WAMC Lab Template
Math Concept(s): Linear Equations
Source / Text: Adapted from "Project – Based Algebra" by Dale J. Adamson
Developed by: Colleen Kost E-Mail: ckost@sheltonschools.org Date: 6/22/2022

Attach the following documents:

- Lab Instructions
- Student Handout(s)
- Rubric and/or Assessment Tool

Short Description (Be sure to include where in your instruction this lab takes place):
Students will use weights, rubber bands and meter sticks to find the best number of rubber bands to drop their weight. This lab is done after writing linear equations and before scatterplots to introduce the concept of scatterplots and lines of fit and review slope and writing equations in slope-intercept form.

Lab Plan
Lab Title: Linear Bungee Jumping

Prerequisite skills:

- Write equations of lines in slope-intercept form and point slope form
- Write linear functions using graphs or tables

Lab objective:

The goal of this project is to use bungee jumping to introduce scatterplots and to reinforce concepts of linear functions. This lab includes collecting data, creating lines of fit, and estimating an equation for the line of best fit.

Standards: *(Note SPECIFIC relationship to Science, Technology, and/or Engineering)*
Mathematics K–12 Learning Standards:

- CCSS.MATH.CONTENT.HSA.CED.A.2
  Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
- CCSS.MATH.CONTENT.HSF.IF.A.1
  Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then $f(x)$ denotes the output of f corresponding to the input x. The graph of f is the graph of the equation $y = f(x)$.
- CCSS.MATH.CONTENT.HSF.IF.B.4
  For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals*

where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.

- CCSS.MATH.CONTENT.HSF.IF.C.7 - Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

Standards for Mathematical Practice:

- CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.
- CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively.
- CCSS.MATH.PRACTICE.MP3 Construct viable arguments and critique the reasoning of others.
- CCSS.MATH.PRACTICE.MP4 Model with mathematics.
- CCSS.MATH.PRACTICE.MP5 Use appropriate tools strategically.
- CCSS.MATH.PRACTICE.MP6 Attend to precision.
- CCSS.MATH.PRACTICE.MP8 Look for and express regularity in repeated reasoning.

K-12 Learning Standards-ELA (Reading, Writing, Speaking & Listening):

- SL.9-10.1 - Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher led) with diverse partners building on others' ideas and expressing their own clearly and persuasively.
- RST.9-10.3 - Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9 -10.7 - Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- W.9 – 10.4 - Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

K-12 Science Standards

- HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy

Technology

- 6.6.A Students choose the appropriate platforms and tools for meeting the desired objectives of their creation or communication

Engineering

- HS – ETS1 – 1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Leadership/21st Century Skills:

21st Century Interdisciplinary themes (Check those that apply to the above activity.)

☐ Global Awareness ☐ Financial/Economic/Business/Entrepreneurial Literacy ☐ Civic Literacy
☐ Health/Safety Literacy ☐ Environmental Literacy

21st Century Skills (Check those that students will demonstrate in the above activity.)

LEARNING AND INNOVATION

Creativity and Innovation
☒ Think Creatively
☒ Work Creatively with Others
☒ Implement Innovations

Critical Thinking and Problem Solving
☒ Reason Effectively
☒ Use Systems Thinking
☒ Make Judgments and Decisions
☒ Solve Problems

Communication and Collaboration
☒ Communicate Clearly
☒ Collaborate with Others

INFORMATION, MEDIA & TECHNOLOGY SKILLS

Information Literacy
☒ Access and Evaluate Information
☐ Use and manage Information

Media Literacy
☐ Analyze Media
☐ Create Media Products

Information, Communications and Technology (ICT Literacy)
☐ Apply Technology Effectively

LIFE & CAREER SKILLS

Flexibility and Adaptability
☒ Adapt to Change
☐ Be Flexible

Initiative and Self-Direction
☒ Manage Goals and Time
☐ Work Independently
☐ Be Self-Directed Learners

Social and Cross-Cultural
☒ Interact Effectively with Others
☒ Work Effectively in Diverse Teams

Productivity and Accountability
☒ Manage Projects
☒ Produce Results

Leadership and Responsibility
☒ Guide and Lead Others
☒ Be Responsible to Others

Teacher Preparation: (What materials and set-up are required for this lab?)

