Lab directions

Math Concept(s): Topic 7 Block 3 Catapult Challenge for MAD

Source / Text: AgileMind and the internet

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Date: Summer Conference 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):

Lab Plan

Lab Title: The Catapult Challenge – finding MAD

Prerequisite skills:

- Calculating the mean, median, mode, range, and interquartile range of a data set
- Converting between fractions, decimals, and percents

Lab objective:

- Use measures of variability to describe a set of data, including mean absolute deviation and standard deviation

Standards: *(Note SPECIFIC relationship to Science, Technology, and/or Engineering)*

Mathematics K–12 Learning Standards:

- S-ID.A.03 (*Statistics and Probability*)
- Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).
- S-ID.B.05 (*Statistics and Probability*)
- Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.
-

Standards for Mathematical Practice:

CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.

- Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution.
- They analyze givens, constraints, relationships, and goals.
- They monitor and evaluate their progress and change course if necessary.

CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively.

- Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.

CCSS.MATH.PRACTICE.MP3 Construct viable arguments and critique the reasoning of others.

- Students at all grades can listen or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments.

CCSS.MATH.PRACTICE.MP4 Model with mathematics.

- They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.

CCSS.MATH.PRACTICE.MP6 Attend to precision.

- They calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the problem context.
-

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

-

K-12 Science Standards

- questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. ♣ **Plan and conduct an investigation individually and collaboratively to produce data** to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), **and refine the design accordingly**. (HS-PS3-4)
- Using Mathematics and Computational Thinking Mathematical and computational thinking at of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, **and computational tools for statistical analysis to analyze, represent, and model data**. Simple computational simulations are created and used based on mathematical models of basic assumptions. ♣ Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)
- Influence of Science, Engineering, and Technology on Society and the Natural World ♣ Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices **to increase benefits** while decreasing costs and risks. (HS-PS3-3)
- Design a test of a model to ascertain its reliability. Science SEP 2

Technology

Standards for Technology Literate & Fluent Students Grades 9-12

- 5. Computational Thinker -Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.
- 5.b. Students collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.

- 7. Global Collaborator -Students use digital tools to broaden their perspectives and enrich their learning by collaborating with others and working effectively in teams locally and globally.
- 7.c. Students contribute constructively to project teams, assuming various roles and responsibilities to work effectively toward a common goal.

Engineering

- ETS1.C: Optimizing the Design Solution♣Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2)

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

- The attached pages
  - Warm up via doc cam or CANVAS
  - Copies of catapult challenge – 1 per group
  - Copies of the summative questions #1 & 2 – 1 per student
- Large and small craft sticks 10 per group
- Rubber bands multiple sizes 6 per group
- Plastic spoon 1 per group
- Binder clip 1 per group
- Plastic cup 1 per group
- Clothespin 1 per group
- Marshmallow 1 per group

Set-Up Required:

- Organize the supplies in bins
- How do you want to form groups – self select or other?
- How are you going to measure the distance?

- I got several feet of poster paper and used my classroom yard sticks to mark off every 2 inches. We estimated to the closest 2 inches when we measured our distances.

Lab Organization Strategies:

Leadership (Connect to 21st Century Skills selected):

CORE LEADERSHIP SKILLS

- Leadership: Individual Skills
  - 1.4 The student will be involved in activities that require applying theory, problem-solving, and using critical and creative thinking skills while understanding outcomes of related decisions. Leadership: Group Skills
  - 2.1 The student will communicate, participate, and advocate effectively in pairs, small groups, teams, and large groups to reach common goals.
- Each team member should have a pair of scissors to start cutting out the cards
  - If you can keep them sorted and not written on this step could be done by your 1st class only
  - Ziploc baggies to store the cards in
  - Be responsible team members and make sure the garbage goes where it belongs.

Cooperative Learning:

- Communicate your ideas with your team members. Make sure they agree on sets you believe you have found.
- Collaborate when a teammate is struggling to determine if they have a match.

Expectations:

Be flexible, manage your time, pick up your trash, return scissors where they belong, store cards in Ziploc bag for next class

Timeline: 1-2 days for the lab

- Be flexible. Some groups will need to have their cards stored for the next class meeting.

