ERUPTIONS: Old Faithful Geyser

Chapter 2 from *Focus in High School Mathematics: Reasoning and Sense Making in Statistics and Probability*, NCTM

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FHSM Key Elements	Reasoning with probability and statistics—data analysis; interpreting statistical studies
FHSM Reasoning Habits	Analyzing a problem—looking for patterns and relationships Implementing a strategy—selecting representations or strategies Monitoring one's progress—evaluating a chosen strategy Seeking and using connections among representations Reflecting on a solution—checking the reasonableness of an answer
PSSM Process Standards	Problem solving—solve problems that arise in mathematics and in other contexts Reasoning and proof—make and investigate mathematical conjectures Representation—create and use representations to organize, record, and communicate mathematical ideas
CCSS Content Standards	S-ID-1. Represent data with plots on the real number line (dot plots, histograms, and box plots). S-IC-1. Understand statistics as a process for making inferences about population parameters based on a random sample from that population.
CCSS Mathematical Practices	1. Make sense of problems and persevere in solving them. 3. Construct viable arguments and critique the reasoning of others. 5. Use appropriate tools strategically.
Task	Investigate wait times between successive eruptions (blasts) of the geyser known as Old Faithful by analyzing data first collected by the National Park Service and the U. S. Geological Survey in Yellowstone National Park. *A classroom-ready activity sheet includes a table of the data.*
Materials	Poster paper (one per group) for graphs, if available. Computers or calculators with graphing capability, if available.
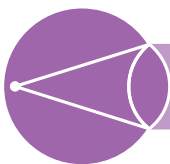
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A teacher might introduce the task to the class by having students recall facts about Old Faithful, including the information that the geyser continues to erupt regularly. Many videos show Old Faithful erupting, and allowing students to view such a video might be a good way to launch the task—especially if students are unfamiliar with the context. Distribute the activity sheet and discuss the information that the table on the first page provides.

Next, assign the students to groups and have them choose two rows of data to analyze, as described on the second page of the activity sheet. Optimally, you might use a random number generator to pick the rows; see www.MathRSM.net/applets/yellowstone for a simple example.

The students should then work individually on numbers 1 and 2 of the activity sheet. Be sure to emphasize the importance of number 1, which asks them to examine their data and jot down "notices" or "wonders"—aspects of the data that they notice or wonder about. Circulating among the students will permit you to see that they are making progress on a graphical representation for each of their two days of data, as requested in number 2 on the activity sheet.

After students have had a chance to come up with individual graphical representations, they should convene in their groups to "share and compare" their work, as suggested in number 3. After several minutes, they should move on to number 4, which invites them to begin to function as "data detectives."

The groups should work for at least 20 minutes, while you circulate among them and watch them reach agreement on a graphical representation (preferably on poster board or butcher paper). Also remind them to include their best estimate of the expected wait time for the next geyser blast and pose questions such as the following: "Are you all in agreement with your conclusion about the wait time?" "Why did your group decide to represent the data that way?" "What does your graph tell you about the data?" "Do you think you will have time to go to the gift shop before it erupts again?"

The groups should then present their graphs and conclusions to the group. As each group presents, solicit responses from the other class members to what the group has done. Encourage the other members of the class to ask questions to clarify for their fellow students what each group has done.

After the group presentations, you might ask the whole class to compare and contrast the different graphs created and used by all the groups, posing such questions as, "What does each type of graph highlight for us?" and, "Do any of the graphs 'mask' some things in the data?"

You might also focus on the statistics that the students use. If the students focus on a measure of central tendency, you might ask them how confident they are about their prediction, probing with questions such as, "What about variability in the blast times; does that bother you?"
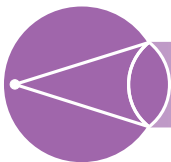
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Focus on Student Thinking

The types of graphs that students might create include (a) a bar graph or a line graph of wait times, ordered by blast number; (b) a stem-and-leaf plot; (c) a frequency graph; (d) a box plot; and (e) a graph over time.

Students might recognize that the frequency graphs can vary considerably, depending on the bin width selected.

A graph over time might focus attention on the seeming alternating behavior of "short" and "long" blasts (a long blast is usually followed by a short blast, and vice versa).

