IMPACT Problem-Based Task

Title of Task: Building a Light Rail **Cluster:**

Course: Math 1 **Unit: Geometry**

Task Overview: This task explores the real world topic of building light rails. Throughout the implementation of this task the students will learn about the cost of building railways and how to implement them within a budget. This task explores such mathematical concepts of using coordinates to find the distance between points, using coordinates to build polygons and find the area and length of sides, and writing equations of parallel lines.

Standards	Objectives
NC.M1.G-GPE.4 ***Use coordinates to prove simple geometric theorems algebraically.*** Use coordinates to solve geometric problems involving polygons algebraically • Use coordinates to compute perimeters of polygons and areas of triangles and rectangles. • Use coordinates to verify algebraically that a given set of points produces a particular type of triangle or quadrilateral.	Students should be able to use the distance formula to find the distance between points. Students should be able to find the area of a triangle by finding the using the distance formula to find the sides.
NC.M1.F-LE.5 ***Interpret expressions for functions in terms of the situation they model.*** Interpret the parameters a and b in a linear function $f(x)=ax+b$ or an exponential function $g(x)=ab^x$ in terms of a context.	Students should be able to write an equation of a line in slope intercept form and interpret what equation means.
NC.M1.G-GPE.5 ***Use coordinates to prove simple geometric theorems algebraically.*** Use coordinates to prove the slope criteria for parallel and perpendicular lines and use them to solve problems. • Determine if two lines are parallel, perpendicular, or neither. • Find the equation of a line parallel or perpendicular to a given line that passes through a given point.	Students should be able to write an equation of a line parallel to another line.

Additional/Prerequisite Skills:

- Finding the distance between points in the coordinate plane (8.G.8)
- Calculating rate of change from two points (8.F.4)
- Identify and interpret parts of expression (NC.M1.A-SSE.1a, NC.M1.A-SSE.1b)
- Construct a function to model a linear relationship and interpret rate of change and initial value (8.F.4)

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Emphasized Standards for Mathematical Practices:

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
4. Model with mathematics.

Making Connections (Hook, Multi-media link, Visual Aid, etc.):

Light rail video explaining the benefits how they run:
https://www.youtube.com/watch?v=knqt3dXZJT4

Map of Raleigh-Durham Area:
http://www.bearoness.com/Raleigh_Store/a_Overview_Map_of_BBM.jpg

Example Map of Light Rail:
http://as.sjsu.edu/asts/images/LRTMAP.gif

Suggested Pacing Calendar (within the unit):		
Day One: Intro video and Task 1	Day Two: Task 2	Day Three: Task 3a & 3b

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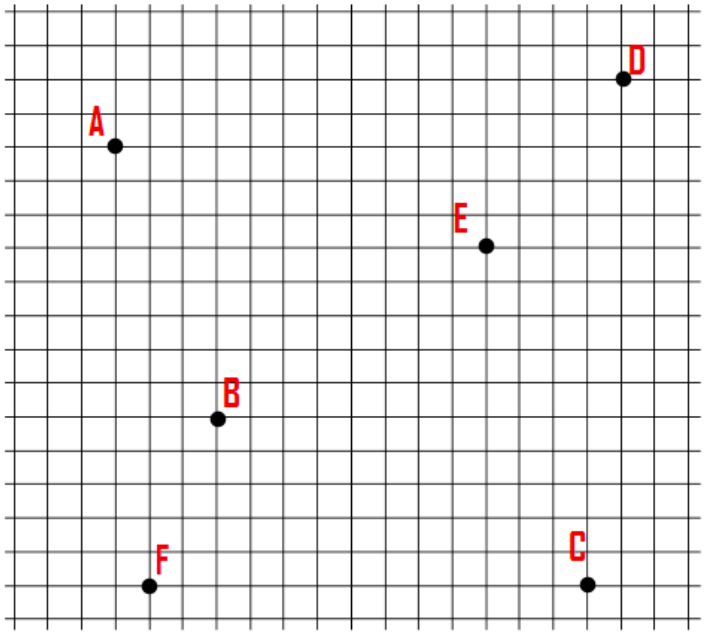
Task 1:

Raleigh is considering adding a light rail system to connect together different parts of the city. In the map to the right, each point represents a different part of the city that could become part of the light rail system **YOU** are in charge of recommending which points the city should connect. Here are the guidelines from the city:

- The city only has enough money to create **4** light rail lines, so you can only make 4 recommendations
- The city wants to connect together the points that are **furthest apart** so travel will be easier between those parts of the city.

Based on these guidelines, which points should the city connect when they build their light rail? Round your answer to the nearest hundredth place if necessary.



Show **neatly** below how you found which segments were the longest.