Post Lab Follow-Up/Conclusions:

Discuss real world application of learning from lab

- Example: If you had a budget for the year that is $450,000. At the end of the year you create a bar graph for each of the months that says how much money was spent monthly. If you wanted to know how much more or less money you spent in each month on average. That would be finding the Mean Absolute Deviation.

Career Applications

- Working together as a team
- Communicating ideas
- Supporting beliefs with facts
- Time management for the activity (1 class period)
- Support team members when you see them struggling, ask for help if you are struggling

Optional or Extension Activities

- 6th grade Khan academy check
  - https://www.khanacademy.org/math/statistics-probability/summarizing-quantitative-data/other-measures-of-spread/e/calculating-the-mean-absolute-deviation--mad-
- YouTube video - Measures Of Spread In Real Life [Application of measures of dispersion in real life]
  - https://youtu.be/hEErJHx--qY

LAB Directions TO PRINT

1 set per group

Catapult Challenge Team #_____

Team Names:_____

Your Goal: Using supplies available to you in the classroom, build the catapult that will launch your chosen projectile the furthest.

You have 10 minutes to research different ways to build simple catapults.

- You might try online research and/or trial and error.

(Google ***how to make a catapult for kids***)

You have 10 minutes to share ideas with your team on how to build your catapult.

- Decide what materials your team wants to use to build their catapult

The materials you will have to choose from to create your catapult are:

Large and small craft sticks	10 altogether
Rubber bands multiple sizes	6 or less
Plastic spoon	1
Binder clip	1
Plastic cup	1
Clothespin	1
Marshmallow (this is your projectile)	1
Materials you have on your desk right now you provided	Up to 3

You have 30 minutes to build, test and modify your catapult.

Number of each of the Materials we chose to use:

Large and small craft sticks	_____
Rubber bands	_____
Plastic spoon	_____
Binder clip	_____
Plastic cup	_____
Clothespin	_____
Marshmallow (this is your projectile)	1
Materials you have on your desk right now you provided	_____

Sketch your catapult:

NEVER AIM YOUR CATAPULT/PROJECTILE AT ANYONE
Remember, inches are measured with FRACTIONS not decimals!
DATA:

Test #	Distance in inches	Changes you made and why
1		
2		
3		
4		
5		

Now you must choose one member of your team to compete against the other teams!

CONTEST DATA AMONG ALL TEAMS:

Team #	Trial #1 Distance in inches	Trial #2 Distance in inches	RANKING
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Show all of your work for the following on a separate sheet of paper that you staple to this one!

Using the CONTEST DATA AMONG ALL TEAMS:

What is the Mean of Trial #1?

What is the Mode of Trial #1

What is the Median of Trial #1?

What is the MAD of Trial #1?

What is the Mean of Trial #2?

What is the Mode of Trial #2

What is the Median of Trial #2?

What is the MAD of Trial #2?

LAB ANSWERS to be made BY YOU as the data is live

RUBRIC FOR LAB

10 criteria to meet

Rubric for Catapult Challenge LAB

4	3	2	1	0
Students • Cleaned their area of supplies and paper scraps • 5 practice shots only • Used fractions not decimals for their inch measurement • Filled on all contest data among all teams • Correctly calculated the MEAN for both trial #1 and #2 • Correctly calculated the MEDIAN for both trial #1 and #2 • Correctly calculated the MODE for both trial #1 and #2 • Correctly calculated the MAD for trial #1 • Correctly calculated the MAD for trial #2 • Shared their work for all calculations	Meets at least 8 of the listed bullet points	Meets at least 5 of the listed bullet points	Meets 1-4 of the bullet points	Refuses to do the LAB OR Misses all10 bullet points

FORMATIVE assessment BEFORE the lab

Display with projector or via CANVAS

WARM UP from AgileMind

1. **REVIEW** Mercedes measured the heights of the 7 tomato plants she is growing in the back yard. The heights of the plants are 33, 24, 28, 23, 37, 29, and 36 inches.

   a. What is the mean plant height? What does this number mean in the context of the problem?

   b. What is the median plant height? What does this number mean in context of the problem?

   c. What is the range of plant heights? What does this number mean in the context of the problem?

   d. What is the mode of plant heights? What does this number mean in the context of the problem?

