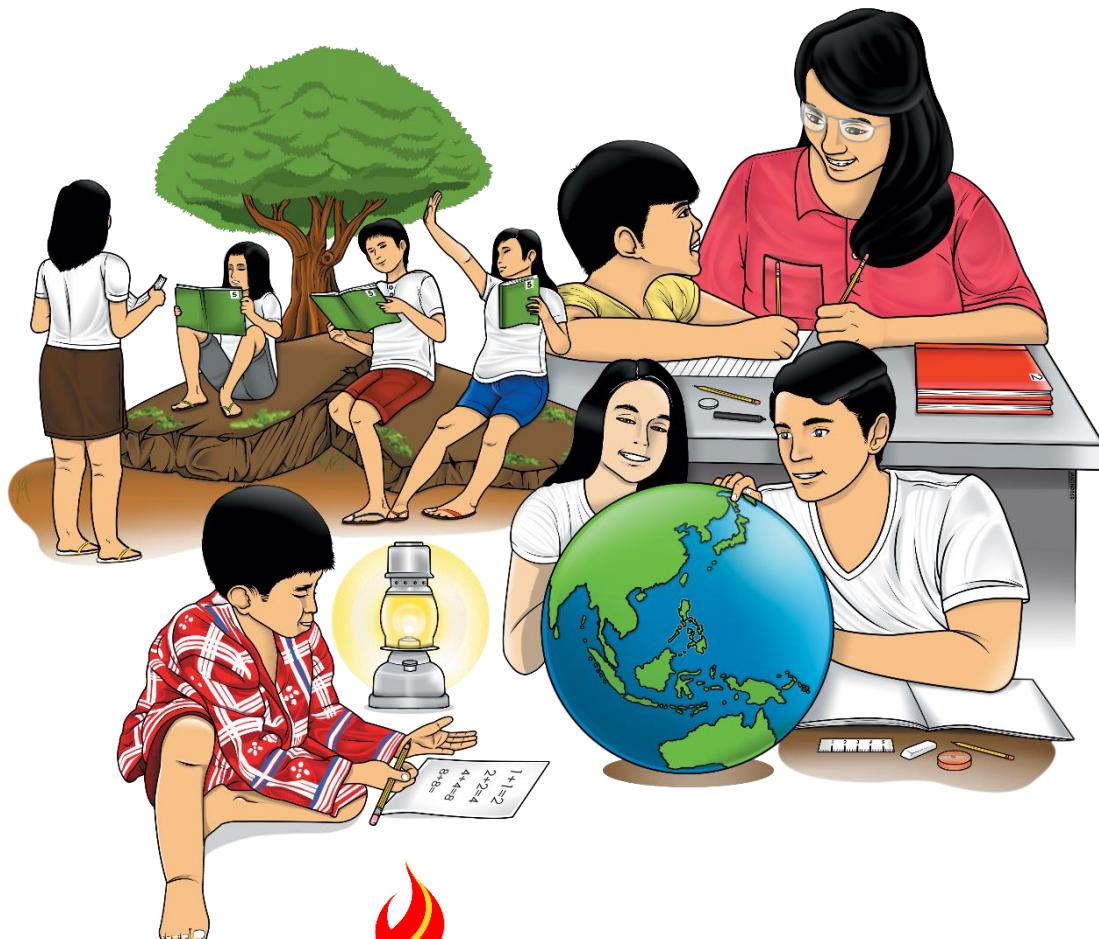


7

Mathematics

Quarter 4 – Module 5: Measures of Variability



Mathematics– Grade 7
Alternative Delivery Mode
Quarter 4 – Module 5: Measures of Variability
First Edition, 2020

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Mathematics

**Quarter 4 – Module 4:
Measures of Variability**

Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

Thank you.



What I Need to Know

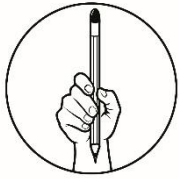
This module was designed and written with you in mind. It is here to help you learn about measures of variability. This module is designed to be self-sufficient for the current learning situation. The language used recognizes your vocabulary level. The lessons are arranged to follow the standard sequence of the course in the curriculum guide. However, the order in which you read them can be changed to correspond with the textbook you are now using.

In this module you will be able to:

- illustrate and calculate the measures of variability (range, average deviation, variance, standard deviation) of a statistical data.

