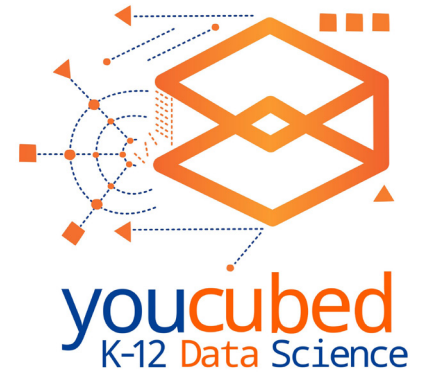


Unit 3: Measures of Center & Spread



Introduction:

In the first lesson, students learn about measures of center by creating and investigating data sets where the mean, median, and mode have particular relationships. This activity allows students to discover intuitive ways to find and interpret measures of center rather than just memorizing a set of steps or rules. In lesson 2 students will work with visualizations of standard deviation within data graphs. This lesson assumes students have some familiarity with calculating mean, median, and mode, but aims to expand those notions and think about them in context.

Lesson 1: Mean, Median, Mode and Mammals

Time	Activity	Materials
10 min	Measures of center film: <ul style="list-style-type: none"> Watch the film, Measures of Center (a link to the film will be provided in July 2020) 	Video file available July, 2020
10 min	Measure of center discussion: <ul style="list-style-type: none"> Ask students to discuss any key points or questions they have about the measures of center presented in the animated film. Ask students to review for you, what is a mode? A mean? Or a median? 	
40 min	Explore: <ul style="list-style-type: none"> Ask student to go to CODAP and explore mean and median inside the mammal data set There are 5 columns, or attributes, with numerical entries in this data set. Ask students to explore these by making a graph for each attribute, including the mean and median in each graph. Ask students to find graphs where the mean and median are the same, or where one is greater than the other. Ask them to describe the shape of the distribution when the mean is greater than the median. And to describe it when the median is greater than the mean. 	https://codap.concord.org/app?url=https://concord-consortium.github.io/codap-data/SampleDocs/Science/Biology/27mammals/Mammals_Sample.codap

10 min	<p>Discuss:</p> <ul style="list-style-type: none"> • What did the different data sets look like when the mean and median were the same? • What did the data set look like when the mean was greater than the median and when the median is greater than the mean? 	
5 min	<p>Reflection/journal entry: What is the meaning of mean, mode and median.</p>	<ul style="list-style-type: none"> • Journal

Measures of center film:

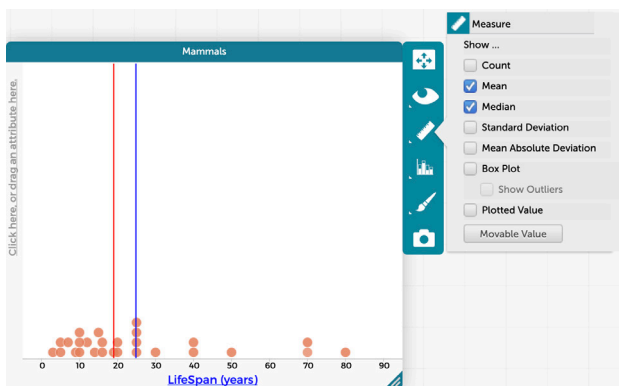
Share the film about measures of center. This film shares the mean, median and mode in a visual story about Jo and her dog, Alfie, and the 15 fastest animals on earth. This film is part of the new online course, 21st Century Teaching and Learning. This short film will be released outside of the online course in July, 2020.

Measures of center discussion:

Ask students to discuss any key points or questions they have about the measures of center presented in the animated film. Ask students to review for you, what is a mode? A mean? Or a median? Some students may not have learned or remember these terms and what they stand for. Include in your discussion a key point regarding the median of a set of data when there are an even number of data points and an odd number of data points.

Explore:

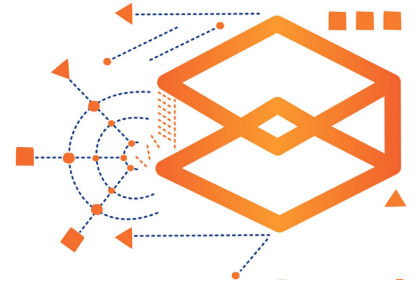
Ask students to work in small groups as they explore a data set about mammals using CODAP. The data contains 9 attributes including five that have numerical data. The goal for this exploration is for students to graph each set of numerical attributes individually, including the mean and median, and consider the shape of the data. Students will find different scenarios where the mean and median are the same, the median is less than the mean and the median is greater than the mean. Students should discuss their findings in groups before the class discussion. Students may find it useful to click and hold on a data point to drag it around the graph. The mean and median lines will adjust. Once students let go of the data point it will move back to its original location. Students may find it challenging to determine the median if their graph window is small. In the example below points look aligned but they are not.



You can add the mean and median to a graph of numerical data by choosing on the ruler.

