The Right Stuff: Appropriate Mathematics for All Students

Promoting the use of materials that engage students in meaningful activities that promote the effective use of technology to support mathematics, further equip students with stronger problem solving and critical thinking skills, and enhance numeracy.

Overview
Students will apply the concepts of

- Numeracy – Students will examine data numerically and graphically and be able to describe their observations in mathematical terms.
- Modeling – Students will model data with a linear function by adjusting the slope and y-intercept until the line "looks" like a good fit.
- Rate of Change – Students will define the coefficient of x with correct units and define it in terms of the context.
- Predict – Students will use a model to predict y given an x.
- Algebra – Students will solve for one variable in terms of another.
- Quantitative Literacy – Students will make decisions using graphs and simple formula.

Supplies and Materials

- 2.1 Student Worksheet
- Either 2.3 Excel file, 2.4 TI-Nspire™ file, or a handheld that will create a scatter plot and find a model for the data

Prerequisite Knowledge
Students must be able to input data into Excel or into a handheld, create a scatter plot, use a slider, and find an appropriate algebraic model for the data.

Instructional Suggestions

1. Discuss why a generator is sometimes needed (emergencies) and why some construction crews might use a generator daily.
2. There are at least two factors that determine the rate of fuel consumption: the size of the generator and the amount of power required of the generator. Discuss the values of the information provided regarding different equipment and how much power each one might require.
3. For what reason has the construction crew gathered this data? Discuss why they would not want to refuel while the generator is hot or why one might want to leave fuel in the tank for long periods of time (gel).
4. The data appears very linear, and should be, as long as the power required during each day was about the same. Use the sliders on the spreadsheet (2.3 Excel) to find a linear model for the data. The student must adjust the slope and vertical intercept in order to find a line of good fit. Require the students to do this independently and discuss why results may be different. Ask "How would you determine the line of best fit?" and discuss the answers. Use the model to answer the questions.
5. Using names for variables other than x and y is important. Too often, students have learned to compute f(x), solve for x given y, find x- and y-intercepts, etc; but have associated no meaning to the outcome. By using real applications, the variables are meaningful as are the intercepts and slope. When discussing slope, be sure to insist on using the correct units.

Assessment Ideas
Provide students with this model for another generator:

Fuel Used (number of hours) = 0.75 (number of hours)

or $F(h) = 0.75h$

Ask the students to solve for h in terms of F and describe the meaning of this new function.

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Introduction

The goal of this activity is to find a way to predict the amount of time a generator will run on a given amount of fuel. The prediction will be based on data obtained experimentally.

WINCO
Portable - Diesel

1 Phase - 60 Hz
6 kW to 6.5 kW

The Winco Model W6010DEX is a Industrial Series generator with 6 kW (6 kVA) 60 Hz, of maximum output and 5.5 kW prime (continuous) power.
Source: www.generatorjoe.net

Directions

1. Consider the following scenario:

   Electric generators are used in a variety of applications. Often they provide power for signs or equipment when normal electrical service is not available. Construction companies will use an electric generator continuously to power their equipment. Generators are also found in homes and used in case of power failure. These units usually run on gasoline or diesel and have a relatively small tank in which the fuel is stored.

   A certain construction company has just purchased a new unit that holds 6.5 gallons of fuel and they want to collect some data to discover how long the fuel will last so they will know when to add fuel without continually checking the unit. They will also want to use this data to know how much fuel to purchase during a lunch break – to refuel the generator after lunch. (Refueling when the generator is cool is safest.)

   They experiment by putting exact quantities of fuel in an empty tank and measuring the length of time the generator runs before shutting off because the fuel is depleted. On the first day, they put in five and one-half gallons and the generator ran 4 hours and 30 minutes, then three gallons and the generator ran for 2 hour and 30 minutes. On the next day, they put in six and one-half gallons, lasting 5 hours and 30 minutes; then two gallons, lasting 1 hour and 40 minutes. On the third day, the generator ran 4 hours and 45 minutes on 5 and one-half gallons of fuel and then 2 hours and 30 minutes on three gallons of fuel.

The following data shows the typical wattage of equipment that might be used on a construction site for which power is supplied by a generator.

Air Compressor, 1 HP	1500 W
3/8-inch 4A Drill	440 W
14-inch Band Saw	1100 W
7 1/4- inch Circular Saw	1400 W
9-inch Table Saw	1500 W
1500-watt Flood light	1500 W

These figures estimate the amount of "running wattage" typical for this equipment. However, the "startup wattage" can be significantly more than the running wattage. Electrical equipment usually requires a surge in power to start the motor, only for a fraction of a second, and then the power required decreases and remains fairly constant.