After going through this module, you are expected to:

1. illustrate the measures of variability (range, average deviation, variance, standard deviation) of a statistical data;
2. describe the measures of variability (range, average deviation, variance, standard deviation) of a statistical data;
3. calculate the measures of variability of ungrouped data; and
4. calculate the measures of variability of grouped data.



What I Know

Select the correct answer. Write the letter on a separate sheet of paper.

For numbers 1-4, refer to the following frequency table.

Classes	f	x	fx	\bar{x}	$x - \bar{x}$	$(x - \bar{x})^2$	$f(x - \bar{x})$	$f(x - \bar{x})^2$
21-30	4	25.5	102	45	-19.5	380.25	78	1521
31-40	6	35.5	213	45	-9.5	90.25	57	541.5
41-50	2	45.5	91	45	0.5	0.25	1	0.5
51-60	3	55.5	166.5	45	10.5	110.25	31.5	330.75
61-70	5	65.5	327.5	45	20.5	420.25	102.5	2101.25
Total	$N = 20$		900					4495

- What is the range of the given data set?
A. 45
B. 50
C. 55
D. 40
- What is the average deviation of the given data set?
A. 12.5
B. 13.5
C. 14.5
D. 15.5
- What is the population variance of the given data set?
A. 222.75
B. 223.25
C. 224.75
D. 225.25
- What is the population standard deviation of the given data set?
A. 14.99
B. 15.79
C. 14.09
D. 15.69
- What is the sample variance of the given data set?
A. 250.41
B. 251.61
C. 252.43
D. 253.63
- What is the sample standard deviation of the given data set?
A. 15.86
B. 15.75
C. 15.64
D. 15.53

For numbers 7-12, Ricky did a survey of the number of mobile games played by his classmates, with the following results: {1, 2, 7, 3, 5, 6}

- What is the range of the given data set?
A. 5
B. 7
C. 6
D. 4

8. What is the average deviation of the given data set?
 A. 2 C. 6
 B. 4 D. 8
9. What is the population variance of the given data set?
 A. 5.67 C. 6.63
 B. 3.76 D. 4.67
10. What is the population standard deviation of the given data set?
 A. 2.61 C. 2.16
 B. 2.26 D. 2.21
11. What is the sample variance of the given data set?
 A. 5.8 C. 5.5
 B. 5.6 D. 5.7
12. What is the sample standard deviation of the given data set?
 A. 2.35 C. 2.37
 B. 3.35 D. 2.33
13. If the range of a set of scores is 10 and the lowest score is 6, what is the highest score?
 A. 16 C. 14
 B. 17 D. 15
14. What is the most reliable measure of variability?
 A. range C. average deviation
 B. variance D. standard deviation
15. What should be the divisor if given data set is an entire population?
 A. n C. $n+1$
 B. $n-1$ D. none of these

Lesson

1

Illustrates and Calculates the Measures of Variability (range, average deviation, variance and standard deviation) of a Statistical Data

In this lesson, we will illustrate and describe measures of variability. Also, we will learn how to calculate the measures of variability of ungrouped and grouped data sets.



What's In

In this part of the lesson, your knowledge about the measures of central tendency will be checked. Your learnings about this concept will help you understand measures of variability.

Activity 1: Solve me!

Instruction: Solve for the mean, median and mode of the ungrouped data set below.

16	15	18	15	14	10	12	15	11
----	----	----	----	----	----	----	----	----

1.

Mean:

Median:

Mode:

32	28	40	28	33	22	50	47
----	----	----	----	----	----	----	----

2.

Mean:

Median:

Mode:

115	145	130	143	127	135	135	155	105	110
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

3.

Mean:

Median:

Mode:



What's New

To introduce the idea of variability, observe the illustration below and answer the guide questions on a separate sheet of paper.