Discuss:

Ask students to share their findings and conjectures about the shape of data in their different data graphs. Ask, "Have you found any patterns in the graphs that lead you to know if the mean is greater than the median by the shape of the data?". Ask students to describe what a data set might look like when the mean is less than the median. Ask students to think about other situations that involve the mean, median and mode. Do they have ideas about when one measure might be better than another? Students often only think about the mean. If there are outliers and the data is skewed the median may be a better measure of center since it is not affected by outliers (as the example of Jo's ball throws for Alfie showed). For example, if you have a series of test scores that make up a grade, one very low grade can skew the data towards a lower overall grade if the mean is used. In this case, is the mean a fair measure or would the median be a better measure of student success? Can students think of a situation where the median would be a better measure of center? Or where the mode would be a better measure of center?

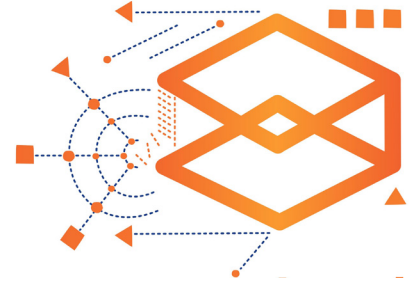
**Look-fors:**

- **Do students notice the difference in the shapes of the graphs?** Do they notice some of the data sets are skewed to the right or left while others seem more balanced?
- **Are students noticing the difference in the median and mean when the data isn't symmetrical?**
- **Are students noticing outliers in the data sets and connecting them to the differences in the mean and median in the data set?**

Reflection/journal entry:

What is the meaning of mean, mode and median?

Lesson 2: Standard Deviation



Introduction:

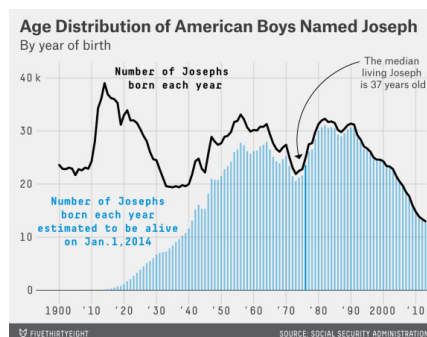
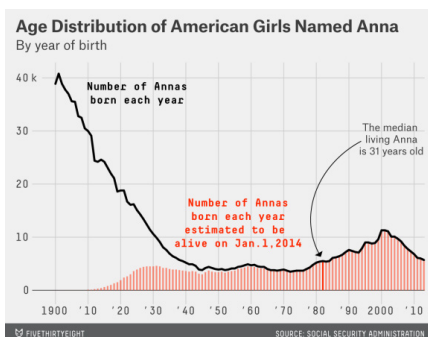
In this lesson students learn about a measure of spread - standard deviation. Students will explore different data representations, watch a short-animated film about standard deviation and use tools in CODAP to calculate standard deviation and show these measures visually. The goal of this lesson is for students to think about standard deviation and the ways it can be useful when talking about the spread of data.

Time	Activity	Materials
20 min	<p>Data talk: This data talk shares the age distribution of Americans named Anna or Joseph. Share the two graphs, side by side. Ask students, “What do you notice?”, “What do you wonder?”</p> <p>Ask students, “Why do you think the graphs focus on the median and not the mean? “Where do you think the mean would be placed for each graph in relation to the median?”.</p> <p>These graphs were chosen because they require close reading of key information.</p>	<p>Age distribution of American kids named Anna & Joseph. Anna: (https://fivethirtyeight.com/wp-content/uploads/2014/05/silver-feature-anna3.png?w=575)</p> <p>Joseph: https://fivethirtyeight.com/wp-content/uploads/2014/05/silver-feature-joseph2.png?w=575</p> <p>The entire article https://fivethirtyeight.com/features/how-to-tell-someones-age-when-all-you-know-is-her-name/</p>
5 min	<p>Watch: Watch Standard Deviation animated film</p>	
5 min	<p>Discuss: Discuss the standard deviation film:</p> <ul style="list-style-type: none"> • Why might standard deviation be useful? • Who might use standard deviation in their work? 	

30 min	<p>Investigate: Ask students to look at the cat data set in CODAP.</p> <p>Ask students to plot separate graphs for each of the numerical attributes: age, weight, body length, and tail length.</p> <p>Ask students to set CODAP to show the standards deviation for each of their graphs. They may want to include the median too.</p> <p>For each graph, ask students to draw 2 SD's each side of the mean - this can be done by taking screenshots of the graphs and drawing on the screen shot, or sketching them out on paper.</p> <p>Ask students, "How many SD's is Tomodachi Joto's Tail Length from the mean?"</p> <p>Extension: Ask students to consider any cats they have at home (they may need to estimate some of the values) and add their class cats to the data set. How does that change the data and the SD's?</p>	<p>Cat data in CODAP: https://codap.concord.org/app?url=https://concord-consortium.github.io/codap-data/SampleDocs/Science/Biology/24cats/24cats.codap</p>
10 min	<p>Discuss: What was going on in the tail length data set? Why do you think Tomodachi Joto's Tail Length was so unusual?</p>	
5 min	<p>Reflection/journal entry: In your own words, what does standard deviation mean?</p>	<ul style="list-style-type: none"> Journal

