| SeaGlide_TEAM | Percentiles and Distribution | Lesson #3 (60 minutes) |
|---|---|---|

**Description:**

A cell phone company wants to evaluate data about text messaging between teenagers so they can better tailor their services for generational needs. They have hired you as a statistical analysts to interpret data from four different high school students. Given data was collected from four different students about their texting habits over a period of 60 days. The data shows how many texts were sent/received in a single day and the frequency of that number during the 60 days. Each students' data shows up in a different distribution. You will use the given information to sketch the distribution for each student then make evidence based conclusions.

**Students will be able to:**

- Define percentiles and apply them to distributions
- Calculate standard deviation and apply it to distributions
- Interpret distributions
- Identify the skew of a distribution

**Students will understand:**

Students will understand how to calculate standard deviation. Scaffolding is provided for students when they are first learning how to calculate it. This is so that a new equation can be broken down into is familiar parts to make the task seem less daunting. Once students have practiced with standard deviation, they will be led to make connections between the calculations of standard deviation to normal distribution curves. Students will practice working through guided examples to help bridge these connections. They will also have the opportunity to practice drawing and labeling their own curve based on information provided to them. After having developed an understanding of normal distributions, students will explore other types of distributions and compare them. This will connect to data analysis and allows students to see why all distributions and curve types are important.

**Key Definitions & Concepts [1]:**

- **Percentile:** a measure used in statistics indicating the value below which a given percentage of samples in a given population falls.
- **Rank:** also referred to as ordinal variables, are those for which the individual observations can be put in order from smallest to largest, even though the exact values are unknown.
- **Distribution:** a listing or function showing all the possible values (or intervals) of the data and how often they occur. When categorical data is organized, you see the number or percentage of individuals in each group.
- **Frequency:** is the number of times the event occurred in an experiment or study and often graphically represented in histograms
- **Probability:** the measure of the likelihood that an event will occur.

**Standards [Copied from: 2]:**
CC.2.4.HS.B.5 Make inferences and justify conclusions based on sample surveys, experiments, and observational studies.
CC.2.4.HS.B.1 Summarize, represent, and interpret data on a single count or measurement variable

## Background Information

**Prior Knowledge:**

- Definitions from all prior *Measurement & Data Analysis* lessons
- Utilization of variables
- Understanding of functions
- Basic arithmetic

| **Mathematical Practices [Copied from: 3]:** | **Core Ideas [Copied from: 4]:** | **Cross Cutting Concepts [Copied from: 5]:** |
|---|---|---|
| ● Construct viable arguments and critique the reasoning of others.<br>● Model with mathematics. | ● Information Processing<br>● Optimizing the Design Solution | ● Scale, Proportion, and Quantity<br>● Patterns<br>● Cause and Effect |

**Possible Preconceptions/Misconceptions:**
Students may not realize that standard deviation is relevant or how it is different from the mean. They may also assume that data should only have one type of distribution curve, when in reality, there are many. The lesson discusses what standard deviation is, how it is used, and why it is important. Multiple distributions are shown and used in this lesson as well. Hence, these preconceptions should be resolved by the end of this lesson.

## Lesson Plan - 5E(+) Model

**Engage:**
Students will individually take a brief *Review Quiz* on the terms given from the concept map in the previous lesson. This allows students to review and recall important statistical definitions that will be referenced throughout the *Measurement and Data Analysis* module. Students should first try to fill out the quiz without any resources. When completing the corrections, students should be given access to their concept maps from the previous lesson so they can correct the *Review Quiz* in their own words. This serves as a way to reinforce understanding of the prior concepts in a recursive manner. Allow students to take 5 minutes to complete the *Review Quiz* without resources, then 5 additional minutes for the students to make necessary corrections. Hence, this should take students 10 minutes to complete.

**Explore:**

Part I: Introduction [1]

Students will individually use the *Statistics Concept Map* worksheet to fill out a concept map of the important concepts in this lesson. Students will be given a list of definitions, and they need to match the correct definition to the words in the bubbles. Students should draw lines between the words that relate to each other; then, on the connecting line, students will write their reasoning to explain why these concepts are connected. This helps students draw connections between words, develop a stronger understanding of the concepts, and bridge any misunderstanding gaps that students may have had prior to this lesson. The teacher should facilitate a discussion of some of the connections students made in their maps as well as go over the correct answers. This should take a total of 10 minutes - 5 minutes for the students to complete the concept map and 5 minutes to review the answers as a class.

**********NOTES FOR THE TEACHER**********

Throughout the *Measurement and Data Analysis* module, students will make concept maps similar to this one for each lesson. It is recommended to have the students turn in their concept maps after each lesson but be able to reference each of their concept maps during the subsequent lessons. Through these worksheets, students can then compile all of their concept maps together to continue to grow their mathematical connections and develop a deeper understanding of statistics. Also, students will be able to visualize how all of the concepts within the *Measurement and Data Analysis* module connect.

Part II: *Benchmark Lesson*: Standard Deviation and Normal Distribution [6]

Students will work in groups of 2 or 3 on the *Standard Deviation and Normal Distribution* worksheet. Throughout the activity, questions are designed so that students can recall and rely on prior knowledge from previous lessons in the *Measurement and Data Analysis* module. This allows students to put what they are learning in a larger context and make deeper connections. In this activity, students will both explore what these new concepts are and engage with them through examples. Students may struggle with the idea and concept of standard deviation. They may become confused by the equation and symbols in it. The worksheet defines all of the variables but students may still be overwhelmed by a new equation with new variables. However, this worksheet provides the framework and scaffolding students need to understand standard deviation and how to calculate it. The worksheet then connects the idea of standard deviation to the normal distribution. This should take about 25 minutes to complete.

Part III: *Investigation Lesson*: Who Texts the Most? [6]

Students will remain in their groups from the prior activity and will apply the knowledge that they learned in the previous activities to explore other types of distributions. They will look at various data sets about text messaging and will have to sketch the distribution for each set. Based on the data spread, the distributions will come out differently then what they are used to seeing. Students will compare the distributions and interpret what they each say about the data. They will also have the opportunity to make connections to previous lessons in this curriculum about data and data interpretation. This should take 15 minutes to complete.