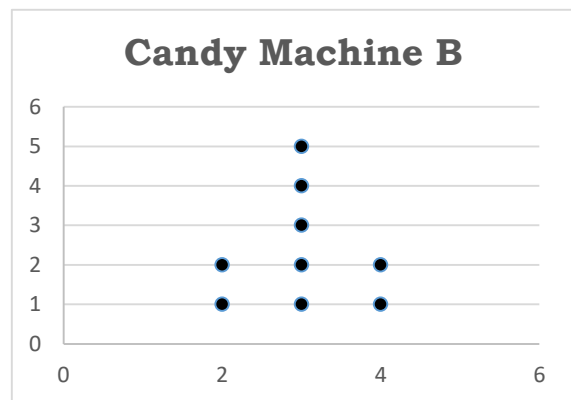
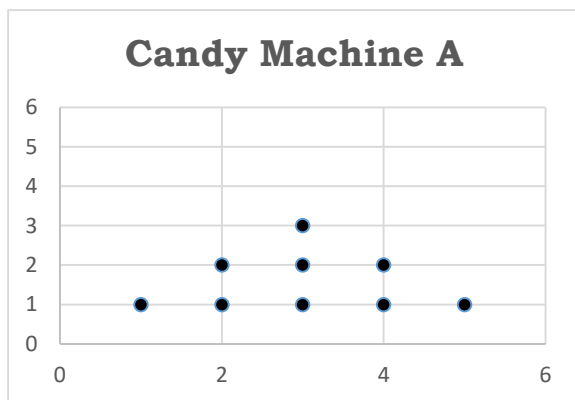
Activity 2: Compare and Answer!

Two candy machines A and B drop candies when 5-peso coin is inserted. In every 5-peso coin inserted, the machine will drop a random number of candies. John, did this 9 times in machine A and Jacob did the same in machine B. The results are as follows:

Candy Machine A: 2, 4, 3, 2, 5, 3, 4, 1, 3
Mean = 3, Median = 3, Mode = 3

Candy Machine B: 3, 4, 3, 3, 3, 2, 2, 3, 4
Mean = 3, Median = 3, Mode = 3

Below is a dot plot for the number of candies dropped from the candy machines.



Guide questions:

1. What is the difference between the two dot plots?
2. Which dot plot displays more spread?



What is It

Measures of Variability

Ungrouped Data

In statistics, variability refers to the spread in a set of data. From the activity **What's New**, the number of candies dropped by candy machine B are closely packed compared to the number of candies dropped by candy machine A. In other words, the data obtained from the candy machine A is more spread compared to the data obtained from the candy machine B.

The simplest way to measure the variability is the **range**. Range is suitable for showing the spread within a data set and for comparing the spread between similar data sets. To find the range we use the formula:

$$\text{Range} = \text{maximum value} - \text{minimum value}$$

Example:

Data Set A: 10, 9, 7, 7, 8, 9, 6, 7, 8

From the data set given above, the maximum value is 10 and the minimum value is 6. Thus, the range of the data set is,

$$\text{Range} = 10 - 6 = 4$$

Data Set B: 35, 40, 55, 48, 25, 31, 52

From our second data set, the maximum value is 55 and the minimum value is 25. Thus, the range of the data set is,

$$\text{Range} = 55 - 25 = 30$$

And by comparing the range of data sets, we can say that data set B is a more spread out compared to data set A because it has a larger range.

The next measure of variability is the **average deviation**. This measure tells us how far each data is from the mean. The following example illustrates how to compute the average deviation:

Example:

Data Set 1: 6, 8, 5, 5, 6

First we need to calculate for the mean. So,

$$\bar{x} = \frac{6+8+5+5+6}{5} = \frac{30}{5} = 6$$

Next, we subtract the mean from every value in our data set. Then take the absolute value of the results.

$$\begin{aligned}x - \bar{x} &= 6 - 6 = 0 \rightarrow |0| = 0 \\x - \bar{x} &= 8 - 6 = 2 \rightarrow |2| = 2 \\x - \bar{x} &= 5 - 6 = -1 \rightarrow |-1| = 1 \\x - \bar{x} &= 5 - 6 = -1 \rightarrow |-1| = 1 \\x - \bar{x} &= 6 - 6 = 0 \rightarrow |0| = 0\end{aligned}$$

Lastly, solve for the average deviation by taking the sum of the absolute values obtained, divided by the total number of data

$$\text{Average Deviation} = \frac{0+2+1+1+0}{5} = \frac{4}{5} = 0.8$$

Another measure of variability is the **variance**. It measures how far a set of numbers is spread out from the mean. To calculate the variance, we use the formula:

$$\text{For population, } \sigma^2 = \frac{\sum(x-\bar{x})^2}{N}$$

$$\text{For sample size, } s^2 = \frac{\sum(x-\bar{x})^2}{n-1}$$

Example:

Solve for the variance of the given data set below (assuming that the data set is the entire population).

