Math in Idaho - Mining: Nearest Neighbor Estimation

background Information

This lesson is designed to engage students in high school level mathematics as applied in the mining industry. The lesson is most appropriate at the Integrated I or Integrated II level as a reintroduction of the distance formula through practical application and its connection to the Pythagorean Theorem.

Lesson Duration

Teachers should use their discretion to keep pace with the needs of students. This introductory lesson is designed for 50 minutes, but this lesson could easily be extended for a longer exploration.

Instructional Sequence Summary

This lesson is built to engage students in guided-inquiry using the 5E lesson model. In this model, there are 5 phases that students will experience; (1) **Engage**: The teacher provides context to engage the students in curiosity and surface existing knowledge through class discussion, (2) **Explore**: The students collaborate to investigate targeted questions from the context; (3) **Explain**: The teacher leads a whole class discussion making explicit connections between student's thinking from the explore phase and formalizing the mathematics; (4) **Elaborate**: The teacher provides context or discussion to generalize the important concepts and their connections beyond the original lesson context; (5) **Evaluate**: Teacher provides students with a brief assessment to gauge understanding and inform future instruction.

Standards alignment:

G.GPE.B.4 Use coordinates to prove simple geometric theorems algebraically, including the distance formula and its relationship to the Pythagorean Theorem.

Student Learning Targets

- I can find an accurate distance between two points on the coordinate plane.
- I can estimate the mineral concentration of soil using the Nearest Neighbor Method

Assessment:

Exit ticket, see the Evaluate Phase

Key Vocabulary:

Mining: Mineral Concentration, Nearest Neighbor Method
Math: Coordinate, distance, percent

Important Questions:

How can we predict the mineral concentration to decide where to mine?

Lesson Plan/Learning Experience

Engage (5-10 minutes)

Students are shown the video about Mining in Idaho. The instructor then leads a discussion about the decision of where to dig for resources, pressing students to connect why proper planning is important to make sure that there are enough materials to justify the dig (if students don't bring up the ideas, the instructor can point to the cost of digging and commitment to choosing a site to dig and mine). Finally, an open discussion for students to predict how this estimation of resources might occur.

Explore (25-30 minutes)

Students are given the following prompt:

"A mining company maps out its mine using a Cartesian coordinate plane with each axis scaled by one meter. The following table shows the four locations that have been sampled and the Cooper concentration that was found at that location:

Sample Site	Location on Grid (x,y)	Cooper Concentration (%)
A	(2,3)	5%
B	(5,1)	6.5%
C	(6,4)	7%
D	(3,6)	4%

They have targeted a location at (4,2) for the next dig. Based on the four samples that you have, predict the Cooper concentration at this location."

Scaffolding questions to push student thinking while monitoring:
"Should all of the sample sites be considered?"
"How far is it from the new point to the existing samples?" - "Do you think that distance matters?"

Explain (Together With Explore Section)

Using the reasoning the students have provided the teacher will formalize the “Nearest Neighbor Method” of estimation. This is simply finding the distance to all of the samples and using the concentration of the sample closest to the desired point as the predicted concentration.

This explanation process should also work to connect and summarize the mathematics that they engaged in. Some students might have remembered the distance formula, some might have used the Pythagorean Theorem. The teacher should engage in this discussion and explicitly connect the distance formula to the Pythagorean Theorem. The conceptual goal being to connect back to their first experience with the distance formula from 8th grade and set the stage for them to further utilize the distance formula in geometry while maintaining its practical application.

Elaborate (10-15 minutes)

The idea behind the elaboration is to expand the connection beyond this specific topic to the broader math landscape. This can also include expanding beyond this specific context to larger contexts. The goal is to deepen student understanding through further connection and engagement. The following questions are offered for consideration, but do not all need to be covered.

- Is the distance formula actually necessary? Why is it helpful?
- Placing our mining site on a Cartesian Coordinate plane unlocked our ability to apply the math we know in this situation. What other instances do we use a similar 2D plane (or are their other instances where we could)?
- What are the limitations of the “Nearest Neighbor Method” of mining estimation?
- What if a site is exactly halfway between two samples, how might you logically handle this?

Evaluate (5 minutes)

Students are given an exit ticket:

A geologist is trying to estimate the gold concentration at different locations of a proposed mining site using the **Nearest Neighbor Method**. Three core samples have been taken from different locations in the region. The coordinates (in meters) and gold concentrations (in grams per ton) at the three sampling locations are:

- Sample A: (10, 30), 2.5 g/ton
- Sample B: (40, 20), 3.8 g/ton
- Sample C: (25, 50), 1.9 g/ton

The company wants to estimate the gold concentration at (30, 45) using the **Nearest Neighbor Method**.

Additional Resources