**Explain:**

During each activity in the exploration of this lesson, students are expected to explain their reasoning, choices, and/or answers (depending the worksheet). In the introduction part of the exploration, students must explain why they chose to connect two words. In the benchmark and investigation parts of the exploration, students must explain the purpose and meaning behind mean, standard deviation, and distributions in terms of their significance in the data set at-hand. They must also explain what each concept tells them about the data set from an analytic standpoint. From this, the students must draw conclusions and support such via reasoning and sound explanations. The teacher should also be asking probing questions during completion of the worksheets that prompt the students to explain what they are doing and why. This allows for students to learn through inquiry and discovery, which ensures that they gain deeper understanding of the learning goals of this lesson.

**Elaborate:**

Students will work with a real-world connection of cell phone usage. High school students can easily relate to texting and the frequency of texting. This becomes engaging as students realize that something in their everyday lives can be turned into data and is actually useful. Companies collect this kind of data regularly to improve their businesses, which students may not realize at first. They will not only have the opportunity to process the kind of data the a company may collect, but they are also working with data that is directly relevant to them.

**Evaluate:**

Students are evaluated both informally and formally throughout the entirety of this lesson. The informal evaluations occur during the open class discussions, and especially during the *Concept Map* activity. When the teacher is circulating the classroom, he/she is able to check for surface level understanding and to make sure that the class is all on the same page by listening to students' discussions and observing students' responses. The instructor gauges student progress through observing whether or not students are struggling to complete the activities. The formal assessments of this lesson are the worksheets, by checking for correctness, and the *Review Quiz*. The *Review Quiz* is an excellent assessment to determine if students retained information from the previous lesson.

**Enrich:**

This lesson can be extended to genetics and distribution of traits. Distribution is important based on what traits are normal or common, such as height. It can also be used in learning about co-dominant traits and the frequency of a phenotype, such as fur color. Each of these examples provide insight into how this lesson is an introduction for learning how distributions are heavily applicable in biology and genetics. Further, this lesson can be used as an introduction for learning about chi-square, which also has ample applications in biology and genetics.

**All associated documents are attached below**

**Reference *Annotated Bibliography* on the very last page of this packet**

Name:_____ Date:_____

Review Quiz

In your own words, define each of the following keywords.

**Mean:**

**Median**:

**Mode**:

**Range**:

**Upper Extreme**:

**Lower Extreme**:

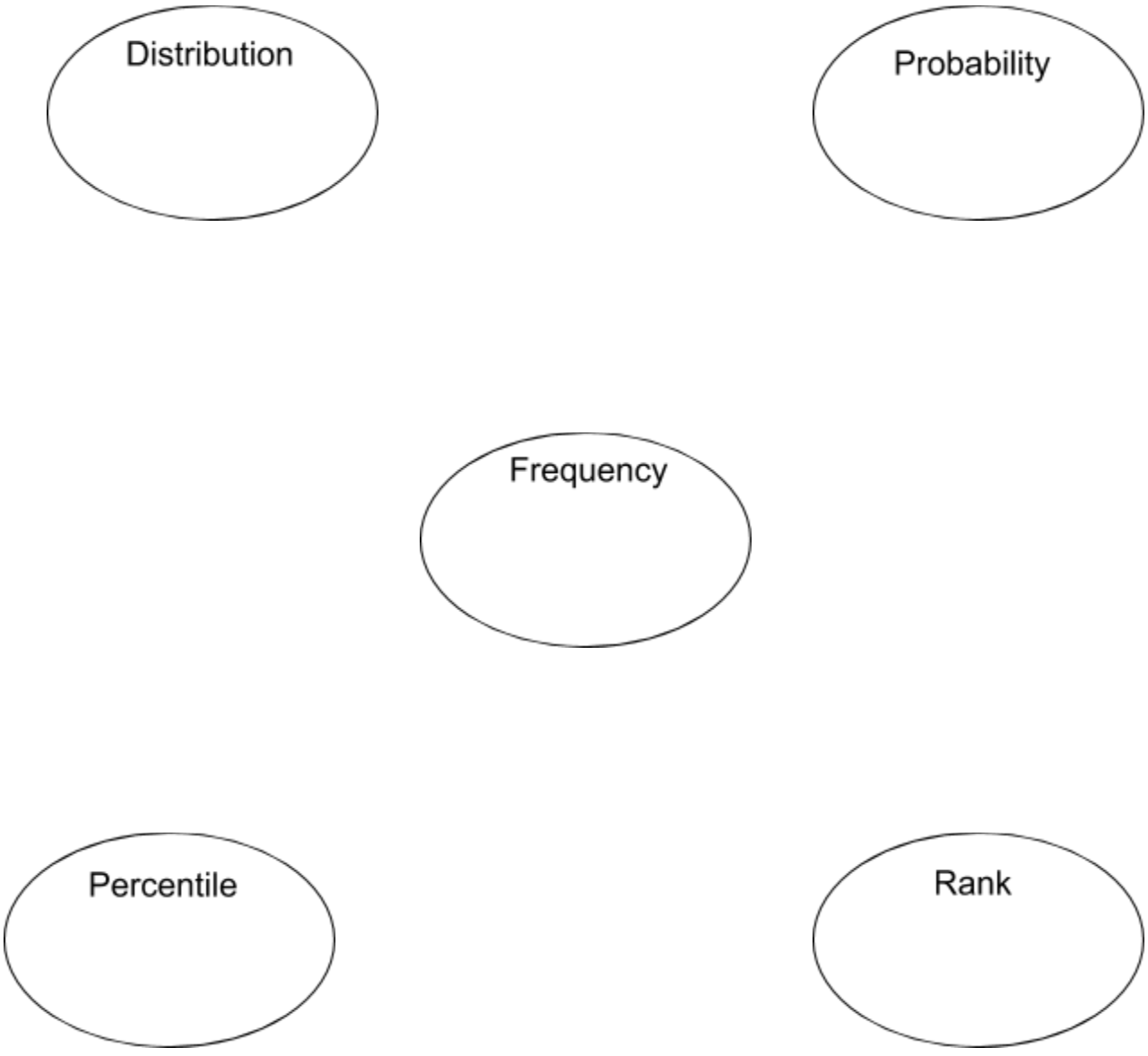
**Qualitative**:

**Quantitative**:

Name:_____ Date:_____

Statistics Concept Map [1]

Use the definition list on the next page to match the word to its definition by writing the corresponding letter inside the bubble. Then draw a line between words that connect with each other. On the line, write a brief reason of why or how they connect.