FOLLOW UP SUMMATIVE ASSESSMENT

Print 1 per student

Assignment from Student Activity Sheet #3 #13 and 14 renumbered

NAME:

1. **REINFORCE** A new method for studying mathematics was tested with 20 freshmen enrolled in an algebra class. Their average test scores before the students used the new method and after they used the new method are listed in this table.

Test Scores

Student	Before	After	Student	Before	After
A	72	80	K	85	85
B	81	85	L	91	87
C	79	79	M	52	60
D	90	92	N	80	83
E	95	93	O	74	75
F	87	89	P	77	77
G	60	67	Q	61	60
H	65	72	R	88	85
I	74	92	S	86	82
J	66	70	T	70	75

a. Construct two histograms, one for exam scores before the new method and one for exam scores after the new method. Label your histograms “Before” and “After.”

b. Describe the data sets. Be sure to compare the centers and spreads of the two data sets.

c. Based on the histograms you constructed and your comparison of the shapes, centers, and spreads of the data sets, should the new method for studying mathematics be implemented in the high school? Explain your reasoning.

2. **REINFORCE** Twenty people at two different companies were surveyed about their salaries and the results are in the table below.

Salary at Company A (in thousands of dollar)	Salary at Company A (in thousands of dollars)
36	49
37	50
37	55
39	56
39	58
42	59
44	60
44	63
46	67
48	70

Salary at Company B (in thousands of dollars)	Salary at Company B (in thousands of dollars)
35	49
36	50
40	55
41	56
42	56
43	60
44	95
45	100
45	110
48	120

a. Create a graphical representation of each set of salary data.

b. Describe the data sets using the appropriate measures of center and spread. What can you conclude from this information?

c. Suppose you were offered jobs at each of these two companies. Based on the salary data, which company would you prefer, and why?

Berry Lesson Plan Topic 7 Descriptive Stats AgileMind

Name(s): Lorraine Berry
Email Address: lorraine.berry@vansd.org
Lesson Title: Topic 7 Descriptive Stats with the Catapult Challenge for MAD
Date: 6/21/2022
Text: AgileMind STEM Correlation: Engineering Lesson Topic 7 Block 3
Length: 9 days

Big Idea (Cluster): Descriptive Statistics

Mathematics K–12 Learning Standards:
S-ID.A.01 (*Statistics and Probability*)
Represent data with plots on the real number line (dot plots, histograms, and box plots).
S-ID.A.02 (*Statistics and Probability*)
Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.
S-ID.A.03 (*Statistics and Probability*)
Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).
S-ID.B.05 (*Statistics and Probability*)
Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.

Mathematical Practice(s):
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CCSS.MATH.PRACTICE.MP6 Attend to precision.
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Content Objectives:	Language Objectives (ELL):
In this block, students will: • Construct graphs with and without technology, including determining maximum and minimum values and appropriate scales for graph axes	**Support for ELL/other special populations**. This topic is heavy in content as well as collateral vocabulary, such as ***roadway***, ***hazard***, ***symmetric***,

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- Describe similarities and differences in graphical representations using appropriate mathematical vocabulary such as **scale**, **horizontal axis**, and **vertical axis**, and use these differences to justify a claim
- Verify that graphs accurately reflect data
- Determine independent and dependent variables in a relationship
- Use the language of justification, along with relevant mathematical vocabulary, to explain how to construct graphs to display data appropriately
- Identify the domain and range of a function and the situation it represents and be able to justify their choices
- Develop a conceptual understanding of the inverse of a function
- Recognize whether a discrete or a continuous graph is appropriate for a given set of data and explain why
- Describe a relationship between two variables or the graph of the relationship using appropriate vocabulary such as ***domain***, ***range***, ***continuous***, and ***discrete***

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and ***equitable***. Make sure students are asking questions about unfamiliar words and adding them to their notebooks.

Language strategy. Do a word wall activity before introducing the new words ***range*** and ***IQR***. Try grouping words — place ***mean***, ***median***, ***measure of center*** and ***numerical data*** together on the board or wall and ask students what criteria you used to group them. Ask students to make a sentence using all the words.

