Short Communication

Scientific calculators: How best to use in statistical problem solving

K. Balasubramanian
Retired Professor of Biostatistics, Chennai, Tamilnadu, India

Corresponding Author: K. Balasubramanian, E-mail: balamanidhanam@gmail.com

Received: 21/11/2024; Revised: 16/12/2024; Accepted: 18/12/2024; Published: 29/01/2025

Abstract
Scientific calculators could be used effectively in data analysis in biological research. Scientists often use calculators to perform statistical calculations like mean, median, standard deviation and more complex regression analysis to analyze experimental results. This paper outlines the necessary steps for using scientific calculators, specifically in statistical calculations, in order to make the process more accessible and beneficial for students.

Keywords: Scientific calculator, standard deviation, means, median, regression analysis.

Introduction

It was found from my teaching experience that students not only from biological science stream but also from mathematical science stream are not using scientific calculators effectively (Figure 1). The aim of this article is to enlighten the best benefits of scientific calculators for students while solving statistical problems. [1,2]

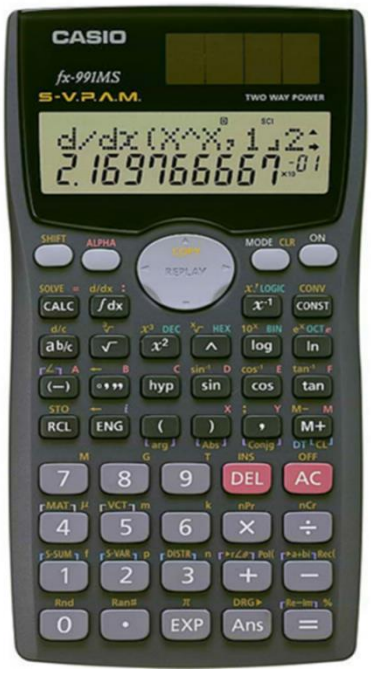

Figure 1: *Scientific calculator IS fx 991 MS*

STEPS FOR USING A SCIENTIFIC CALCULATOR

1. ERASE MEMORY STORAGE

This is done by

Click "SHIFT KEY". Then click "MODE / CLR" key

In display: you can see

1 2 3

Mc1 Mode All

Press "3", then = and Press "AC" Key.

2. SETTING CALCULATOR FOR STATISTICAL CALCULATIONS

A. To calculate AM [or Mean] & SD [Standard deviation]

This is done by setting "SD" Mode.

For this, Click "MODE" once. Check the display.

If SD is not seen, Click once more.

Now you will see "SD". You can also see a number below "SD".

Now Click that number. If the number is "2" Click number "2".

If the number is "1" Click number "1" in the number key.

Now, in the display you will see "SD".

Also, you will see "D". Do not worry about this. Let it be there.

I. Entering data

As an example:

Find SD of 2, 3, 4, 5, 6

Click "2" in the number key and then click "M+" key.

Now the display will be "n = 1"

Then, click "3" and Click "M+".

Now the display will be "n = 2"

Go on entering like that.

When you finish pressing "6" and "M+" key, the display will be "n = 5". Now, data entry over.

Now, you have entered all values in calculator memory.

II. Getting Σ x, Σ x^2 for the calculations using the formulas.

Press "Shift" { note the color } key and then Number "1" key[you can see "S-SUM" above it { note the color }] key.

The display will be

Σ x^2 Σ x n

1 2

2

Now, press "1" and then "=" key to get Σ x^2 which will be = 90 in the display.

Again, Press "Shift" and then Number "1" keys. Now, Press "2" and "=" to get Σ x which will be = 20. Press "shift" and Number "3" to get "n" which will be = 5

III. Calculating AM and SD

Use the formula as follows

$$AM = \frac{\sum x}{n} = \bar{x} = \frac{20}{5} = 4$$

The SD formula used is from

$$SD = \sqrt{\frac{\sum (x-\bar{x})^2}{n}} \quad (1)$$

$$S = SD = \left\{ \sqrt{\frac{\sum (x^2)}{n} - \left(\frac{\sum x}{n} \right)^2} \right\}$$

$$= \sqrt{\frac{90}{5} - (\frac{20}{5})^2} = \sqrt{18 - 16} = \sqrt{2} = 1.4142$$

If someone wish to use the formula for SD as

$$\sqrt{\frac{\sum (x-\bar{x})^2}{n-1}} \quad (2),$$

Then calculate it using S * $\sqrt{\frac{n}{n-1}}$ { 'S' calculated as per formula (1).