Name:_____ Date:_____

Definition List [1]

**A:** a measure used in statistics indicating the value below which a given percentage of samples in a given population falls.

**B:** also referred to as ordinal variables, are those for which the individual observations can be put in order from smallest to largest, even though the exact values are unknown.

**C:** a listing or function showing all the possible values (or intervals) of the data and how often they occur. When categorical data is organized, you see the number or percentage of individuals in each group.

**D:** is the number of times the event occurred in an experiment or study and often graphically represented in histograms

**E:** the measure of the likelihood that an event will occur

Name:_____ Date:_____

Standard Deviation and the Normal Distribution [6]

**Standard deviation** is statistical method used to determine how spread out the data is from the mean. This shows how much variation from the mean there is in a set of data.

Standard Deviation in denoted by lower case greek letter sigma σ.

The formula for standard deviation is

$$\sigma = \sqrt{\frac{\sum (x - \overline{x})^2}{n}}$$

Σ = summation
$\overline{X}$ = average or mean of the data points
n = number of data points

Lets walk through an example to better understand how to calculate the standard deviation.

Let's say we kept track of the daily low temperatures for a week. The temperatures are: 24, 26, 21, 20, 25, 26, 27.

First find the mean of the data set (so find $\overline{X}$):

$\overline{X}$ =

Now use the following table to help you calculate the next few steps:

| Daily Low Temperature | Difference from the Mean | Difference from the Mean Squared |
|---|---|---|
| 24 | 24 - $\overline{X}$= | |
| 26 | 26 - $\overline{X}$= | |
| 21 | 21 - $\overline{X}$= | |
| 20 | 20 - $\overline{X}$= | |
| 25 | 25 - $\overline{X}$= | |
| 26 | 26 - $\overline{X}$= | |
| 27 | 27 - $\overline{X}$= | |

Now we will find the summation of the difference from the mean squared, to do this add together the number you found in the third column to find

$\Sigma(X-\overline{X})^2 =$

Now divide you're new value by n to find:

$\Sigma(X-\overline{X})^2/n =$

Now take the square root to get

$$\sigma = \sqrt{\frac{\Sigma\ (x-\overline{x})^2}{n}}$$

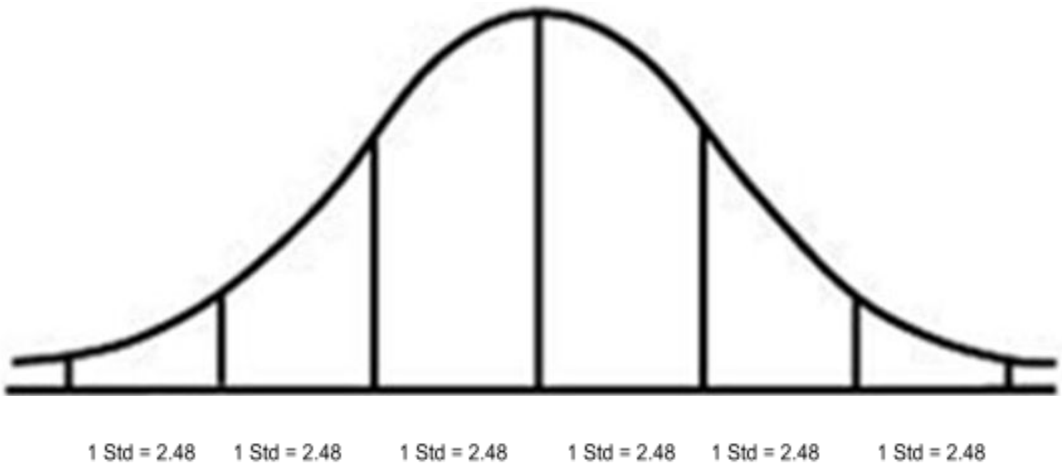
$\sigma =$

What does a large standard deviation tell us about a data set?

What does a small standard deviation tell us about a data set?

The picture below is of a normal distribution curve. Each section is equivalent to 1 standard deviation (which we just calculated). The center line (at the highest point of the curve) is the mean. Using the calculations from above, label the mean on the graph. Also, compute and label the values at the other lines using the standard deviation and mean.

Normal Distribution Curve




How does the mean being the middle line on the graph relate to the median, and mode? What does this say about data in a normal distribution curve?

What percent of data points are 1 standard deviation from the mean? How about 2 and 3 standard deviations from the mean?

How can standard deviation be helpful in data analysis?

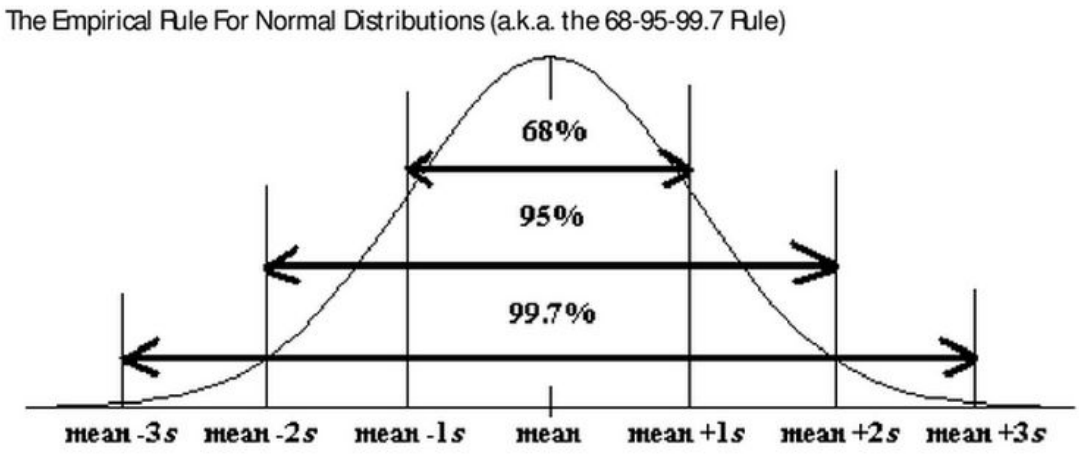
Say the mean score for the math portion of the SAT was 520 and has a standard deviation of 98. First, sketch a Normal Distribution Curve using the mean and standard deviation. Then, answer the following questions.

Sketch

What percent of students scored higher than a 520?

What was the median score?

