CASIO

Using Spreadsheets to Calculate the Mean and the Standard Deviation

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LEVEL
High school or university students with basic knowledge in Mathematics.

OBJECTIVES
To use the calculator's built-in spreadsheet tool to make elementary statistical evaluations for real-life problems.

Corresponding eActivity
S01MEAN.g1e (for Activity1), S01DEVIA.g1e (for Activity2)

OVERVIEW
We will see how to collect data for a statistical evaluation with the use of calculator and how to evaluate their simplest characteristics.

EXPLORATORY ACTIVITIES
[Note]
We shall use small letter *x* instead of capital X as shown on the calculator throughout the paper.

Here we describe two activities. For their mathematical background refer for example to [LM], page 63-64 and 88-90.

Activity 1 (S01MEAN.g1e):
Frequently, a mass of real-life data must be described using a single value (or very few values). The *mean* (also called the *average value*) is likely the most popular among these characteristics. Its formula is rather simple:

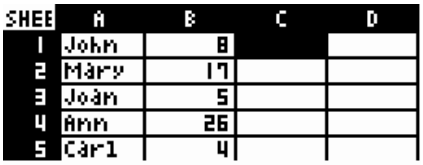
$$\mu = \frac{\sum_{i=1}^{n} x_i}{n}$$

where the Greek letter μ (pronounced "mu") stands for the mean, x_i stands for a particular value (of the measured or evaluated set of elements), $\sum$ is the Greek capital "sigma" and indicates the summation of all measured elements. Their total number is n; the symbols below and above $\sum$ indicated that all – starting from the 1st to nth must be included into the sum.

a) How to calculate the mean?
b) What is its meaning?
c) What does it describe in real-life problems?

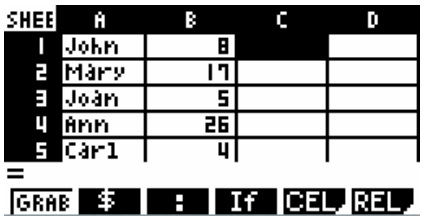
Solution:
Thus, the mean is produced in the following way: *All discussed values are added. The intermediate result is then divided by their number*. *The obtained value is the mean.*

(a) (Refer to Five Students) Upon a mutual agreement, five students measured the time they spend on their morning walk to school. Their data are stored in the table and their mean is evaluated. Their names and the times are shown in the columns A and B, respectively. To calculate the mean into cell C1, move the cursor to it.



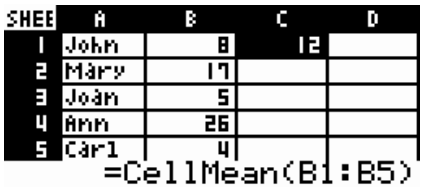
SHEE	A	B	C	D
1	John	8		
2	Mary	17		
3	Joan	5		
4	Ann	26		
5	Carl	4		

To calculate the mean, a built-in spreadsheet function must be used. Start as usual when typing a formula i.e. press [SHIFT] [•] to get the symbol "=" in the beginning of the edit line. The function menu should now look as follows.



Press now [F5] (CEL) to get the menu with six built-in spreadsheet functions:

Press [F3] (Mean). Type the range of its values – B1 to B5 in our case – and press [EXE]. The result appears.



Notice that typing the function name and parameters "=CellMean(B1:B5)" gives an optically identical result, but ends up with an error message. The mean function *must* be selected from the menu.

(b) (Refer to Modify One) Increase one of the values by 1. What happens to the average? Do changes of different values in the column B have different effects?

(c) (Refer to Modify All) Increase all values by 1. What happens to the average?

EXERCISES A

Exercise 1.
Discuss the results of two previous activities. How does the change of *one* value by 1 affect the mean? How does the change of *all* values by 1 affect the mean? Explain your observations.

Exercise 2.
The mean of a set of values is 63. Increase one value by 5. Decrease another value by 5. Predict the value of their mean.

SOLUTIONS to EXERCISES A

Exercise 1.
Increasing one value by 1 changes the mean by 1/n. Increasing all values by 1 increases the mean by 1.

Exercise 2.
The increment and decrement "neutralize" each other. The mean value remains the same.

(d) (Refer to Shoe Size) Ask all your classmates to report their shoe size. Type their answers into a spreadsheet. Calculate the average shoe size of your class.

(e) (Refer to All Sizes) Using a balance, weigh out one shoe of every student of your class. Put their weights into a sheet. Calculate the mean.

(f) (Refer to Same Size) Select all students with the shoes of the same shoe size. Weigh out their shoes. Calculate their mean. (Different students should preferably select different sizes for this activity.)

EXERCISES A

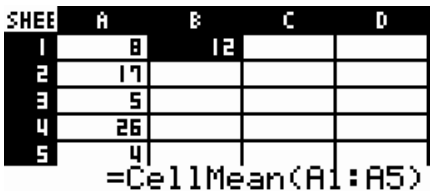
Exercise 3.
Compare the results of the activities *Shoe weight* and *Same Size*. Can you observe

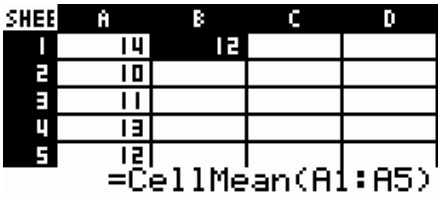
differences? Discuss.