My Answer:

The city should connect ___ and ___ because the distance between them is _____ units.
The city should connect ___ and ___ because the distance between them is _____ units.
The city should connect ___ and ___ because the distance between them is _____ units.
The city should connect ___ and ___ because the distance between them is _____ units.

To make this happen, it costs the city around $45 million per mile for each light rail. How much will it cost the city to build the light rail with the given parameters.

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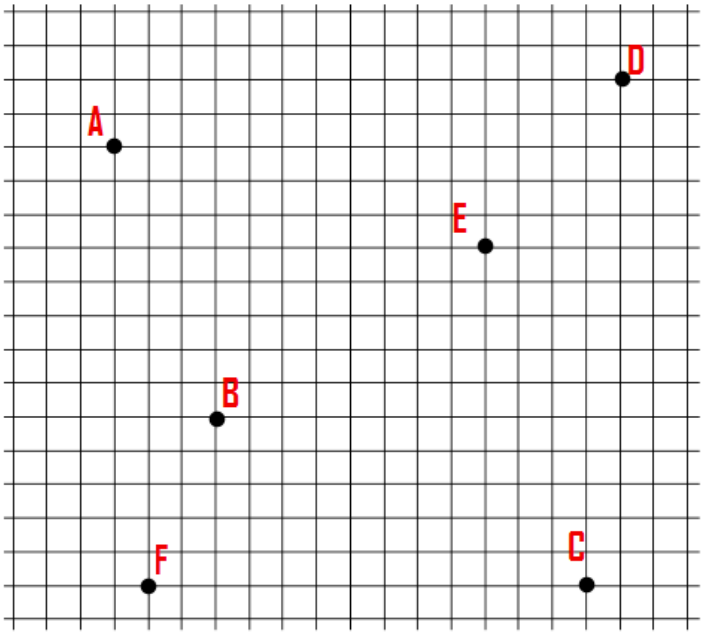
Task 2

One of the community groups within the city is against the building of this light rail because it will occupy too much of the area of the city. Projects like these cannot exceed 200 square miles. Your job is to show them that the area in which the stops occupy do not exceed 200 square miles. Each square mile costs the city 1.5 million dollars, how much money did the light rail engineer save the city by not maximizing the 200 miles?



KEY: 1 unit = 1 mile

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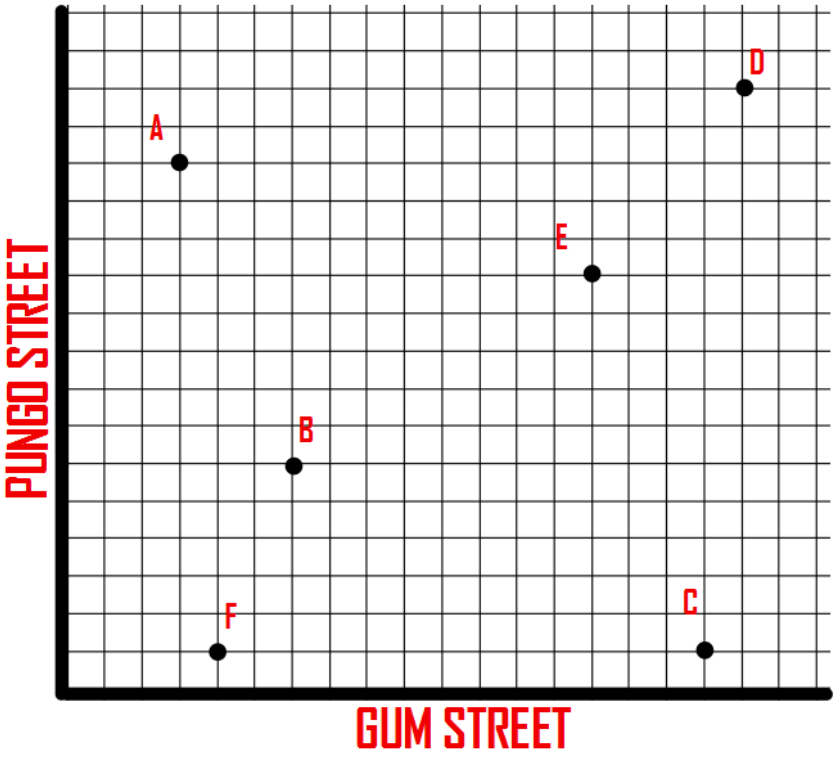
Task 3a

Sam looks online and find the plans for the light rail. He lives at the intersection of Gum and Pungo Street. He would have to take a bus to point F along the diagonal and then travels to point B to get to Point E where he works. He wishes that they would add a light rail stop along Pungo Street so he could just travel straight from the new stop **"G"** to B to E. He believes this would be a lot shorter than traveling from home to stop F. If this did happen how far away will the stop be from his home now? Which stop would be a shorter distance from home F or G? How much shorter?



