Engineering

Level: 3–5
Facilitator Guide

LESSON DETAILS

Objective: Students will apply the engineering design process to plan and carry out a model of the mining process.

Standards

NVACSS and NGSS

- **4-ESS2-2:** Analyze and interpret data from maps to describe patterns of Earth's features.
- **5-ESS3-1:** Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
- **3-5-ETS1-1:** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- **DCI:** Human Impacts on Earth Systems
- **SEP:** Constructing Explanations and Designing Solutions
- **CCC:** Interdependence of Science, Engineering, and Technology

Career Readiness

- **1.2.8:** Demonstrate time, task, and resource management skills by organizing and implementing a productive plan of work.

Materials

- cupcakes with frosting and filling (e.g., Hostess)
- trays or parchment paper
- a variety of tools for mining the cupcake (e.g., straws, flat toothpicks, plastic knives and spoons)
- foam blocks
- small containers for collecting extracted minerals and waste rock
- computer with internet access
- printouts of select pages of ***I am a Mining Engineer*** booklet by **MineralsEd** (optional)

Lesson Summary

Students will apply the engineering design process to the challenge of removing the filling from a cupcake, which will act as an analogy to extracting a mineral from a mine site. Students will try out different types of tools to describe their potential uses. A discussion of the types of mines and the different types of equipment used to construct and operate them will help students understand the mining process. The class will use what they learned to establish rules that groups must follow and will update their plans to operate within the rules and consider the impact of mines on the environment. The lesson concludes with students carrying out their mining plan and discussing methods and equipment that were successful in extracting the mineral (cupcake filling) while reducing environmental impact (assessing the condition of the cupcake after it is "mined").

Preparation

Before beginning this lesson, read about or review the **engineering design process**, as needed. You may want to share this diagram with students and discuss the steps as you go through them. Note that there are no numbers or arrows on the diagram, meaning that steps can be revisited or reordered depending on the particular challenge these steps are being applied to.

Engage

1. Provide each student group with a cupcake (on a tray or piece of parchment paper) that has a hard frosting layer on top and filling on the inside. Tell them:
    a. the cupcake represents a mine site;
    b. the frosting represents the ground/topsoil;
    c. the cupcake represents inside the Earth (rock); and
    d. the filling represents a mineral deposit that is buried within the rock.
2. Tell students that they will be creating and carrying out a plan to extract the mineral from the mine site.
    a. Have students share what they already know about mining. Record their ideas.
    b. Have students ask questions about what they would like to know about mining. Record their questions.
    c. Both of these lists can help students think about how the mining process works and how it might apply to their mine site.
3. Give students a few minutes to start developing a plan for extracting the mineral from the mine site.
    a. One person from each group should take notes so their plan can be continuously developed and revised throughout this lesson.
    b. Students should also record questions they have about their plan (e.g., what tools are available, or what rules they will need to follow).

Explore

1. Give each group a range of tools that mimic those used in mining (including parts of vehicles or larger equipment found at mine sites).

2. Have students try out each tool on a foam block to see how they can be used.

3. Choose a video (or use clips from each of the following options) for students to learn about tools and vehicles used in mining:

   - **Toolkit for Herkimer Diamond Mining**: An amateur miner describes the hand tools he uses (or use this related **image of hand tools**).
   - **How Iron Ore Mining Works**: A tour of an active mine site that shows equipment and gives insight into the steps needed to extract minerals.
   - **Underground Mining Equipment and Their Operations**: A compilation of vehicles used in underground mining, without narration.

   a. Have students compare the shapes of the tools they used with the hand tools or parts of the large equipment and vehicles shown in the video(s).

   b. Discuss why so many different types of tools and equipment are needed for mining.

4. Have student groups refine their plan they started in **Engage** by selecting the tools they would like to use at their mine site. You may want them to include a brief description of why they chose each tool and how they plan to use them.

Explain

1. Have students make observations of Figure 1, which shows two mines in Nevada that have been combined into one operation called the Turquoise Ridge Complex.

