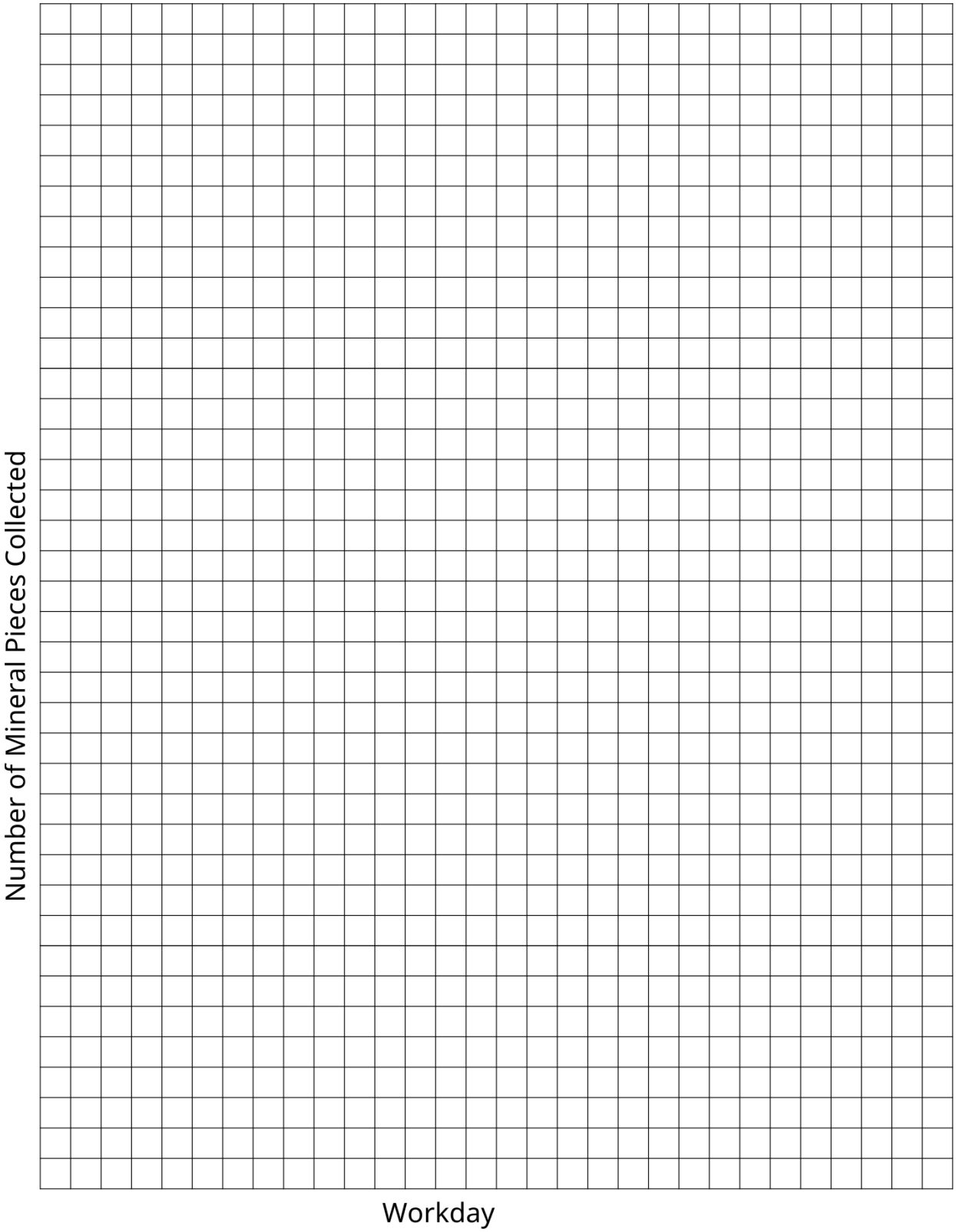


The environmental pillar emphasizes the need to protect nature and its resources. A healthy environment is essential for our well-being and economic success. Sustainable practices in this area include reducing pollution, protecting wildlife, and considering how human activity affects water quality and ecosystem health. This can mean using renewable energy, cutting down on waste, and caring for the land and all the living things that use it. By putting considering the environment in all we do, we ensure that our natural resources will last for a long time, supporting both our economy and society.


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

Mining and the Sustainable Development Goals

SDGs	The geosciences...	Mining companies...
1. No poverty	have a large number of high paying jobs.	create jobs in many local communities.
2. Zero hunger	study soil health and water quality to inform crop production.	promote responsible land use and provide minerals used in food production (e.g., iron).
3. Good health and well-being	collect data on environmental problems that can affect humans (e.g., spread of pollution).	ensure safe working conditions in and around mines.
4. Quality education	encourages learning about how Earth's systems function and interact.	offer educational programs and training for employees and local communities.
5. Gender equality	have increased the percentage of women who study and work in earth science fields.	advocate for gender diversity in the mining workforce.
6. Clean water and sanitation	can locate drinking water sources.	build infrastructure to prevent water contamination during mining.
7. Affordable and clean energy	can help identify ideal locations for solar and wind fields and can locate oil and mineral resources.	locate minerals used to make alternative energy technologies (e.g., solar panels).
8. Decent work and economic growth	includes many disciplines kind of variety of work opportunities.	support fair wages and employee rights and are a vital part of the supply chain, providing raw materials for production.
9. Industry, innovation, and infrastructure	assess bedrock and soil in areas that are being developed.	invest in sustainable mining technologies to reduce environmental impacts.
10. Reduced inequalities	can work anywhere around the world to help all human populations.	implement fair employment practices.
11. Sustainable cities and communities	assess natural hazards around the world.	collaborate with local governments to develop sustainable urban planning initiatives.
12. Responsible consumption and production	access quantities of natural resources and make predictions about future supplies.	monitor the sourcing of minerals and rocks to encourage that they be done responsibly.
13. Climate action	study climate change and its impacts.	reduce greenhouse gas emissions and engage in habitat restoration to offset environmental impacts.
14. Life below water	study conditions in marine environments.	implement practices to prevent water pollution.
15. Life on land	study how environmental conditions and changes affect ecosystems.	rehabilitate abandoned mines to reestablish local ecosystems.
16. Peace, justice, and strong institutions	share research and data so everyone around the world has a better understanding of Earth's processes and resources.	engage with local communities.
17. Partnerships for the goals	collaborate with other geoscientists and people working in other fields from around the world.	collaborate with governments to ensure best practices for sustainability.


Number of Mineral Pieces Collected
Workday