Startup wattage required

Air Compressor, 1 HP	4500 W
3/8-inch 4A Drill	600 W
14-inch Band Saw	1400 W
7 1/4- inch Circular Saw	2300 W
9-inch Table Saw	3000 W
1500-watt Flood light	0 W

Weather events, like hurricanes and ice storms, can cause the homeowner to wish for a generator. They come in many different sizes, up to ones that produce over 1750 kW of power.
In this activity, the student will find a model that shows how much time the generator will run on a given amount of fuel. The variables are clear, but how one poses the question might cause the model to be written as Time(fuel) or Fuel(time). Discuss this with students. Also discuss how the output of a generator is measured and to what equipment the generator might supply power. In the event that you had no power at your home, for what would you want electricity?

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2. What are the variables that need to be considered in this scenario? Which is the independent variable? Which is the dependent variable?

Let 'fuel used' be the independent variable and 'running time' be the dependent variable. (In the context of this problem, this assignment is appropriate.) However, if the student switches the variables, let them proceed and discover the model for that relationship.

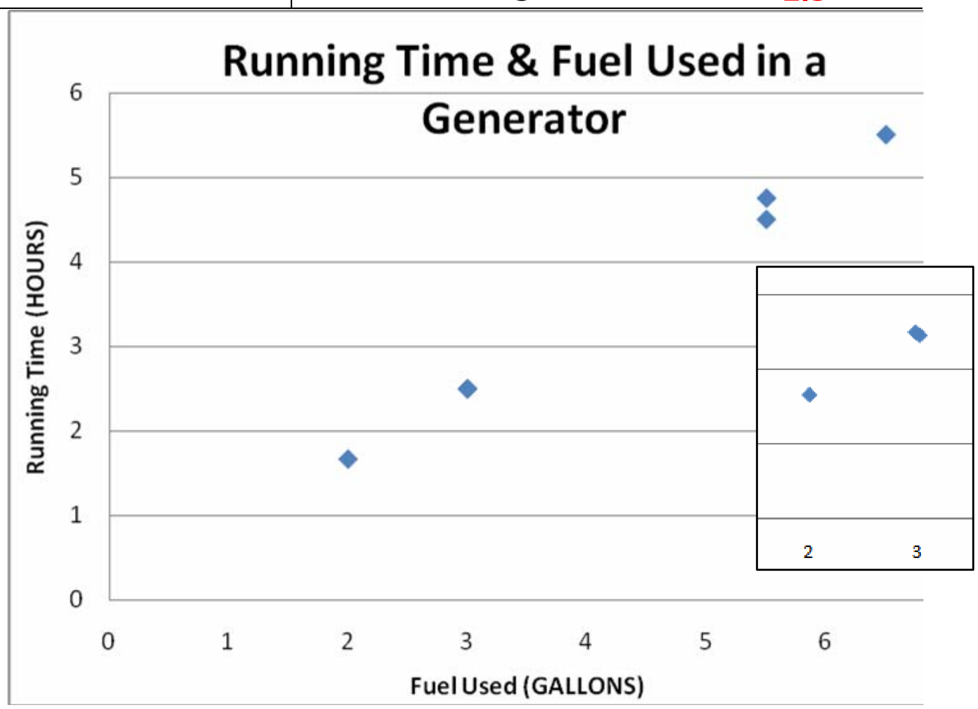
3. Complete the table using the information provided in the scenario.

Amount of Fuel Used (gal.)	Running Time (hours)
5.5	4.5
3	2.5
6.5	5.5
2	1.67
5.5	4.75
3	2.5

4. Construct a scatter plot of the data.

Ask your students why they see only five dots on the scatter plot and there are six data points.

Will the fact that one of the points is "hidden under another" have any effect on the statistics from excel? Does it have an effect on the reader?



<The sixth data point shows that the trend is even stronger than if we see only five points. You can insert "noise" into the graph (adding or subtracting small random numbers to the values, to see all points.) The insert shows the two data points with noise.>

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5. Describe the trend you see in the data.

   Discuss the problem – the goal is to determine the amount of fuel a generator will need in order to run a predetermined amount of time.

   Do you think the data is sufficient? Reliable?

   In order to collect the data you need for a good model, would you have done anything different?

The trend appears very linear.

Ask your students why this might be the case. What might cause the generator to burn more fuel? Students may not associate a higher load on the generator as requiring more fuel. But these two variables are also related and important to consider in a real problem.