Data Set: 10, 15, 25, 10, 12, 18

First, calculate the mean of the data set,

$$\bar{x} = \frac{10+15+25+10+12+18}{6} = \frac{90}{6} = 15$$

Next, solve for $\sum(x - \bar{x})^2$. To get the sum of squares, subtract the mean from each values, square it and add them all.

$$\begin{aligned}(x - \bar{x})^2 &= (10 - 15)^2 = (-5)^2 &= 25 \\(x - \bar{x})^2 &= (15 - 15)^2 = (0)^2 &= 0 \\(x - \bar{x})^2 &= (25 - 15)^2 = (10)^2 &= 100 \\(x - \bar{x})^2 &= (10 - 15)^2 = (-5)^2 &= 25 \\(x - \bar{x})^2 &= (12 - 15)^2 = (-3)^2 &= 9\end{aligned}$$

$$\begin{aligned} (x - \bar{x})^2 &= (18 - 15)^2 = (3)^2 &= \frac{9}{} \\ \sum(x - \bar{x})^2 &= 168 \end{aligned}$$

Lastly, solve for the population variance by using the formula,

$$\sigma^2 = \frac{\sum(x-\bar{x})^2}{N} = \frac{168}{6} = 28$$

Conversely, if the data set is just a sample of an entire population then we will use the formula for the sample variance,

$$s^2 = \frac{\sum(x-\bar{x})^2}{n-1} = \frac{168}{5} = 33.6$$

The last measure of variability for this lesson is the square root of the variance called the **standard deviation**. It measures the spread around the mean making it the most reliable measure of variability. In symbols,

$$\text{For population, } \sigma = \sqrt{\sigma^2}$$

$$\text{For sample size, } s = \sqrt{s^2}$$

Let us use the same data set from our previous example,

Data Set: 10, 15, 25, 10, 12, 18

We already found out that the variance for this data set is,

<u>If Population</u>	<u>If Sample</u>
$\sigma^2 = \frac{\sum(x-\bar{x})^2}{N} = \frac{168}{6} = 28$	$s^2 = \frac{\sum(x-\bar{x})^2}{n-1} = \frac{168}{5} = 33.6$

To get the standard deviation we'll just take the square root of the variance. We have,

$$\begin{aligned} \sigma &= \sqrt{\sigma^2} \\ \sigma &= \sqrt{28} \\ \sigma &= 5.29 \end{aligned}$$

$$\begin{aligned} s &= \sqrt{s^2} \\ s &= \sqrt{33.6} \\ s &= 5.8 \end{aligned}$$

Grouped Data

This section of the module will discuss measures of variability of grouped data. Let's use the following grouped data to illustrate and compute for the different measures of variability.

Classes	Frequency
10 – 14	5
15 – 19	2
20 – 24	6
25 – 29	7
30 – 34	5

Let us begin with the **range** of the grouped data above. The range is still the difference between the maximum and minimum values. However, as we take the maximum and the minimum values we need to consider the class boundaries.

The largest upper class boundary is 34.5 and the smallest lower class boundary is 9.5. Before we calculate the range, we will, add 0.5 to the maximum value and subtract 0.5 to the minimum value. Now we have,

$$\begin{aligned}\mathbf{Range} &= \text{largest upper class boundary} - \text{smallest lower class boundary} \\ &= 34.5 - 9.5\end{aligned}$$

$$\mathbf{Range} = 25$$

For the **average deviation** of our grouped data, we will add some columns to our frequency distribution table,

Classes	Frequency (f)	Midpoint (x)	fx	$x - \bar{x}$	$ x - \bar{x} $	$f x - \bar{x} $
10 – 14	5	12	60	-11	11	55
15 – 19	2	17	34	-6	6	12
20 – 24	6	22	132	-1	1	6
25 – 29	7	27	189	4	4	28
30 – 34	5	32	160	9	9	45

$$N = 25$$

First, we need to calculate the midpoint(x) values. To calculate the values of our midpoint, we'll take the mean of every class limit in an interval. To do that we, add each lower boundary values to its respective upper boundary values and divide it by two. Observe the process below,

<u>Lower Limit</u>	<u>Upper Limit</u>	<u>Midpoint(x)</u>
10	14	$\frac{10+14}{2} = 12$
15	19	$\frac{15+19}{2} = 17$
20	24	$\frac{20+24}{2} = 22$
25	29	$\frac{25+29}{2} = 27$
30	34	$\frac{30+34}{2} = 32$

Now that we are done with the midpoint, we will now compute for the values under ***fx***. To obtain these values, all we need to do is to multiply each frequency values to its respective midpoint values.