KEY: 1 unit = 1 mile

Task 3b

Sam's best friend, Keisha, lives along Pungo Street and she would prefer that there would be a stop near her house. She works at stop D and would prefer the light rail she catches to run alongside the light rail line connecting BE. Where is Keisha's light rail stop on Pungo Street as an ordered pair? How far away is it from Sam's stop? What equation represents the light rail stop of Keisha's light rail?

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Solutions:

Task 1

My Answer:

The city should connect **F** and **D** because the distance between them is **20.52** units.
The city should connect **A** and **C** because the distance between them is **19.10** units.
The city should connect **B** and **D** because the distance between them is **16.4** units.
The city should connect **D** and **A** because the distance between them is **15.13** units.

45,000,000 x 71.15 = $3,201,750,000 OR 3.20175×10^9

Task 2

(Area of the Square 15 x 15 = 225 miles) – (Sum of the area of the smaller triangles (6.5+15+7.5 = 29)) = 196 square miles

196 x 1,500,000 = $294,000,000
(200)(1,500,000) = 300,000,000
300,000,000 – 294,000,000 = 6,000,000.

Task 3a

Line BE has a slope of 5/8 and you can use the Point B (6, 6) and find the y-intercept of the line.
6 = 5/8(6) + b ➔ 6 = 3.75 + b ➔ b = 2.25. So Sam's new spot is 2.25 miles away from his house.

Find the distance from Sam's home to Stop F by using the distance formula and you get ~ 4.12 miles. Subtract the two numbers 4.12 – 2.25 = 1.87. So Sam's new stop of "G" would be 1.87 miles shorter.

Task 3b

BE has a slope of 5/8 and you can use the point D (14,15) and write an equation in slope intercept form and solve for b.
15 = 5/8(14) + b ➔ 15 = 8.75 + b ➔ b = 6.25. So Keisha's house is at (0, 6.25). Therefore Keisha's hous is 4 miles away from Sam's stop at 2.25. The equation representing the track of light rail HD is y = 5/8x + 6.25.

Scaffolding:

Task 1:

1. What are some ways we can find the distance between two points?
2. What is the shortest distance between two points?
3. It's a grid couldn't you make this into a coordinate plane?

Task 2:

1. How can I make the quadrilateral into an easier quadrilateral to work with?
2. What shapes are formed when you inscribe the image with a square?
3. How could we ONLY find the area of what the railways are occupying?
4. How much money would it cost if they used all 200 square miles?

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Task 3a:

1. What does connecting the points B&E form?
2. Every line has an equation, can you find the equation of the line?
3. What does the "b" represent in your equation?
4. How could you find the distance between two points?

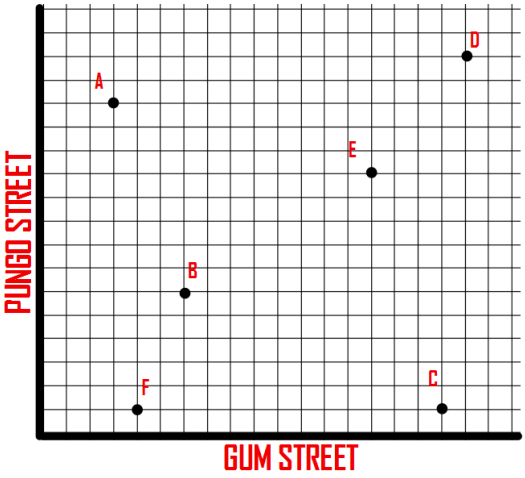
Task 3b:

1. If Keisha's light rail runs alongside the connecting railway BE, what does that mean mathematically?
2. What do you need from the line connecting BE that will help you find the equation of the line forming Keisha's stop HD?
3. What do you know about parallel lines

Instructional Strategies:

Before introducing the task, it may be beneficial to first review concepts (such as area of polygons inscribed in other polygons, distance formula, The Pythagorean Theorem, area of triangles, parallel lines, and slope intercept form).

I strongly encourage having students use a straight edge ruler for the task and to plot points on their land. Using freehand sometimes gets messy and confusing.



For high-level students:

- Assign to partners during two class periods.
- Withhold scaffolding questions unless needed.

For lower-level students:

- Split the task apart over several days.
- Would strongly recommend more than one day on this assignment or choose one task when talking about a particular subject i.e. parallel lines would work for Task 3b. The distance formula would work for both tasks 1-3a. Area works well for Task 2.
- A lot of students may find the distance formula hard but have the tendency of remembering The Pythagorean Theorem. IF you show them the distance formula can be derived from the Pythagorean Theorem, students will understand better how to use it.