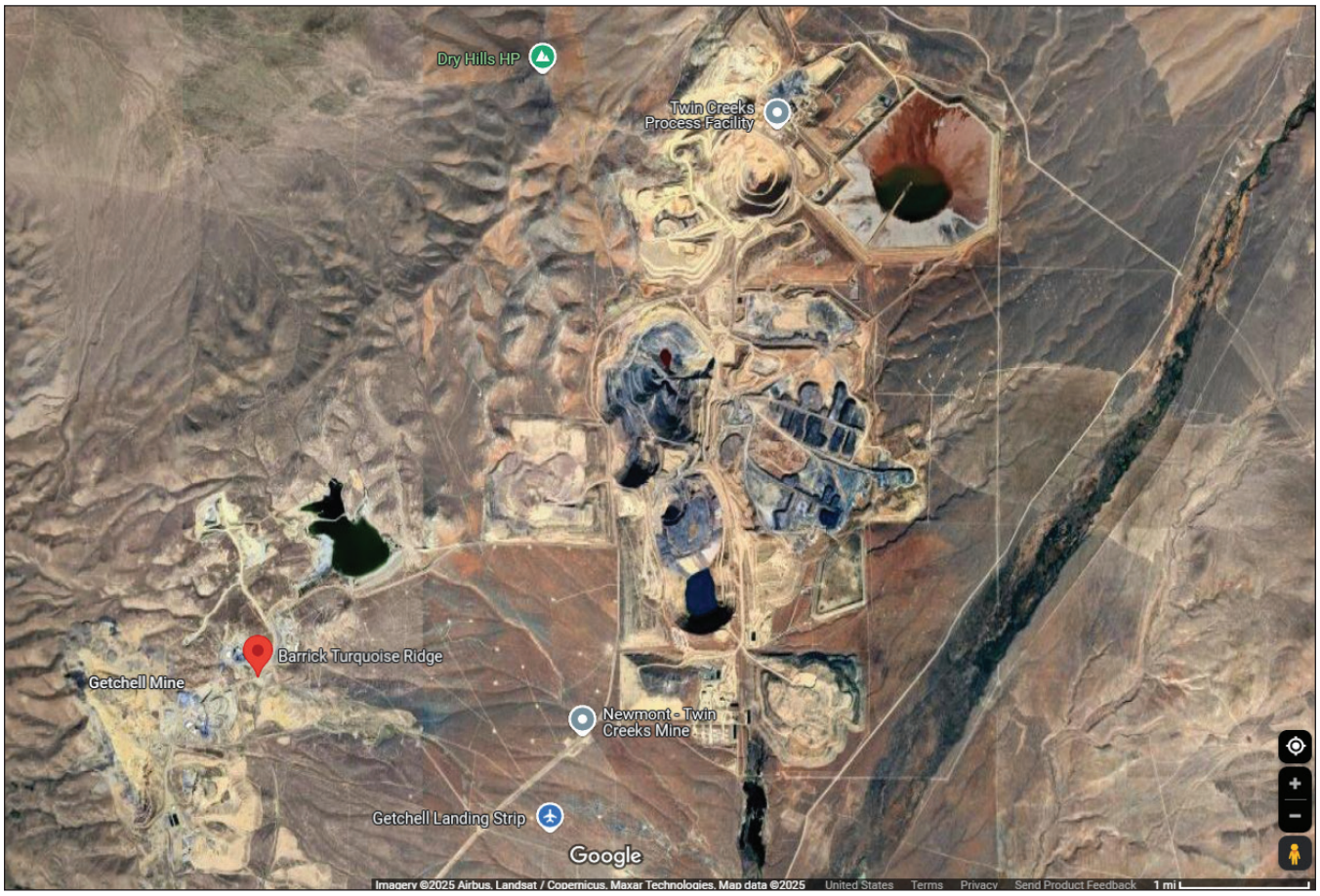

FIGURE 1. TURQUOISE RIDGE IN GOLCONDA, NEVADA.
Credit: Google Maps, May 2025.

a. If possible, use a mapping program, like Google Maps, to search for Barrick Turquoise Ridge or Twin Creeks Mine to be able to zoom in on the area and examine it in more detail.

b. As a class, discuss:

- differences between the mines, especially size (use the scale on the map to measure each mine or its features) and the presence of open pits at the Twin Creeks Mine; and
- similarities between the two mines, like water features, roads, buildings, and areas that have been altered by human activity.

c. Have students discuss with their group why they think these two mines are so different, even though they are next to each other. You may want to ask them questions for consideration, such as:

- ▸ *Do you think these mines are extracting the same minerals?*
- ▸ *Do you think these mines use the same equipment?*

- *Do you think these mines are the same age?*
- *Which mine do you think is deeper?*

2. Introduce students to two types of mines with a **short video** or images (**open pit collection**, **Nevada image collection** showing both mine types, **underground mine shaft** description and images).