<u>Frequency (f)</u>	<u>Midpoint(x)</u>	<u>fx</u>
5	12	(5) (12) = 60
2	17	(2) (17) = 34
6	22	(6) (22) = 132
7	27	(7) (27) = 189
5	32	(5) (32) = 160

Next, we solve for the mean (\bar{x}). To get the mean, add all the values in *fx* column and divide it by the total number of data (*N*).

$$\bar{x} = \frac{60+34+132+189+160}{25} = \frac{575}{25} = 23$$

Then, we take the difference between the values of midpoint(*x*) and the mean (\bar{x}). Get the sum of the absolute values and multiply it by the frequency (*f*).

<i>x</i>	-	\bar{x}	=	$x - \bar{x}$	→	$ x - \bar{x} $	<i>f</i> $ x - \bar{x} $
12	-	23	=	-11	→	$ -11 = 11$	(5) (11) = 55
17	-	23	=	-6	→	$ -6 = 6$	(2) (6) = 12
22	-	23	=	-1	→	$ -1 = 1$	(6) (1) = 6
27	-	23	=	4	→	$ 4 = 4$	(7) (4) = 28
32	-	23	=	9	→	$ 9 = 9$	(5) (9) = 45

Lastly, we can now solve for the average deviation by getting the sum of all the values in $f|x - \bar{x}|$ and divide it by the total number of data (N).

$$\text{Average Deviation} = \frac{55 + 12 + 6 + 28 + 45}{25} = \frac{146}{25} = 5.84$$

Hence, the average deviation of the grouped data is 5.84.

For the **variance** and **standard deviation**, we need to square the difference between the midpoint and the mean.

We already found the value of our mean from the solution that we've had from the average deviation. Recall that our computed mean is 23.

Classes	Frequency (f)	Midpoint (x)	fx	$x - \bar{x}$	$(x - \bar{x})^2$	$f(x - \bar{x})^2$
10 – 14	5	12	60	-11	121	605
15 – 19	2	17	34	-6	36	72
20 – 24	6	22	132	-1	1	6
25 – 29	7	27	189	4	16	112
30 – 34	5	32	160	9	81	405

$$N = 25$$

The square of the difference between the midpoint and the mean is found in the column labeled $(x - \bar{x})^2$. To solve for this, observe the solution below.

$$\begin{aligned} (-11)^2 &= (-11) (-11) = 121 \\ (-6)^2 &= (-6) (-6) = 36 \\ (-1)^2 &= (-1) (-1) = 1 \\ (4)^2 &= (4) (4) = 16 \\ (9)^2 &= (9) (9) = 81 \end{aligned}$$

Afterwards, we will multiply these values to its respective frequency.

$$\begin{aligned} f(x - \bar{x})^2 \\ (5) (121) &= 605 \\ (2) (36) &= 72 \\ (6) (1) &= 6 \\ (7) (16) &= 112 \\ (5) (81) &= 405 \end{aligned}$$

Then, we take the sum of the values above and use this slightly modified formula for the population variance,

$$\sigma^2 = \frac{\sum f(x - \bar{x})^2}{N} = \frac{605 + 72 + 6 + 112 + 405}{25} = \frac{1200}{25} = 48$$

As for the standard deviation, remember that it's just the square root of the variance. To get the standard deviation of our grouped data, we have,

$$\begin{aligned} \sigma &= \sqrt{\sigma^2} \\ \sigma &= \sqrt{48} \\ \sigma &= 6.93 \quad \text{*rounded to the nearest hundredths} \end{aligned}$$

Note that we actually assumed that our grouped data to be the entire population. But if assumed that it is not, we will use the sample variance formula.