Materials

- Size #32 rubber bands
- Measuring tapes
- Small brass weights (or other dense objects that can be dropped)
- Unsharpened #2 pencils
- Optional: Student devices (for slow-motion video)
- Optional: Classroom devices (for using technology to confirm a line of best fit)

Set-Up Required:

- Plan on having small groups of 2-3 students and prepare stations for each group. Each station needs about 15 rubber bands, a pencil, measuring tapes, and a brass weight (or other reasonably dense object).
- Adhere measuring tapes to the wall vertically. If the tapes are short, you may need to stick multiple tapes together. It is recommended that you have at least 2 meters of measuring tape on the wall for each group.
- As a culminating activity, students will test their bungee cords from a pre-determined height. After deciding where students will try their final bungee cords, you will need to measure the drop distance. Possible drop locations include the second or third floor of a building or from the roof if you have access. The best way to measure that distance is to drop a weighted line from the top and subsequently measure the length of the line.

Lab Organization Strategies:

Leadership (Connect to 21st Century Skills selected):

-

Cooperative Learning:

-

Expectations:

-

Timeline:

-

Post Lab Follow-Up/Conclusions:

Discuss real world application of learning from lab

- This was already introduced as a bungee jumping exercise, we will discuss how what they found relates to bungee jumping.
- How many rubber bands would you need for your weight to bungee jump and make it interesting?
- How tall would the platform need to be?

Career Applications

- Economists – scatterplots are used for economic predictions

Optional or Extension Activities

- Raise the stakes with an egg drop – Calculate the weight of the egg and determine how many rubber bands would be needed to drop the egg from a predetermined height.

Lab Procedure

- Divide students into groups of 2-3 students.
- Students will be creating their own bungees cords using rubber bands and testing the "drop distance" of different length bungees.
- Each group needs to decide on a standardized procedure for connecting rubber bands, and then continue to use that same procedure for the duration of the project. (The instructor may want to explore this ahead of time and offer a plan to students).
- Groups will first connect a single rubber band to the brass weight. We will call this band the "harness," and it will not count towards the bungee's rubber band count.
    - Using different size brass weights will ensure that different groups are not sharing data and answers along the way.
- Next students will add one rubber band at a time and measure how far the weight falls. To measure how far the weight drops, students will place the eraser side of an unsharpened number 2 pencil on the wall at the top of the measuring tapes. Then they will slide the rubber band onto the pencil. Next, one student will drop the weight, and a teammate will approximate the lowest point the weight falls to on the measuring tape.
- Once each group has a general idea of the distance the weight will fall, groups should do a second drop, attempting to take a more exact measurement. (Optional: Most smartphones have access to a slow-motion feature that works great for increasing the precision of measurements in this step. If you are comfortable doing so, I would recommend allowing students to use one phone per group in this step).
- Students will repeat the above procedure multiple times, adding more rubber bands each time. They should record all data in the table provided on the student handout.
- After collecting all their data, students should create a scatterplot of the data and approximate a line of best fit (Remind students that a line of best fit does not have to pass through the origin)
- Using their line of best fit, students can now estimate the number of rubber bands needed to drop their weight from the predetermined drop location.
    - Should students round up or down on the number of rubber bands needed?
- Have students build their final bungee and attach the weight/harness.
    - Make sure that groups use the same weight for all measurements and the final drop to account for any differences in the brass weights used)
- Finally, the students (or the teacher if using the roof of the building) will drop the weights and allow students to see how well they were able to model bungee cord drop distance using linear functions.