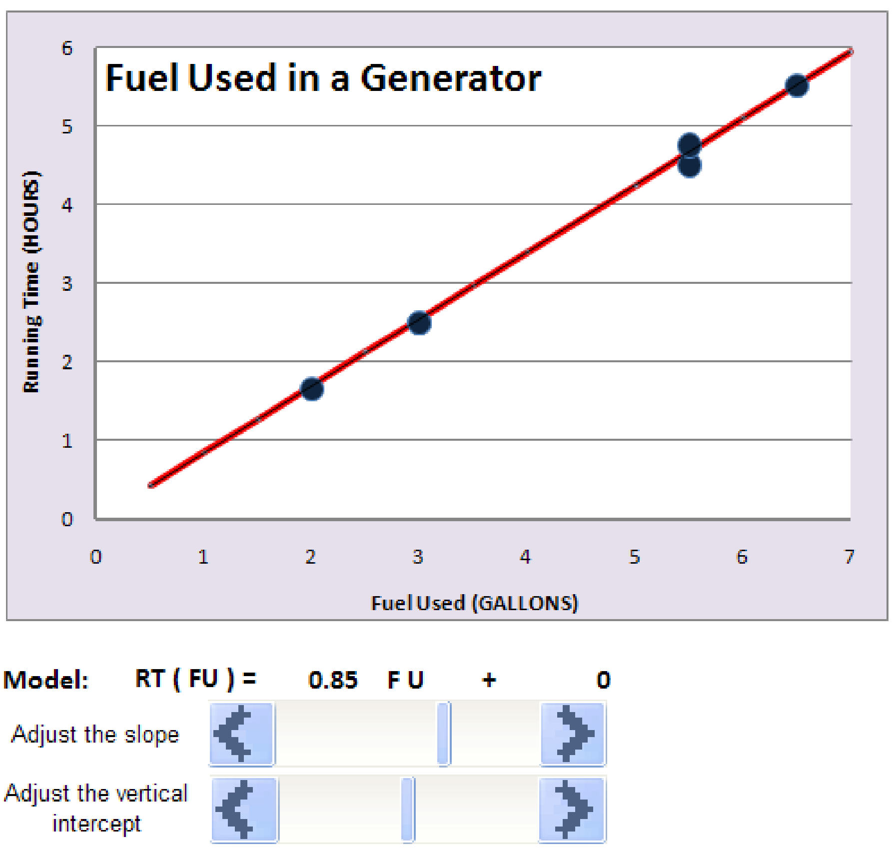
For example, the generator shown in the scenario uses 1.1 gal/hr at 50% load, 1.7 gal/hr at a 75% load and 2.2 gal/hr at 100% load. <Note, the size of the fuel tank in the scenario is greater than what comes normally on this generator.>

The data should be sufficient to produce a close approximation to the amount of time the generator will run on a given amount of fuel.

6. Use the spreadsheet provided (2.3 Excel) to find an appropriate linear model for the data.

Allow students to adjust the slope and the intercept to find a line that models the data fairly well.

The students will want to know when you know you have a line of best fit. You probably want to avoid the statistics behind regression analysis. Ask them to give you indications when a line is a good fit: it passes through a lot of the points, it passes near all of them, about half or above and half below the line…



Module 2
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7. Write the linear model you found in (6) using functional notation with the variables "fuel used" and "running time."	**Model: RunningTime (Fuel Used) = 0.85 x Fuel Used + 0** Ask students to supply additional points using this relationship. (see #8, #9) Why is and why should the vertical intercept be zero? What is the slope? The slope is 0.85 hours per gallon.
8. Predict the time that the generator will run on four gallons of fuel.	Running Time (4 gallons) = 0.85(4) = 3.4 hours 3 hours and 24 minutes
9. How much fuel will be needed to run the generator ten hours?	10 hours = 0.85 (fuel used) fuel used = 11.76 gallons or about 11 ¾ gallons
10. Solve the equation so that the construction crew can input the time they are going to want the generator to run making the output the number of gallons of fuel necessary. What is the slope of this new model?	Running Time = 0.85 x Fuel Used Fuel Used (Running Time) = 1.176 x Running Time The slope is 1.176 gallons per hour.
11. The generator that the crew purchased provides a maximum output of 6 kW. However, it is recommended that the generator not be required to sustain maximum output for no longer than 30 minutes. The manual says it will run well at 90% of the maximum output – called *prime continuous power*. Find the prime continuous power for this generator. If the crew actually needed a generator with 8kW of prime continuous power, what maximum output would they need to look for?	The prime continuous power is 90% of the maximum power: 0.90 x 6 kW = 5.4 kW 8kW = .90 x Max 8.9 kW = Max Thus, the crew might want to look for a generator with at least a 9kW maximum rating.