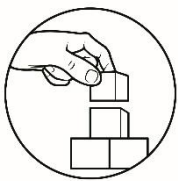
$$s^2 = \frac{\sum f(x - \bar{x})^2}{n - 1}$$

Assuming that our grouped data is just the sample size of the entire population, the solution would be,

$$s^2 = \frac{\sum f(x - \bar{x})^2}{n - 1} = \frac{605 + 72 + 6 + 112 + 405}{25 - 1} = \frac{1200}{24} = 50$$

And our standard deviation is,

$$\begin{aligned} s &= \sqrt{s^2} \\ s &= \sqrt{50} \\ s &= 7.07 \quad \text{*rounded to the nearest hundredths} \end{aligned}$$



What's More

Compute for the range, average deviation, variance and standard deviation of each set of ungrouped data considering that these are samples data sets. Write your answers on a separate answer sheet and round your answers to the nearest hundredths.

1) 7, 12, 11, 8, 13, 9

Range: _____ Ave. Dev.: _____ Variance: _____ Standard Dev.: _____

2) 18, 17, 24, 24, 17, 25, 24, 22, 24, 25

Range: _____ Ave. Dev.: _____ Variance: _____ Standard Dev.: _____

3) 2, 7, 2.5, 3.2, 3.6, 3.8, 3.3, 2.3

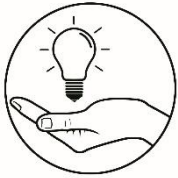
Range: _____ Ave. Dev.: _____ Variance: _____ Standard Dev.: _____

4) 1.81, 1.63, 1.42, 1.8, 0.95, 0.76, 1.23, 1.15, 1.24

Range: _____ Ave. Dev.: _____ Variance: _____ Standard Dev.: _____

5) 92, 92, 89, 88, 81, 91, 93, 90, 95, 87

Range: _____ Ave. Dev.: _____ Variance: _____ Standard Dev.: _____

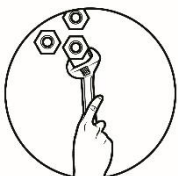


What I Have Learned

Fill in the missing word in the blank. Choose the correct answer from the box.

range	variability variance	average deviation standard Deviation
--------------	---------------------------------------	---

1. It is suitable for showing the spread within a data set and for comparing the spread between similar data sets.
2. It refers to the spread in a set of data.
3. This measure tells us how far each data is from the mean.
4. It measures how far a set of numbers is spread out from the mean.
5. It measures the spread around the mean making it the most reliable measure of variability.



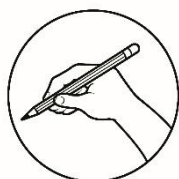
What I Can Do

Use the appropriate formula to find the average deviation and standard deviation of the grouped data set below.

Scores of contestants during MMC (Metrobank-MTAP-DepEd Math Challenge)

Scores	Frequency
16-20	5
21-25	1
26-30	17
31-35	10
36-40	15
41-45	21
46-50	16

$N = 85$



Assessment

Select the correct answer. Write the letter on a separate sheet of paper.

For numbers 1-4, refer to the data below. Choose the letter of the correct answer:

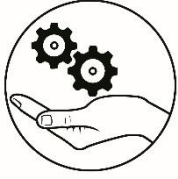
Classes	f	x	fx	\bar{x}	$x - \bar{x}$	$(x - \bar{x})^2$	$f(x - \bar{x})$	$f(x - \bar{x})^2$
1-10	1	5.5	5.5	25.5	-20	400	20	400
11-20	3	15.5	46.5	25.5	-10	100	30	300
21-30	3	25.5	76.5	25.5	0	0	0	0
31-40	1	35.5	35.5	25.5	10	100	10	300
41-50	2	45.5	91	25.5	20	400	40	800
Total	$N = 10$		255					1800

- What is the range of the given data set?
 A. 50
 B. 45
 C. 30
 D. 40
- What is the average deviation of the data set?
 A. 10
 B. 11
 C. 12
 D. 13
- What is the population variance of the given data set?
 A. 158.5
 B. 160
 C. 162.5
 D. 164
- What is the population standard deviation of the given data set?
 A. 12.56
 B. 14.28
 C. 12.65
 D. 16.65

5. What is the sample variance of the given data set?
 A. 177.78 C. 178.88
 B. 187.77 D. 187.87
6. What is the sample standard deviation of the given data set?
 A. 13.23 C. 13.33
 B. 13.32 D. 12.33