3. Revisit Figure 1 and have students look for evidence of each mine type.

   a. Ask students to share their reasoning for classifying each mine as open-pit or underground, providing specific evidence from Figure 1 or on the online mapping program. Guide them toward recognizing that Barrick Turquoise Ridge is an underground mine.

   b. If you access the map online, zoom in near the middle of the Barrick Turquoise Ridge Mine or show students Figure 2 as evidence of this being an underground mine. Highlight the nearly 100 ft long shadow of the mine shaft as evidence of its depth. You will not find this same feature at Twin Creeks Mine.

FIGURE 2. AN OVERHEAD VIEW OF THE BARRICK TURQUOISE RIDGE MINE SHAFT.
Credit: Google Maps, May 2025.

4. Tell students that these two mines primarily extract gold, but also mine for silver, copper, and other metals. The largest pit at Twin Creeks Mine has been built to extract gold veins at 600–1200 feet (183–366 meters) underground, while the Barrick Turquoise Ridge Mine shaft is the deepest in Nevada at 3,200 feet (975 meters).

5. Optionally, show students **part of a video** (recommended 0:50–3:20) that explains why a mining operation might transition from open pit to underground mining.

6. Have students use what they have learned to revise their plans, considering how it might be easiest to access the mineral at their mine site.

Elaborate

1. Use pages from the **I am a Mining Engineer** booklet to learn about how mines are planned.

   a. Display or print select pages. It is not recommended you give students access to the online version of the booklet, as answers are included on page 24.

   b. It is recommended students read (using the page numbers at the bottom of each page):

   - **Page 4—Feasibility Study:** You may want to start by defining *feasibility*, or have students read through the pages to determine its meaning from context.
   - **Page 5—Feasibility Study Web:** This is particularly important for students to determine what limitations mine companies have to work with.
   - **Page 7—Engineering and Construction:** To discuss detailed plans and to make an analogy to the students' model mine site.
   - **Page 9—Simple Machines:** A review of simple machines and how they relate to the function of mining equipment.
   - **Page 11—Engineering Team:** To discuss how roles are split between specialists and experts to work efficiently.

2. Revisit Figure 1 to discuss potential environmental impacts of mines. Have students reference specific parts of the mine as evidence for their ideas. If you can view the mine online, scroll through the area around the mine to see how it differs from where mining is taking place.

3. Have students use what they have learned to discuss and establish clear rules that each group should follow while mining, such as:

   - Limit the number of tools that can be used, as tools have a cost (including wages for specialists who use each tool).

- Set a time-limit, as mineral resources are required to make products in a timely fashion.
- Groups cannot pick up or change the position of the mining site.
- Plans should be submitted for approval, as all mines require permits.
- Limit environmental impacts or have a plan to remediate the area after mining is done.
- Other rules that relate to other parts of the mining process that you want to include.

4. Discuss how adding rules more accurately depicts the limitations faced by mining companies.
5. Provide each group with four small containers for what they remove from the cupcake: topsoil (frosting), mineral (filling), ore (filling that cannot be separated from cupcake), rock (cupcake).
6. Students will use what they have learned to revise the plans they wrote in **Engage**.
7. Each group should submit their plan for approval (to "obtain all necessary permits"). Have groups exchange plans to check that all of the established rules and regulations are being followed.

Evaluate

1. Groups will carry out their plan to extract the mineral from the mine site. The goal is for students to remove as much of the mineral (filling) as possible with as little damage to the ground (frosting) and rock (cupcake) as possible.
2. Allow groups to make observations of each other's mining sites and containers of what was removed.
3. Facilitate a discussion about how each group performed.
   a. Discuss which group(s) the class thinks was/were the most successful, and why.
   b. Discuss the plans for the most successful groups and what likely contributed to their success. Lead students to consider the tools they chose, the methods they used, what type of mine their site mimics [surface, underground, or a combination], how detailed their plan was, how well their team worked together.