Language strategy. Many of these words are new and sound similar. Throughout this topic, use word wall activities to give students the opportunity to interact with them

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Vocabulary:
categorical data, ***numerical data***, ***univariate data***, ***bivariate data***, ***measure of center***, ***measure of spread***, ***outlier***, ***variance***, ***standard deviation***, ***mean absolute deviation***, ***marginal relative frequency***, ***joint relative frequency***, and ***conditional relative frequency***.

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Connections to Prior Learning

- Plotting points and labeling axes
- Identifying independent and dependent variables
- Reading data from a table or from a graph
- Calculating the mean, median, mode, range, and interquartile range of a data set
- Converting between fractions, decimals, and percents
- Creating two-way tables to represent bivariate categorical data

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Questions to Develop Mathematical Thinking:

- To help students understand why other measures of spread are important, ask students to describe the disadvantages of each measure. For example, range only uses two observations to describe the spread of the entire data set and IQR only describes the range of the middle fifty percent of the data. So, in order to get an accurate reflection of the spread of a set of data, we may

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Common Misconceptions:

- They only get to try their catapult 5 times before the class competition
- MAD is the mean of all the means
- Using the absolute value of the differences in the calculations

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want to use all of the observations. • Suppose you have two sets of data with the same mean but very different standard deviations. How do you think the histograms would compare? What would this mean in terms of the data? • What if you had two sets of data with the same standard deviation but very different means? How do you think the histograms would compare? What would this mean in terms of the data? • In which cases is one measure of spread better than the other? Why? • How do you think the addition of an outlier will affect these two measures of spread?	

Assessment (Formative and Summative):

- Formative: the warm up question and their solution to the class data MAD
- Summative: Questions #1 and 2 at the end from SAS #3, Q13a-d, and 14a-b

Materials:

- AgileMind online
- Hardcopies of
  - SAS2 Q12a-f and 13a-c
  - *More practice* p1-5 and SAS2 Q21
  - *More practice* p6-7 and SAS3 Q13a-c and 14a-c
  - SAS4 Q5a-b, 6a-e
  - *More practice* p8-14 and SAS4 Q16-17
  -

Instruction Plan:

Block description	Agile Mind resources	Suggested assignment
Block 1 focuses on ways to represent categorical and numerical data and how to determine and interpret the center of a univariate numerical data set.	*Overview* *Exploring* "Measures of center" p1-5 SAS1 SAS2	SAS2 Q12a-f and 13a-c
Block 2 focuses on comparing two sets of data using the mean and median. Students will also discover the effects of outliers on	*Exploring* "Measures of center" p6-13 SAS2	*More practice* p1-5 SAS2 Q21

measures of center and which measure is a better representation of the data in these instances.		
Block 3 focuses on how to determine and interpret the spread or variability of a univariate numerical data set. Measures of spread, including the mean absolute deviation, will be calculated for a univariate numerical data set. Students also determine when to use mean absolute deviation and standard deviation, comparing two data sets using the mean absolute deviation and standard deviation.	*Exploring* "Measures of spread" SAS3	*More practice* p6-7 SAS3 Q13a-c and 14a-c
LAB – The Catapult Challenge		
Block 4 focuses on organizing bivariate categorical data in a two-way frequency table and finding the marginal and grand totals.	*Exploring* "Bivariate categorical data" p1-6 SAS4	SAS4 Q5a-b, 6a-e
Block 5 focuses on computing and interpreting joint, marginal, and conditional relative frequencies for categorical data organized in a two-way table, and using these relative frequencies to make conclusions about association in a problem.	*Exploring* "Bivariate categorical data" p7-13 SAS4	*More practice* p8-14 SAS4 Q16-17
Block 6 provides students with an opportunity to compare two different data sets.	*Constructed response* 1	*Guided practice*
Block 7 provides time for a topic-level assessment.	*Automatically scored Constructed response* 2 or 3	None

Summarize:
Students will use measures of spread, including the mean absolute deviation They will be calculated for a univariate numerical data set. Students also determine when to use mean absolute deviation and standard deviation, comparing two data sets using the mean absolute deviation and standard deviation.

Career Application(s):

- Flexibility in plans
- Cooperation with coworkers
- Communication of ideas

Leadership/21st Century Skills:

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

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