The following picture is an illustration on the empirical rule:




**We use the Empirical Rule to analyze data when original values are unknown.**

Here *s* stands for standard deviation. Each percentage is the percent of the population that falls within that range.

Use the empirical rule to work through the following example.

Given that the times required for a group of students to complete the physical fitness obstacle course results in a normal curve, that the mean time 21 minutes and that the standard deviation is 4, sketch the Normal Distribution Curve

What percent took longer than 29 minutes?

What percent took less than 29 minutes?

What percent took between 13 and 29 minutes?

What percent took between 13 and 25 minutes?

What percent took longer than 17 minutes

Name:_____ Date:_____

Who Texts the Most? [6]

A cell phone company wants to evaluate data about text messaging between teenagers so they can better tailor their services for generational needs. They have hired you as a statistical analyst to interpret data from four different high school students. Below is data collected from four different students about their texting habits over a period of 60 days. The data shows how many texts were sent/received in a single day and the frequency of that number during the 60 days. Each students' data shows up in a different distribution. Use the given information to first sketch the distribution for each student. An easy way to do this is to first make a bar graph or dot plot for the given student, and then use that plot to sketch the curve of the distribution.

SALLY - Roughly Normal Distribution with Mean = 60 and Standard Deviation = 4.18

| Number of Text Messages | Frequency |
|---|---|
| 60 | 6 |
| 58, 59, 61, 62 | 5 |
| 56, 57, 63, 64 | 4 |
| 55, 65 | 3 |
| 53, 54, 66, 67 | 2 |
| 51, 52, 68, 69 | 1 |

Sketch of Distribution:

JAMAL - Bimodal Distribution with Mean = 60 and Standard Deviation = 39.78

| Number of Text Messages | Frequency |
|---|---|
| 40, 80 | 1 |
| 5, 35, 85, 115 | 2 |
| 10, 110 | 3 |
| 15, 30, 90, 105 | 4 |
| 20, 25, 95, 100 | 7 |

Sketch of Distribution:

IVY - Skewed Distribution with Mean = 74.25 and Standard Deviation = 31.36

| Number of Text Messages | Frequency |
|---|---|
| 5, 60 | 1 |
| 25, 65, 75, 80, 85, 105 | 2 |
| 10, 30, 40, 50 | 3 |
| 55, 70 | 4 |
| 90, 115 | 6 |
| 100 | 14 |

Sketch of Distribution:

TOM - Scattered Distribution with Mean = 60 and Standard Deviation = 35.64

| Number of Messages | Frequency |
|---|---|
| 45 | 1 |
| 0, 15, 75, 80, 90 | 2 |
| 5, 50 | 3 |
| 85 | 4 |
| 10 | 6 |
| 70 | 8 |
| 40 | 11 |
| 105 | 14 |

Sketch of Distribution:

Interpret the results by answering the following questions.

What happens to the shape of the sampling distributions as the size of the sample varies?

How is the shape of the sampling distribution related to the shape of the population from which the samples were drawn?

How do the population distributions compare to each other? Compare shape, center, and spread.

How do the sampling distributions compare to each other?

What are the means of the sampling distributions?

How would you describe the spread of the sampling distributions?

How can you use this information to make a decision about which student texted more?

Name:_____ANSWER KEY_____ Date:_____

Review Quiz

**Mean**: The average of the data set. Found by finding the sum of the data points then dividing by the number of data points

**Median**: The number that is the midpoint of the data set

**Mode**: The number that occurs most frequently in the set

**Range**: The difference between the lowest and highest values in a data set

**Upper Extreme**: The largest number in the data set

**Lower Extreme**: The smaller number in the data set

**Qualitative**: Scientific method of observation to gather non-numerical data. This type of research "refers to the meanings, concepts, definitions, characteristics, metaphors, symbols, and description of things" and not to their “counts or measures”.

**Quantitative**: Information about quantities; that is, information that can be measured and written down with numbers.

Name:_____ANSWER KEY_____ Date:_____

Statistics Concept Map [1]

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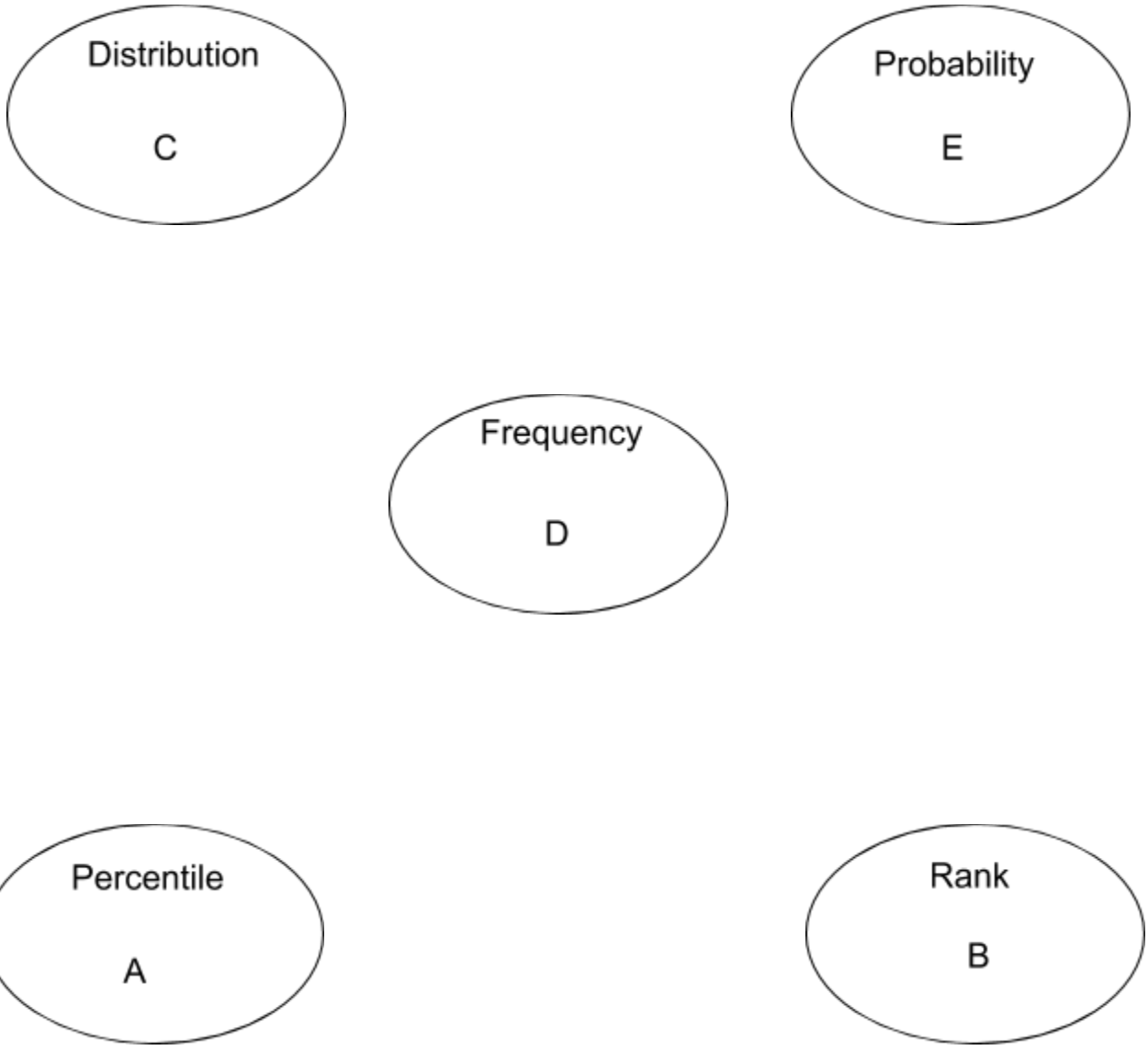