SOLUTIONS to EXERCISES A
Exercise 3.
If the size of shoes is close to the mean of sizes, their mean weight be close to the mean weight of all shoes. The bigger is the difference of sizes from their mean, the bigger difference in weights one can expect.

Activity 2 (S01DEVIA.g1e):

Look at the two sets of figures. Both have the same mean (i.e. 12).





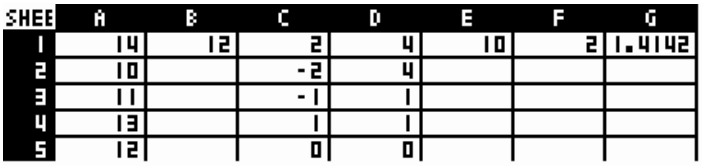
You likely feel that there is a difference in their quality. The values in the column A in the left table are more scattered, whilst those in the right one are positioned "more densely around the mean". We will refer to them as to "Scattered Set" and "Dense set".

We can express our feeling with a number: The degree of "diffusion" of a set of values from its mean is expressed by its *standard deviation*. The standard deviation is calculated using the formula

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \mu)^2}{n}}$$

(a) (Refer to Dense set) The calculation of the standard deviation is executed using the following steps[1]:

1. Calculate the mean – see B1.
2. Calculate all differences between the values and the mean. (When copying the formula from C1, refer to B1 using its absolute address B1 - see the column C.)
3. Square them (the column D).
4. Sum the squares (the cell E1).
5. Divide the result by the number of elements (the cell F1).
6. Calculate the square root of the intermediate result (the cell G1).



[1] The size of the screen has been artificially expanded using a graphic editor.

The standard deviation of *Dense Set* is 1.4142.

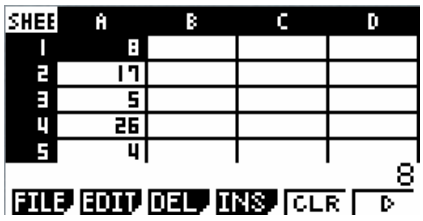
(b) (Refer to Scattered Set) Let us calculate the same value for Scattered Set. Notice that its mean – the value in B1 - is identical. The same calculation produces a different result:

SHEET	A	B	C	D	E	F	G
1	8	12	-4	16	350	70	8.3666
2	17		5	25			
3	5		-7	49			
4	26		14	196			
5	4		-8	64			

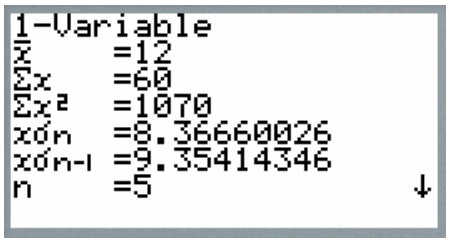
The standard deviation is now much larger because the input values are more dispersed. It equals 8.3666.

(c) (Refer to Using CALC Tool) The above calculations explain "the complete way" to the standard deviation. But it needs not to be evaluated in such a detailed manner. The spreadsheet supports a function that performs the direct calculation.

Let us start for example with data from *Scattered Set*. Its values occupy the A column.



Press F6 (for going to the extended menu). In the extended menu, press F2 (CALC – to display its submenu). In the submenu select F1 (1VAR). The new window is displayed:



Its rows have the following meanings:

1. The first row contains the text "1-Variable" indicating that one column was used in the calculations. (It is always the column in which the cursor is located.)
2. The second row shows the sum of all values in the column.
3. The third column shows the sum of their squares.
4. The fourth column contains the standard deviation. (We know it in its rounded format as 8.3666).
5. The fifth column contains another characteristic of the set called *sample standard deviation*.

6. The sixth row informs about the number of elements in the set.

(d) (Refer to Modify two) The sheet contains *Scattered Set*. The calculation is executed in identical manner as in the above cases i.e. the standard deviation is in G1.
Select randomly two cells in the column A. Increase one value by 7. Decrease one other value by 7. The mean remains the same. What happens to the standard deviation?

(e) (A class activity - refer to Different Pairs) Let us start again with original *Scattered Set*. Split the class into four groups of students. Each group will change a different pair of cells:

1. Increase A1 by 4; decrease A4 by 4.
2. Decrease A1 by 4; increase A4 by 4.
3. Increase A2 by 6; decrease A3 by 6.
4. Decrease A2 by 6; increase A3 by 6.

Notice that all pairs of operations preserve the mean.
Each group should refer to the others what happened to the standard deviation: Did it grow? Did it decline?

EXERCISE B

Exercise 1.
Make a hypothesis on how the changes of paired values manipulate the standard deviation. Test your hypothesis: Find a pair of values that increases it as well as a pair that will decrease it.

SOLUTION to EXERCISE B
Exercise 1.
When the change moves each value in the pair close to the mean, the standard deviation becomes smaller. When each value goes farther from the mean, the deviation grows.

REFERENCE

[LM] Douglas A. Lind and Robert D. Mason, *Basic Statistics for Business and Economics*, Irwin/McGraw-Hill, 1997. ISBN 0-256-19408-4