For numbers 7-12, Mike did a survey about the variety of plants owned by his neighbors, with the following results: {4, 2, 7, 1, 6}

7. What is the range of the given data set?
 A. 5 C. 6
 B. 7 D. 4
8. What is the sample variance of the given data set?
 A. 6.4 C. 6.6
 B. 6.5 D. 6.7
9. What is the sample standard deviation of the given data set?
 A. 2.55 C. 2.45
 B. 2.50 D. 2.40
10. What is the average deviation of the given data set?
 A. 8 C. 4
 B. 6 D. 2
11. What is the population variance of the given data set?
 A. 5.4 C. 6.3
 B. 4.5 D. 5.2
12. What is the population standard deviation of the given data set?
 A. 3.28 C. 4.27
 B. 2.29 D. 1.26
13. If the range of a set of scores is 10 and the lowest score is 5, what is the highest score?
 A. 25 C. 10
 B. 15 D. 30
14. The process of finding the range of a given data set is?
 A. maximum \div minimum C. minimum \times maximum
 B. maximum + minimum D. maximum – minimum
15. Standard deviation is the square root of?
 A. range C. average deviation
 B. variance D. total frequency



Additional Activities

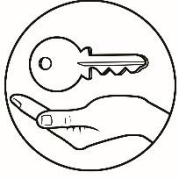
1. Mr. Santos, a teacher at a very small private school, assigns statistics practice problems to be worked via the net. All Grade 7 students must use a password to access the problems and the time of log-in and log-off are automatically recorded for the teacher. At the end of the week, the teacher examines the amount of time each student spent working the assigned problems. The data is provided below in minutes.

15, 28, 25, 48, 22, 43, 49, 34, 22, 33, 27, 25, 22, 20, 39

Find the ***range, average deviation, variance & standard deviation*** of the recorded data above.

2. A sample of high school students were asked how much they spent on a Piso WiFi everyday during their online classes.

Daily Piso WiFi Cost	Number of Students
10 - 19	8
20 - 29	16
30 - 39	21
40 - 49	11
50 - 59	4



Answer Key

Assessment		
1. A	6. C	11. D
2. A	7. C	12. B
3. B	8. B	13. B
4. C	9. B	14. D
5. A	10. A	15. B

<p>What I Have Learned</p> <ol style="list-style-type: none"> 1. Range 2. Variability 3. Average 4. Deviation 5. Variance 5. Standard Deviation 	<p>Lesson 1</p> <p>What Can I Do</p> <ol style="list-style-type: none"> 1. Average Deviation = $\overline{7.24}$ 2. Standard Deviation = $\overline{8.57}$
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What's More			
1. Range: 6	Ave.Dev: 2	Variance: 5.6	Standard Dev: 2.37
2. Range: 8	Ave.Dev: 2.8	Variance: 11.11	Standard Dev: 3.33
3. Range: 5	Ave.Dev: 1.00	Variance: 2.45	Standard Dev: 1.57
4. Range: 1.05	Ave.Dev: 0.30	Variance: 0.13	Standard Dev: 0.37
5. Range: 14	Ave.Dev: 2.84	Variance: 15.29	Standard Dev: 3.91

<p>What I Know</p> <ol style="list-style-type: none"> 1. B 2. B 3. C 4. A 5. B 6. A 7. C 8. A 9. D 10. C 11. B 12. C 13. A 14. D 15. A 	<p>Lesson 1</p> <p>What's In</p> <ol style="list-style-type: none"> 1. Mean = 14 Median = 15 Mode = 15 2. Mean = 35 Median = 32.5 Mode = 28 3. Mean = 130 Median = 132.5 Mode = 135 	<p>What's New</p> <ol style="list-style-type: none"> 1. The spread 2. Candy Machine A
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References

Insigne, Ligaya, et.al, Creative Mathematics 7. (Quezon City: Mission book Publishing, Inc., 2013), pp. 76-79

Mathematics – Grade 7 Learner’s Material First Edition, 2013, ISBN: 978-971-999060-4, pp. 76- 82.

Padilla, John Richard C., Empowering Through Math 7 First Edition. (Quezon City: Ephesians Publishing Inc., 2017), pp. 119- 127.

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