Name:_____ANSWER KEY_____ Date:_____

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Σ = summation
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Lets walk through an example to better understand how to calculate the standard deviation.

Let's say we kept track of the daily low temperatures for a week. The temperatures are: 24, 26, 21, 20, 25, 26, 27.

First find the mean of the data set (so find $\overline{X}$):

(24 + 26 + 21 + 20 + 25 + 26 + 27)/7 = 24.14

$\overline{X}$ = 24.14

Now use the following table to help you calculate the next few steps:

| Daily Low Temperature | Difference from the Mean | Difference from the Mean Squared |
|---|---|---|
| 24 | 24 - $\overline{X}$ = 0.14 | 0.196 |
| 26 | 26 - $\overline{X}$ = 1.86 | 3.4596 |
| 21 | 21 - $\overline{X}$ = 3.14 | 9.8596 |
| 20 | 20 - $\overline{X}$ = -4.14 | 17.1396 |
| 25 | 25 - $\overline{X}$ = 0.86 | 0.7396 |
| 26 | 26 - $\overline{X}$ = 1.86 | 3.4596 |
| 27 | 27 - $\overline{X}$ = 2.86 | 8.1769 |

Now we will find the summation of the difference from the mean squared, to do this add together the number you found in the third column to find

$\Sigma(X - \overline{X})^2 =$ 43.0336

Now divide you're new value by n to find:

43.0336 / 7 = 6.1477

$\Sigma(X - \overline{X})^2/n =$ 6.1477

Now take the square root to get

$$\sigma = \sqrt{\frac{\Sigma\ (x - \overline{x})^2}{n}}$$

$\sigma =$ 2.48

What does a large standard deviation tell us about a data set?

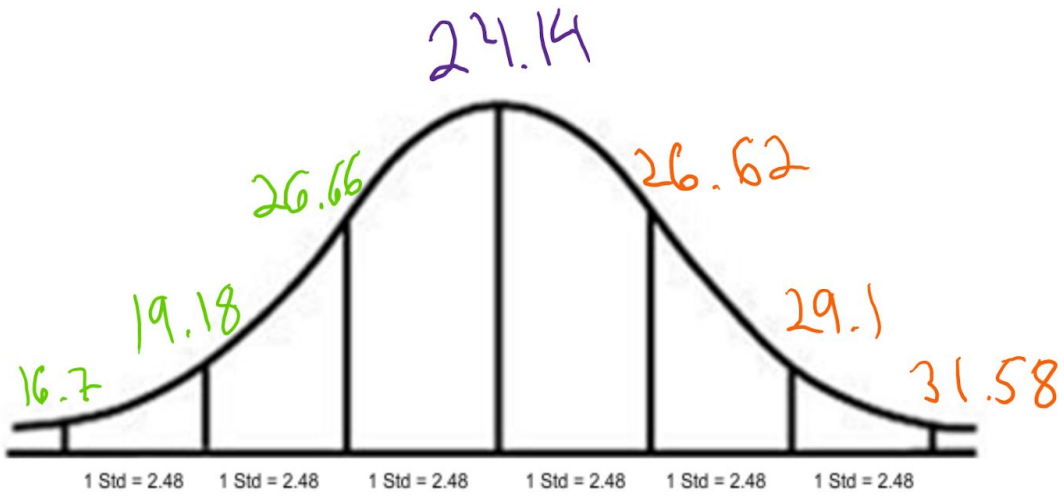
The data is more spread out.

What does a small standard deviation tell us about a data set?

The data is more clustered together.

The picture below is of a normal distribution curve. Each section is equivalent to 1 standard deviation (which we just calculated). The center line (at the highest point of the curve) is the mean. Using the calculations from above, label the mean on the graph. Also, compute and label the values at the other lines using the standard deviation and mean.

Normal Distribution Curve




How does the mean being the middle line on the graph relate to the median, and mode? What does this say about data in a normal distribution curve?

Here we can see that the mean, median, and mode are all the same value. This shows a good spread of data.

What percent of data points are 1 standard deviation from the mean? How about 2 and 3 standard deviations from the mean?