I would like to mention here that S * $\sqrt{\frac{n}{n-1}}$ is the formula for $\tilde{\sigma}$ [Estimate of $\sigma, the\ Population\ Mean - called\ the\ Parameter$] when the small sample is small { sample size 'n' < 29 }. This is referred as sample SD in textbooks. But I would advise to use calculate SD using formula (1).

The divisor in formula (2) is nothing but degrees of freedom.

Please note that Standard Error [SE] is used in applied statistics which will be same using the SD formulas (1) Or (2).

IV. Verification of answers of AM and SD { <u>The advantage in Scientific calculators</u> }

For this,

Press "shift" and then "2" [you can see "S-VAR" above it] keys

The display will be

$\bar{x}$ x σ_n x σ_{n-1}

1 2 3

Now, press "1" and "=" keys to get $\bar{x}$ which will be = 4

Note that the SD value we must take is xσ_n (The result got using formula (1). If you take x σ_{n-1}, it is the result of formula using (2).

In some calculators these options are a little different

$\bar{x}$ σxSx

1 2
3

Here also take option '2' for SD value.

Again, Press "Shift" and Number "2" keys. Now, Press "2" and "=" to get 'S' $\{x\sigma_n\}$which will be = 1.4142

THE ADVANTAGE IN USING SCIENTIFIC CALCULATOR IS GETTING THE $\Sigma x^2 \Sigma x$ and n VALUES QUICKLY AND VERIFYING THE ANSWERS
NOTE: THE STUDENTS ARE UNABLE TO GET ANY FORMULAE BY USING A SCIENTIFIC CALCULATOR. THE CALCULATOR TYPE IS fx 991 MS

V. Calculating Coefficient of Variation [CV]

CV = $\frac{SD}{Mean}$ * 100 = $\frac{1.4142}{4}$ * 100 = 35.355 = 35.36

CV value cannot be verified since the formula is not built in, in the calculator.

B. To calculate Coefficient of correlation ["r" value]

This is done by setting "REG" Mode.
For this, Click "MODE" once. Check the display.
If "REG" is not seen, Click once more. Now you will see "REG". You can also see a number below "REG".
Now Click that number. If the number is "2" Click number "2".
If the number is "1" Click number "1".
There will again a display where you can see the following.
Lin Log Exp
1 2 3
Now, in the display you will have to select "Lin".
If the number is "1" Click number "1".
Now, in the display you can see "REG"
Also you will see "D". Do not worry about this. Let it be there.

Now, the calculator is set for both "Correlation" and "Regression" calculations

I. Entering data

If the problem is
Find Correlation coefficient of
X: 2 3 4 6 8
Y: 5 7 8 9 10
Click "2", then click ",", then click "5" and Click "M+" key.
Now the display will be "n = 1"
Now, the first pair of values is entered.
Now, click "3", then click ", ", then click "7" and Click "M+" key.
Now the display will be "n = 2"
Now, the second pair of values is entered.
Go on entering like that.
When you finish the last pair, the display will be "n = 5". Now, data entry over.

II. Getting Σ x, Σ x^2, Σ y, Σ y^2, Σ xy and "n"for the calculations using the formulas.

For this, Press "Shift" and Number "1" [you can see "S-SUM" above it] keys.
The display will be
Σx^2 Σ x n
1 2
2
You can see a "REPLAY" button in the middle of the calculator. Also you can see an: RIGHT ARROW [like triangle]. Press on it and there will be display where you can see
Σy^2 Σ y Σ xy
1 2
3
Now, pressing the corresponding numbers and "=" keys, all the six values [Σ x, Σ x^2, Σ y, Σ y^2, Σ xy and "n"] can be got.

$\Sigma x^2 = 129$ $\Sigma x = 23$ $n = 5$
$\Sigma y^2 = 319$ $\Sigma y = 39$ $\Sigma xy = 197$

THE ADVANTAGE IN USING SCIENTIFIC CALCULATOR IS GETTING Σx, Σx^2, Σy, Σy^2, Σxy and "n" VALUES QUICKLY AND VERIFYING THE ANSWERS - THE CALCULATOR TYPE IS fx 991 MS OR SIMILAR

III. Calculating Correlation coefficient and Regression equation

The following formulas will be the best for the Correlation and Regression calculations.