Some students might use statistics such as the mean and median to predict the wait time. They might note that the two measures can be quite different in this case.

Students who make box plots might also note the usefulness of the interquartile range in providing a measure of the variability of the expected wait time.

Assessment

As the students are working, walk around the room and observe what they are doing.

After the class discussion, you might ask each group to finalize a group report of what it did or ask each student to complete an individual write-up. A sample prompt for such an exercise might be, "Write a letter to a friend who is going to visit Old Faithful. What would you tell your friend about how long to expect to wait for the geyser to blast, and why?"

Afterward, you might be able to present some of the extensions outlined for this task in the book from which it is drawn.

Source

National Council of Teachers of Mathematics (NCTM). *Focus in High School Mathematics: Reasoning and Sense Making in Statistics and Probability*. Reston, Va.: NCTM, 2009. Chapter 2,"Eruptions of the Old Faithful Geyser—Becoming a Data Detective," pp. 25–41.
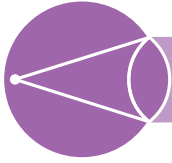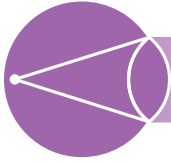
Student Activity Sheet

The following table gives successive wait times in minutes for Old Faithful, collected over a period of two weeks in 1985. Each row represents approximately one day's worth of eruption times.

Old Faithful Data – Minutes between Blasts

1)	86	71	57	80	75	77	60	86	77	56	81	50	89	54	90	73	60	83
2)	65	82	84	54	85	58	79	57	88	68	76	78	74	85	75	65	76	58
3)	91	50	87	48	93	54	86	53	78	52	83	60	87	49	80	60	92	43
4)	89	60	84	69	74	71	108	50	77	57	80	61	82	48	81	73	62	79
5)	54	80	73	81	62	81	71	79	81	74	59	81	66	87	53	80	50	87
6)	51	82	58	81	49	92	50	88	62	93	56	89	51	79	58	82	52	88
7)	52	78	69	75	77	53	80	55	87	53	85	61	93	54	76	80	81	59
8)	86	78	71	77	76	94	75	50	83	82	72	77	75	65	79	72	78	77
9)	79	75	78	64	80	49	88	54	85	51	96	50	80	78	81	72	75	78
10)	87	69	55	83	49	82	57	84	57	84	73	78	57	79	57	90	62	87
11)	78	52	98	48	78	79	65	84	50	83	60	80	50	88	50	84	74	76
12)	65	89	49	88	51	78	85	65	75	77	69	92	68	87	61	81	55	93
13)	53	84	70	73	93	50	87	77	74	72	82	74	80	49	91	53	86	49
14)	79	89	87	76	59	80	89	45	93	72	71	54	79	74	65	78	57	87
15)	72	84	47	84	57	87	68	86	75	73	53	82	93	77	54	96	48	89
16)	63	84	76	62	83	50	85	78	78	81	78	76	74	81	66	84	48	93

Student Activity Sheet

The table on the previous page gives data on wait times between successive eruptions (blasts) of the geyser known as Old Faithful. These data were first collected by the National Park Service and the U. S. Geological Survey in Yellowstone National Park.

In your group, pick any two rows of the wait times so that your group has two sample days of Old Faithful wait times. (For best results, use a random number generator in the selection of your rows!)

First, working individually, take the following steps:

1. Look over the data. Is there anything that you notice, or anything that you wonder about in your two samples of data? Jot down some of your "notices" and "wonders."

2. Create at least one type of graphical representation for each of the two days of data to help you visualize any patterns in the wait times. Jot down any additional notices and wonders that occur to you.

Next, working as a group, do the following:

3. Share and compare. Share your graphical representation of the data in your group. What do you notice, or wonder about, as you look through your group's graphical representations?

4. Accept the challenge to act as data detectives. Agree as a group on a graphical way to display your data. On the basis of your data, make a group decision about how long you would expect to wait between blasts of Old Faithful if you showed up at Yellowstone Park and Old Faithful had just finished erupting. Be prepared to present your graph to the other groups in class and to defend your group's data-based prediction for the expected wait time.