Follow Up Student Product

1) Students should have completed the worksheet, including all questions not specified in the directions attached.
2) Optional: Students can write a post-lab summary that outlines the purpose of the activity, the data collection process, and all results/conclusions. This gives students an opportunity to reflect on the purpose of the activity formally and to practice writing academically across the curriculum.

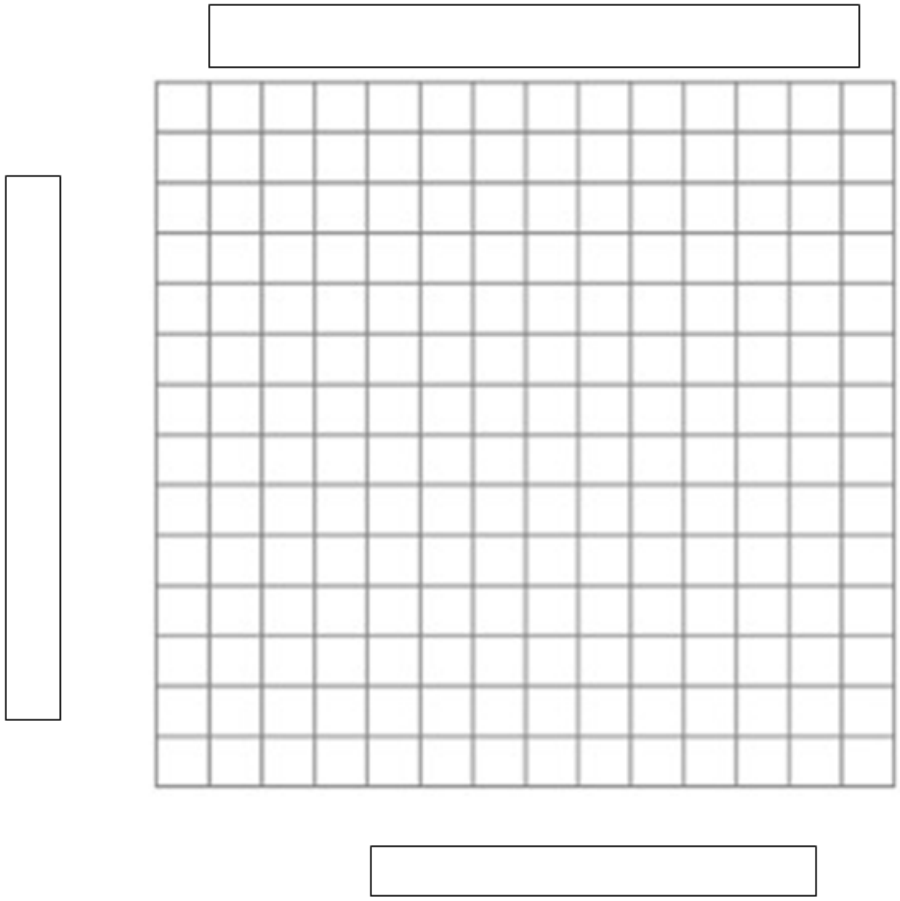
Name: _____ Partners: _____ Date: _____

Bungee Jumping with Algebra

What is the investigation about?

Number of rubber bands							
Distance fallen							

Use the above data to create a scatter plot on the grid below. Label the graph/axes and write your own scale (The x-axis and y-axis do not have to have the same scale). Finally, estimate the line of best fit.



Once your scatter plot is complete:
Use the metal rod to create a line of best fit. Find two of your points that are closest to the line of best fit. Use those two points to generate an equation in slope-intercept form. Show your work here.

Point: _____ **Point:** _____ **Rate of Change:** _____

What is the equation for the line of best fit? _____

What does the slope represent in this equation?

What does the y-intercept represent in this equation?

Make a prediction: Based on your line of best fit, how many rubber bands should be used to safely drop your weight from a height of _____?