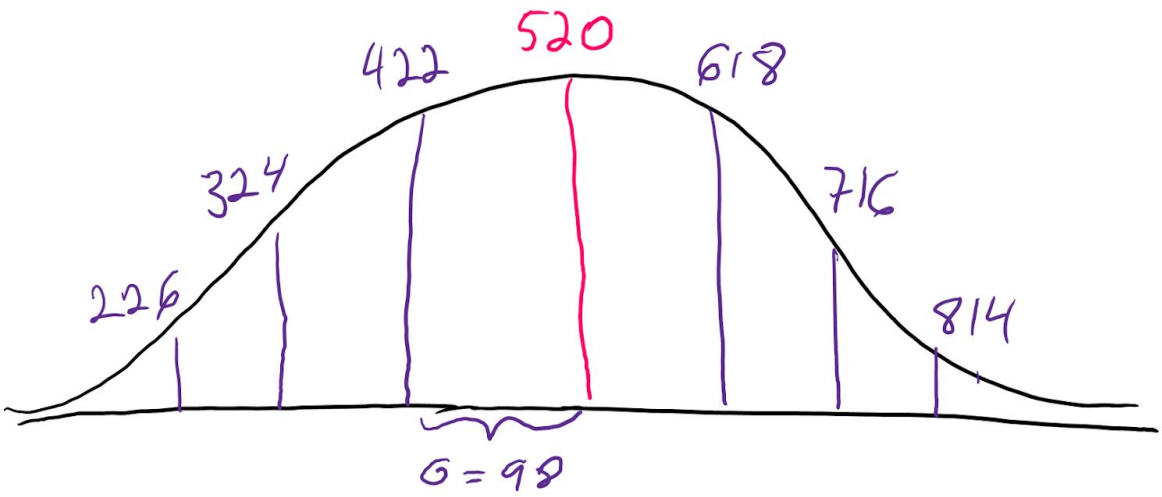
68% are within 1 standard deviation
95% are within 2 standard deviations
99.7% are within 3 standard deviations

How can standard deviation be helpful in data analysis?

Standard deviation allows us to see percentages of the population and where they fall on the curve. It allows gives us a visual representation of the data so we can interpret it qualitatively. It allows us to better understand the population in reference to the mean.

Say the mean score for the math portion of the SAT was 520 and has a standard deviation of 98. First, sketch a Normal Distribution Curve using the mean and standard deviation. Then, answer the following questions.

Sketch

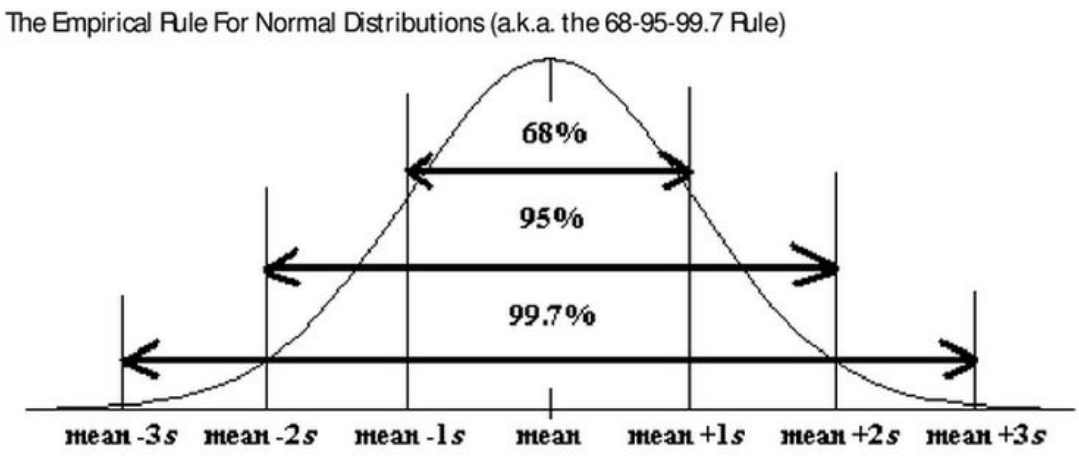



What percent of students scored higher than a 520?

50%

What was the median score?

520
The following picture is an illustration on the empirical rule.

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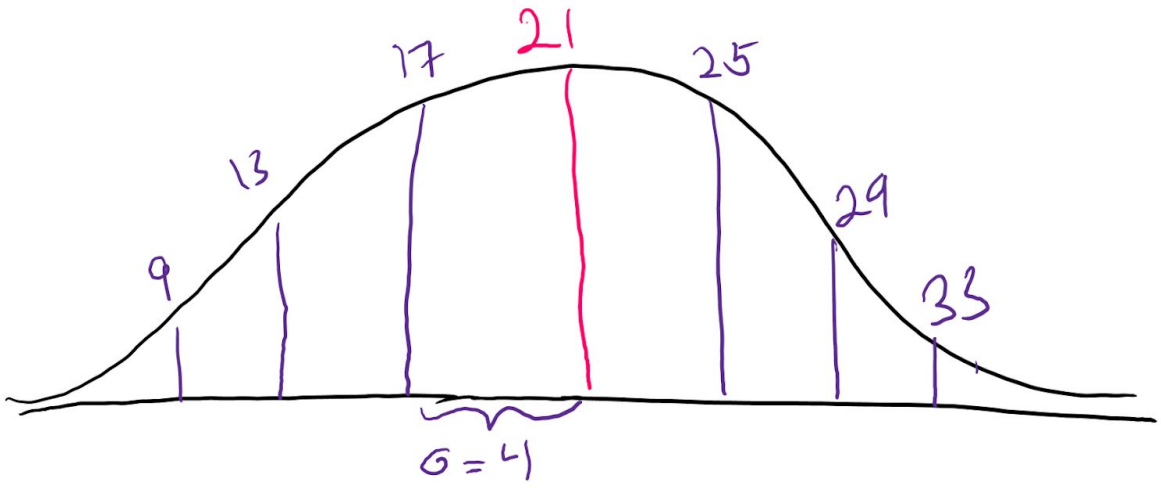


What percent took longer than 29 minutes?

30%

What percent took less than 29 minutes?

40%

What percent took between 13 and 29 minutes?

25%

What percent took between 13 and 25 minutes?

45%

What percent took longer than 17 minutes?