$$S_{xx} = \sum x^2 - \left[\frac{(\sum x)^2}{n}\right] =$$

23.2

$$S_{yy} = \sum y^2 - \left[\frac{(\sum y)^2}{n}\right] =$$

14.8

$$S_{xy} = \sum(xy) - \left[\frac{(\sum x)(\sum y)}{n}\right]$$

= 17.6

Then, $r = \frac{Sxy}{\sqrt{(Sxx).(Syy)}} = \frac{17.6}{\sqrt{23.2*14.8}}$

$= \frac{17.6}{18.53} = 0.9498$

Then the general form of the regression equation (linear) is given as y = b x + a

In this,

'b' is calculated as $b = \frac{Sxy}{Sxx}$

$= \frac{17.6}{23.2} = 0.7586$

and 'a' is given by $a = \bar{y} - b.\bar{x}$

Also $\bar{x}$ and $\bar{y}$, the Mean of 'x' and Mean of 'y' is to be obtained.

$\bar{x} = \frac{\Sigma x}{n} = \frac{23}{5} = 4.6$

and $\bar{y} = \frac{\Sigma y}{n} = \frac{39}{5} = 7.8$

a = 7.8 - 0.7586*4.6 = 4.3103

The Regression equation is Y = 0.7586x + 4.3103

IV. Verification of answers of Correlation coefficient [r], Regression coefficient [b] and Y-intercept [a]

For this

Press "shift" and "2" [you can see "S-VAR" above it] keys

The display will be

$\bar{x}$ x σ_n x σ_{n-1}

1 2 3

In the **"REPLAY" button in the middle of the calculator Click RIGHT ARROW [like triangle].** Now, there will be display where you can see

$\bar{y}$ y σ_n y σ_{n-1}

1 2 3

Again, click in the "REPLAY" button in the middle of the calculator Click RIGHT ARROW [like triangle]. Now, there will be display where you can see

A B

r

1 2

3

'r, Correlation Coefficient 'B' [b] and 'A' [a] the coefficients in the Regression equation y = b x + a

Pressing the corresponding numbers and pressing "=", the corresponding values can be seen in the display.

Calculated answers can be verified.

C. 't' test and paired 't' also

For these calculations the above procedures can be used to get Mean and SD to apply in the respective formulas.

The following formulas could possibly be advantageous in "t" test calculations.

Significance Tests – Small Samples (n < 30)

When samples are small, the test statistic follows Student's ' t ' distribution

Tests based on Student's 't' distribution

I. Testing sample mean against population mean (One Sample 't' Test)

Null hypothesis is set as H_0: $\mu = \mu_0$. Alternate hypothesis can be any one of the following.

(1) $H_1 : \mu \neq \mu_0$
(2) $H_1 : \mu < \mu_0$
(3) $H_1 : \mu > \mu_0$

'σ', the population SD is unknown, 't' is calculated as

$$t = \frac{|\bar{x} - \mu_0|}{\left(\frac{S}{\sqrt{n-1}}\right)}$$

df = n-1

NOTE:

The SD is calculated as S = SD = $\sqrt{\frac{\sum (x-\bar{x})^2}{n}}$ **, The divisor is 'n' only.**

NOTE:

If SD calculated using S = SD = $\sqrt{\frac{\sum (x-\bar{x})^2}{n-1}}$ **Then the formula used for the 't' calculation will be** $t = \frac{\bar{x}-\mu_\circ}{\frac{S}{\sqrt{n}}}$

Students please, do not use this formula.

II. Testing of Two Means Based on 't' Test (Two independent samples 't' test)

The test statistic is set as

$$t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\frac{n_1 S_1^2 + n_2 S_2^2}{n_1 + n_2 - 2}} \cdot \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

$df = n_1 + n_2 - 2$

It will be easy to use the formula given correlation coefficient calculation to get $n_1S_1^2$ and $n_2S_2^2$ Calculate and $n_2S_2^2$

$$Sxx = n_1S_1^2 = \sum x^2 - \left[\frac{(\sum x)^2}{n}\right]$$

; $(\sum x)^2$ = $(\sum x)$ $(\sum x)$

Financial support and sponsorship
Nil

Conflict of interest
There are no conflicts of interest.

References

1. Trouche L. Calculators in Mathematics Education: A Rapid Evolution of Tools, with Differential Effects. In: The Didactical Challenge of Symbolic Calculators. Springer. 2005:36: 9-39.
2. Close S, Oldham E, Shiel G, Dooley T, Oleary M. Effects of calculators on mathematics achievement and attitudes of ninth-grade students. J Educ Res. 2012;105(6):377–90.