Answer: _____ rubber bands

WAMC Lesson Plan

Name(s): Colleen Kost
Email Address: ckost@sheltonschools.org
Lesson Title: Writing Equations to Model Relationships
Date:6/22/2022
Text: Illustrative Math STEM Correlation: Science Research Lesson Length:1-2 days

Big Idea (Cluster): Writing Linear Equations

Mathematics K–12 Learning Standards:

- HSA-CED.A.2: Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
- HSA-CED.A.3: Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.

Mathematical Practice(s):

- MP 1 – Make sense of a problem and persevere in solving them.
- MP 2 – Reason abstractly and quantitatively.
- MP 4 – Model with mathematics.
- MP 6 - Attend to precision

Content Objectives:

- Given a description of a situation or an equation, identify quantities that vary and quantities that don't.
- Understand that letters can be used to represent both quantities that vary and those that are constant.
- Write equations with numbers and variables to describe relationships and constraints.

Language Objectives (ELL):

- Student can use the appropriate vocabulary for each part of the equation.
- Student can summarize the situation for better understanding.

Vocabulary:

- Equation
- Constant
- Variable
- Relation
- Axes
- Table
- Graph

Connections to Prior Learning:

- 6.RP.A.3.c: Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, give a part and the percent.

Questions to Develop Mathematical Thinking:

- What is this problem about?
- What problems have you done in the past that are similar?
- What do you know?
- Where do you begin?

Common Misconceptions:

- All numbers are significant
- Identifying independent vs dependent
- Some students will confuse the terms "vertex", "faces" and "edges"
- Students may misinterpret where the operation goes in their equation
- Students may not realize they can have more than one variable

Assessment (Formative and Summative):

- Formative – Exit Ticket – A word problem developed for students to identify important parts of the problem
- Summative – Unit Test

Materials:

- Worksheet
- Calculators

Instruction Plan: Writing Equations that Model Relationships

Introduction: Math Talk – Percent of 200

Explore:

A Platonic Relationship (geometry of 3d shapes)
Blueberry Earnings (Writing equations modeling the sales of blueberries)
Car Prices (writing equations involving interest)
Shirt Colors (Writing equations involving trend percentages)

When I observe students: Students are collaborating in groups of 2-4. Everyone should be contributing. Students will have questions about some vocabulary and how to write equations with more than 2 variables. Look for students that have checked out and guide them back into the problem.

Questions to Develop Mathematical Thinking as you observe:
How many edges would each of these solids have?
What do you think happens when you have 4 different unknowns?

Answers:
Depending on shape answers will vary
You need different variables for each different quantity

Summarize:
To help students synthesize their work in the lesson, consider asking them to write a response to one or both of the following prompts:

- We could use numbers or letters to represent the quantities in a situation. When might it make sense to use only numbers? When might it make sense to use letters?

You've heard the phrases "a quantity that varies" and "a quantity that stays constant" in this lesson. Describe what they mean in your own words. If possible, give an example of a situation that has a quantity that varies and a quantity that stays constant.

Career Application(s):

- Business Managers – Evaluating raises
- Computer Programmers – Troubleshooting software
- Research Scientist – Ingredient portions and evaluating data

Leadership/21st Century Skills:

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Unit 2 Lesson 2: Writing Equations to Model Relationships (Part 1)

Goals

Given a description of a situation or an equation, identify quantities that vary and quantities that don't.
Understand that letters can be used to represent both quantities that vary and those that are constant.
Write equations with numbers and variables to describe relationships and constraints.