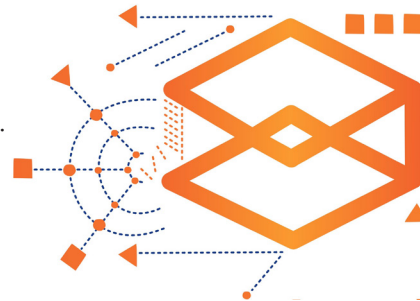
Data talk:

For this data graph talk we have chosen two graphs illustrating name data from an article that you can view at <https://fivethirtyeight.com/features/how-to-tell-someones-age-when-all-you-know-is-her-name/>. We chose these two graphs because they require careful, close reading. There is a lot of interesting information presented in these two data graphs for the names Anna and Joseph. While the graphs are not complicated the black line, orange bars and median line present an opportunity for good conversation. What do the orange bars mean and why is there white space with no orange bars under the black line? Why is the median shown and not the mean? Where do you think mean would be located? Why? These are all interesting questions and students will most likely find many more questions to wonder about. Students may ask where the data comes from. This is another interesting conversation you may choose to discuss. If students are curious you may want to share the article so they can continue their own study of the name data.



SD Film:

Show the animated short film about standard deviation. This film is part of the free online course for teachers called 21st Century Teaching and Learning. For more information about this course go to <https://www.youcubed.org/resource/data-literacy/>.

**Discuss:**

Ask students, “How might standard deviation be useful as a measure?”. You might also ask what they think about the visual representation of the way standard deviation is represented in the film. Another question to consider is, “Who might use standard deviation in their work?”

Investigate:

This investigation follows the Standard Deviation film with a similar data set to the one Jo used in the film. Ask students to go to the CODAP data set for cats.

(<https://codap.concord.org/app?url=https://concord-consortium.github.io/codap-data/SampleDocs/Science/Biology/24cats/24cats.codap>) The goal is for students to use CODAP to calculate the standard deviation for the different numerical attributes in the data set. Students can do this by making a graph for each of the attributes and adding the standard deviation using the measure tool (ruler symbol). Students may want to include the median too. The mean is part of the standard deviation measure but they may want to add the mean to the diagram since it makes it easier to see (by choosing it in the measure tool). In the graphs the measure tool only shows one standard deviation on either side of the mean. Ask students to recreate the graphs through screenshots or sketching by hand so they can add more standard deviations to each graph. Ask students to determine the attributes for each cat that are 1, 2, 3 or more standard deviations from the mean. What does this tell us about a specific cat? What does the standard deviation help us see? Ask, “How many standard deviations is Tomodachi Joto’s Tail Length from the mean?” Students may want to explore the data set further and in their own way. That is what data scientists do! CODAP has included a box with some other questions that students may want to discuss. We love to encourage exploration in maths. It’s a beautiful thing.

Discuss:

Ask students, “Why do you think Tomodachi Joto’s Tail Length was so unusual?” Students will most likely have some very interesting ideas about this cat’s tail. This is a perfect time to let student discussion flow. Our favorite time is when students start discussing with each other and the conversation is not going to or through the teacher. As students offer their ideas, ask them to clarify their position and provide any justification for their responses.

Are students noticing the mean and the median positions are different when the data doesn’t look symmetrical? This is an important point and a discussion about skewed data and outliers is important.

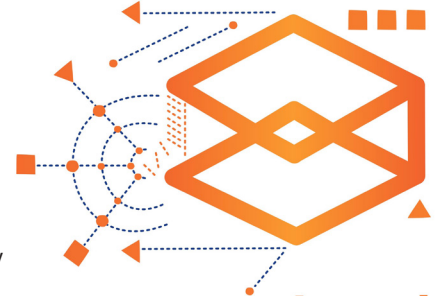
Extension:

Ask students to consider any cats they have at home (they may need to estimate some of the values) and add their class cats to the data set. How does that change the data and the SD’s?

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Extension:

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Look-fors:

- **Are students showing creativity?** Are students exploring interesting ideas and trying to answer their own questions? Are they engaging with the data in different ways across groups?
- **Are students paying careful attention to the shape of the graphs?** Are they noticing if the graphs are symmetric or skewed in one direction?
- **Have students developed some intuition about the shape of a graph and where the median might be in relation to the mean?** When the data is skewed to one side the mean is often pulled towards those outliers while the median remains towards the center.
- **Are students making connections between the mathematical operation of finding the mean or median and the position of these values in a graph?**
- **Are students noticing that the width of the shaded region showing the standard deviation changes based on the data?** Do they notice or wonder about what might be causing the width differences?

Reflection/journal entry:

In your own words, what does standard deviation mean?

Data Talk