16%

Name:_____ANSWER KEY_____ Date:_____

Who Texts the Most? [6]

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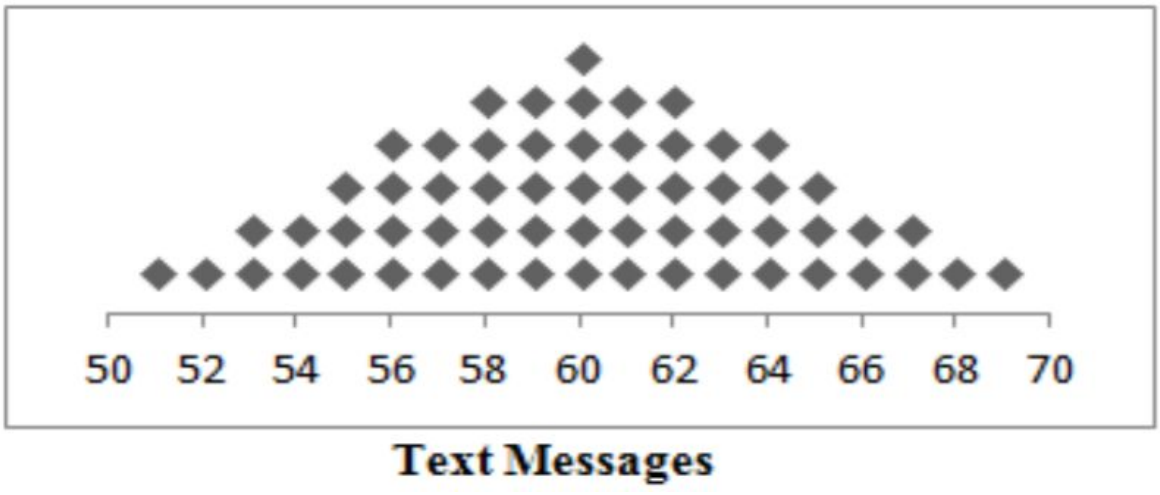
| 55, 65 | 3 |
| 53, 54, 66, 67 | 2 |
| 51, 52, 68, 69 | 1 |

Sketch of Distribution:



JAMAL - Bimodal Distribution with Mean = 60 and Standard Deviation = 39.78

| Number of Text Messages | Frequency |
|---|---|
| 40, 80 | 1 |
| 5, 35, 85, 115 | 2 |
| 10, 110 | 3 |
| 15, 30, 90, 105 | 4 |
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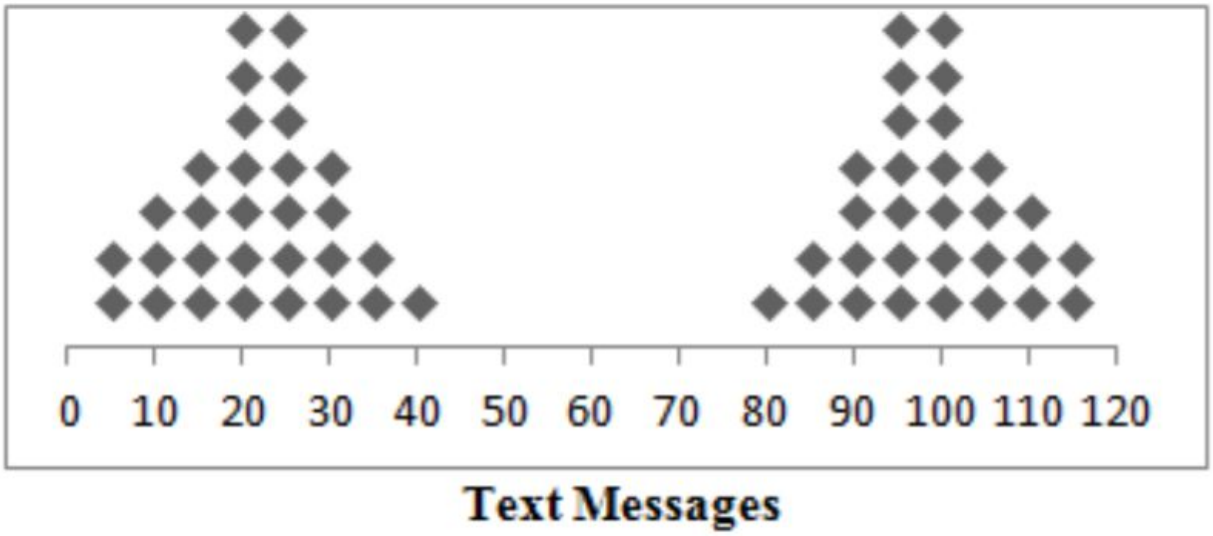
Sketch of Distribution:




IVY - Skewed Distribution with Mean = 74.25 and Standard Deviation = 31.36

| Number of Text Messages | Frequency |
|---|---|
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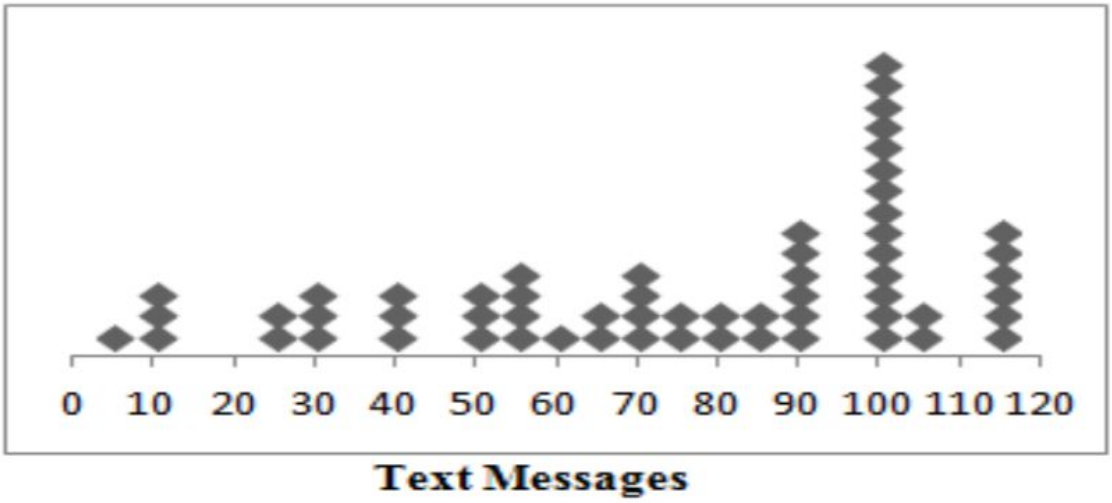
| 25, 65, 75, 80, 85, 105 | 2 |
| 10, 30, 40, 50 | 3 |
| 55, 70 | 4 |
| 90, 115 | 6 |
| 100 | 14 |

Sketch of Distribution:




TOM - Scattered Distribution with Mean = 60 and Standard Deviation = 35.64

| Number of Messages | Frequency |
|---|---|
| 45 | 1 |
| 0, 15, 75, 80, 90 | 2 |
| 5, 50 | 3 |
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| 10 | 6 |
| 70 | 8 |
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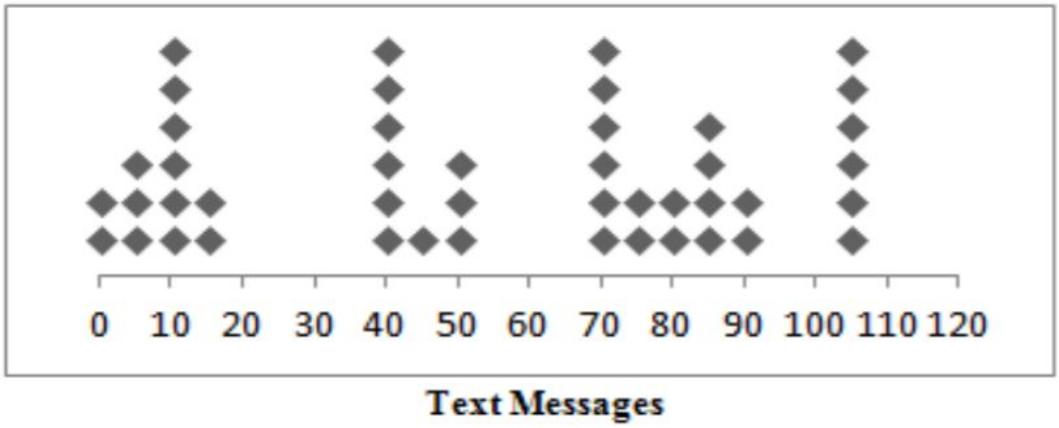
| 105 | 14 |

Sketch of Distribution:



Interpret the results by answering the following questions.

What happens to the shape of the sampling distributions as the size of the sample varies?

Students should conclude that, for each of the sampling distributions, the shape becomes closer to being normal as the size of the sample increases.

How is the shape of the sampling distribution related to the shape of the population from which the samples were drawn?

As the size of the sample increases, the shape of the sampling distribution resembles the shape of a normal distribution and no longer resembles the shape of the population distribution.

How do the population distributions compare to each other? Compare shape, center, and spread.

SHAPE: The population distribution for Sally is approximately normal, Jamal's is bimodal, Ivy's is skewed to the left, and Tom's is scattered.
CENTER: Sally's, Jamal's and Tom's population distributions all have mean $\mu = 60$, while the mean of Ivy's population distribution is considerably higher at $\mu = 74.25$.
SPREAD: The standard deviation of the population distribution for Sally is $\sigma = 4.18$, which is much smaller than the standard deviations of the other three, which range from $\sigma = 31.36$ for Ivy to $\sigma = 39.78$ for Jamal.

How do the sampling distributions compare to each other?

As the sample size increases, the shapes of all four sampling distributions become approximately normal. It should also be noted that the means of the sampling distributions for Sally, Jamal and Tom are approximately 60, while the mean of the sampling distribution for Ivy is considerably higher at approximately 74. Students should observe that the spreads of the sampling distributions for Jamal, Ivy and Tom are greater than the spread of the sampling distribution for Sally.

What are the means of the sampling distributions?

The means of the sampling distributions for Sally, Jamal and Tom should be approximately 60, while the mean of the sampling distribution for Ivy is approximately 74.25.

How would you describe the spread of the sampling distributions?

The spreads of all four sampling distributions decrease as the sample size increases.

How can you use this information to make a decision about which student texted more?

If students decide to use the mean as a way of comparison: since the mean number of text messages sent/received by Ivy was more than the mean number for Sally, Jamal and Tom, then Ivy was the student who sent/received the most text messages. Students can observe this result by observing the sampling distributions.

From the sampling distributions, students can discuss how likely it is that Sally, Jamal, Tom, and Ivy text message above a certain amount in a 60- day period. Students could also observe the population distributions and note that Ivy's distribution had a very large spread. This may suggest that Ivy had some peak activity of text messages on a few days but was not as consistent in her use as for example, Sally.

Students may provide potential descriptions of why the population text message data looks the way it does for the four students. For example, Jamal could have gone on vacation for a part of the 60 days where he had no phone usage, and Tom's distribution may suggest that he has some specific weekly patterns in his text usage.

Annotated Bibliography

[1] Lane, D. M. (n.d.). [2.0]. Retrieved from http://onlinestatbook.com/Online_Statistics_Education.pdf
This online textbook was used for reference within the Percentile and Distribution lesson plan as part of the Measurements and Data Analysis module. This reference aided in the completion of providing definitions for the key concepts and definitions sections as well as for the concept map activity. Examples and definitions from the textbook were used, compiled, and modified to create better clarity and on grade-level definitions. This book was useful because of its layout and completeness. The lesson expands upon the material used form this book as it uses the material in the creation of worksheets and activities that are not provided in the textbook.

[2] Standards Aligned System. (n.d.). Retrieved from https://www.pdesas.org/
This website was used in each lesson in the Measurements and Data Analysis module to select proper Pennsylvania State standards, which are based in Common Core, that each lesson is centered around.

[3] Standards for Mathematical Practice. (n.d.). Retrieved from http://www.corestandards.org/Math/Practice/
This website used in every lesson in the Measurements and Data Analysis module to find Standards for Mathematical Practices that are applicable in each lesson.

[4] Nsta. (n.d.). Disciplinary Core Ideas. Retrieved from https://ngss.nsta.org/DisciplinaryCoreIdeasTop.aspx
This website was used in each lesson in the Measurements and Data Analysis module to select appropriate disciplinary core ideas set forth by the NSTA that are at the center of each lesson.

[5] Nsta. (n.d.). Crosscutting Concepts. Retrieved from https://ngss.nsta.org/CrosscuttingConceptsFull.aspx
This website was used in each lesson in the Measurements and Data Analysis module to selecting appropriate crosscutting concepts set forth by the NSTA that apply to each mathematics lesson.

[6] Bargagliotti, B., & Gibson, J. (n.d.). Who Sends the Most Text Messages? Retrieved from https://www.amstat.org/asa/education/stew/home.aspx
This website and lesson plan was used for adaptation within the Percentiles and Distributions lesson in the Measurement and Data Analysis module. This reference aided in the completion of Standard and Normal Distribution worksheet as well as the Who Texts the Most? worksheet. Concepts were taken from the lesson as well as images, numbers, and figures. The concepts were then tailored to fit within the context of the lesson and unit.