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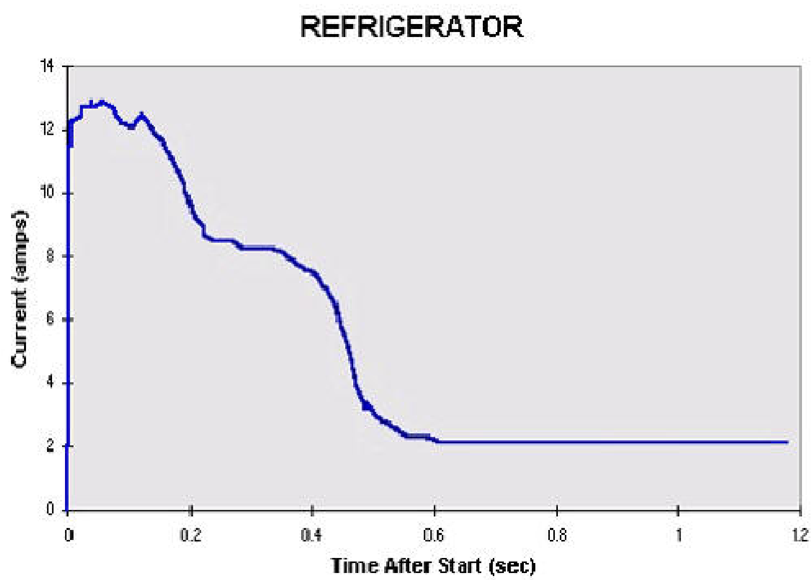
12. The crew typically uses their 1 HP air compressor all day. The 3/8-inch drill, 14-inch band saw, 7 ¼-inch circular saw and the 9-inch table saw are used periodically. Sometimes, when working in dark areas, the crew uses several 1500-watt flood lights. What advice would you give the crew concerning what equipment to use and when?	First, the air compressor should be started before anything else is running. The startup amps required are almost a maximum load for the generator. When the flood lights are on, the crew must be careful to only use two of the saws. The generator could possible support all the equipment at one time, if the load on any of the saws was not great. But, this should be kept to a minimum and certainly less than 30 minutes at one time.
13. The starting wattage required by equipment is usually much greater than the power required to run it continuously. The graph shows the current needed to start a refrigerator motor. The refrigerator and most household appliances run on 120V current. The relationship between Amps, Watts, and Volts is Watts = Volts x Amps According to the graph, the refrigerator will require about 13A of starting current for a fraction of a second. That equates to 1560 W. 1560 Watts = 120 V x 13 A	 http://www.generatorjoe.net/html/calculations.html Ask your students about the units on this graph.

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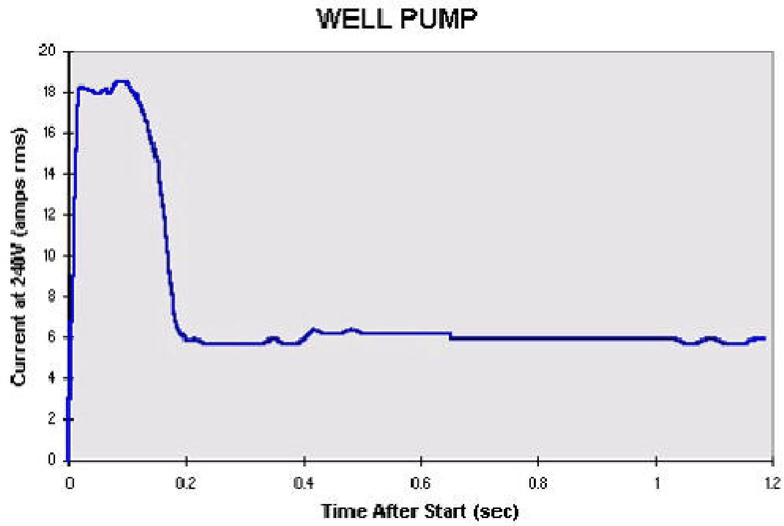
14. A graph showing the starting current required for a well pump is shown here. The motor is rated ¾ hp and 240V.

Find the startup wattage required by the motor as well as the running wattage.



http://www.generatorjoe.net/html/calculations.html

The startup wattage required by this pump is
Watts = Volts x Amps

Startup Wattage:
= 240 V x 19 A
= 4560W = 4.6kW

Running wattage:
= 240 V x 6A
= 1440W = 1.4kW

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