Math Talk: Percent of 200

Warm Up, 5 m **Instructional Routines**
Math Talk
MLR8: Discussion Supports

Student Task Statement
Evaluate mentally.
25% of 200
12% of 200

2.2 A Platonic Relationship

Regular, 10 m

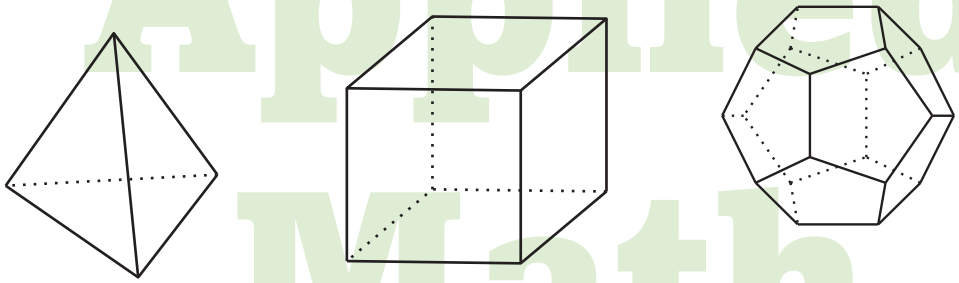
Instructional Routines

- MLR2: Collect and Display

Student Task Statement

These three figures are called Platonic solids.

Tetrahedron **Cube** **Dodecahedron**



The table shows the number of vertices, edges, and faces for the tetrahedron and dodecahedron.

	faces	vertices	edges
tetrahedron	4	4	6
cube			
dodecahedron	12	20	30

1) Complete the missing values for the cube. Then, make at least two observations about the number of faces, edges and vertices in a Platonic solid.

2) There are some interesting relationships between the number of faces (F), edges (E), and the vertices (V) in all Platonic solids. For the example, the number of edges is always greater than the number of faces, or $E > F$. Another example: The number of edges is always less than the sum of the number of faces and the number of vertices, or $E < F + V$.

There is a relationship that can be expressed with an equation. Can you find it? If so, write an equation to represent it.

Extension:

There are two more Platonic solids: an octahedron which has 8 faces that are triangles and an icosahedron which has 20 faces that are triangles.

1) How many edges would each of these solids have? (Keep in mind that each edge is used in two faces.)
2) Use your discoveries from the activity to determine how many vertices each of these solids would have.
3) For all 5 Platonic solids, determine how many faces meet at each vertex.

Blueberries and Earnings

1. Write an equation to represent each situation.
   a. Blueberries are $4.99 a pound. Diego buys pounds of blueberries and pays $14.95.
   b. Blueberries are $4.99 a pound. Jada buys pounds of blueberries and pays dollars.
   c. Blueberries are dollars a pound. Lin buys pounds of blueberries and pays dollars.
   d. Noah earned dollars over the summer. Mai earned $275, which is $45 more than Noah did.
   e. Noah earned dollars over the summer. Mai earned dollars, which is 45 dollars more than Noah did.
   f. Noah earned dollars over the summer. Mai earned dollars, which is dollars more than Noah did.
2. How are the equations you wrote for the blueberry purchases like the equations you wrote for the Mai and Noah's summer earnings? How are they different?

Car Prices

The tax on the sale of a car in Michigan is 6%. At a dealership in Ann Arbor, a car purchase also involves $120 in miscellaneous charges.

1. There are several quantities in this situation: the original car price, sales tax, miscellaneous charges, and total price. Write an equation to describe the relationship between all the quantities when:
a. The original car price is $9,500.
b. The original car price is $14,699.
c. The total price is $22,480.
d. The original price is *p*.

2. How would each equation you wrote change if the tax on car sales is %
and the miscellaneous charges are *m* dollars?

Shirt Colors

A school choir needs to make T-shirts for its 75 members and has set aside some money in their budget to pay for them. The members of the choir decided to order from a printing company that charges $3 per shirt, plus a $50 fee for each color to be printed on the shirts.

1. Write an equation that represents the relationship between the number of T-shirts ordered, the number of colors on the shirts, and the total cost of the order. If you use a variable, specify what it represents.

2. In this situation, which quantities do you think can vary? Which might be
fixed?

Lesson Debrief

To help students synthesize their work in the lesson, consider asking them to write a response to one or both of the following prompts:

We could use numbers or letters to represent the quantities in a situation. When might it make sense to use only numbers? When might it make sense to use letters?

You've heard the phrases "a quantity that varies" and "a quantity that stays constant" in this lesson. Describe what they mean in your own words. If possible, give an example of a situation that has a quantity that varies and a quantity that stays constant.