04/09/25

ASSIGNMENT:

TWO WAY ANOVA.

Q2 How do teaching method (Lecture Vs Interactive) and Gender (Male vs Female) affect student grades?

Factors:

IV1 : Teaching Method (2 levels : Lecture, Interactive)

IV2 : Gender (2 levels : Male, Female)

DATA SET:

STUDENT ID	TEACHING METHOD	GENDER	FINAL GRADE
1	Lecture	Male	71.89578175
2	Interactive	Male	79.09319158
3	Interactive	Female	82.10880519
4	Interactive	Female	72.95457329
5	Lecture	Female	70.08352993
6	Interactive	female	81.86850209
7	Lecture	Female	75.30929169

Step ①

a = 2 levels of Teaching Method (Lecture, Interactive)

b = 2 levels of Gender (Male & Female)

N = 7 Total Observations

cells = 4 groups [Lecture x Male = 1, Interactive x Male = 1; Lecture x Female = 2, Interactive x Female = 3]

Step ② Means :

Grand Mean $\bar{Y} = \frac{\sum Y}{N} = \frac{533.6136745}{7} = 76.23052493$

Computed Steps in EXCEL

$\frac{533.52}{7} \simeq 76.217$

76.23

Marginal Means :-

Teaching Method :-

$$\text{Lecture} = \frac{71.896 + 70.084 + 75.309}{3} = 72.429$$

$$\text{Interactive} = \frac{79.093 + 82.409 + 72.955 + 81.869}{4} = 79.081$$

Gender :-

$$\text{Male} :- \frac{71.896 + 79.093}{2} = 75.495$$

$$\text{Female} :- \frac{82.409 + 72.955 + 70.084 + 81.869 + 75.309}{5} = 76.544$$

Cell Means :-

(n=1) Lecture x Male = 71.896

(n=2) Lecture x Female = $(70.084 + 75.309)/2 = 72.697$

(n=2) Interactive x Male = 79.093

(n=3) Interactive x female = $(82.409 + 72.955 + 81.869)/3$

$= 79.078$

Step ③ SST - Total Sum of Squares

$$SS_T = \sum (X - GM)^2$$

Rounding Values (taking 2 decimals)

$$= (71.90 - 76.23)^2 + (79.09 - 76.23)^2 + (82.41 - 76.23)^2$$
$$+ (72.95 - 76.23)^2 + (70.08 - 76.23)^2 + (81.87 - 76.23)^2$$
$$+ (75.31 - 76.23)^2$$

$$= 18.73 + 8.21 + 38.25 + 10.74 + 37.87 + 31.76 + 0.85$$

$$\boxed{SS_T = 146.41}$$

Step ④ Between Group - Sum of Squares

FACTOR A (TEACHING METHOD)

$$SS_A = \sum n_j (\bar{X}_j - GM)^2$$

$$= 3(72.43 - 76.23)^2 + 4(79.08 - 76.23)^2$$

$$\boxed{SS_A = 75.71}$$

Factor B : Gender

$$SS_B = \sum n_k (\bar{x}_k - GM)^2$$

$$= 2(75.50 - 76.23)^2 + 5(76.72 - 76.23)^2 = 3.11$$

$$\boxed{SS_B = 3.11}$$

Interaction AB :

$$SS_{AB} = n \sum_{ij} (\bar{Y}_{ij} - \bar{Y}_i - \bar{Y}_j - \bar{Y})^2$$ for balanced datasets (Same n)

Here we use = $SS_{cells} = \sum n_{ij} (\bar{x}_{ij} - GM)^2$

$\Rightarrow 1(71.90 - 76.23)^2 + 2(72.70 - 76.23)^2 + 1(79.07 - 76.23)^2$
$+ 3(79.08 - 76.23)^2$

$\Rightarrow 18.73 + 24.91 + 8.21 + 24.46$

$SS_{cells} = 76.31$

Formula (approx for unequal n)

$$SS_{AB} = SS_{cells} - SS_A - SS_B$$

$$SS_{AB} = 76.31 - 75.71 - 3.11 \Rightarrow -2.81 \approx 0$$

Negative comes from rounding, so effectively 0

Step 5 : SS_{Error}

$$SS_E = SS_T - SS_A - SS_B - SS_{AB}$$

$$SS_E = 146.41 - 75.71 - 3.11 - 0 = 67.29$$

$$\boxed{SS_E = 67.29}$$

Step 6 : Degrees of Freedom :

$a = 2$ $df_A = a - 1 = 1$

$b = 2$ $df_B = b - 1 = 1$

$N = 7$ $df_{AB} = (a-1)(b-1) = 1$

$df_T = N - 1 = 6$

$df_E = df_T - (df_A + df_B + df_{AB})$

$= 6 - 3 = 3$

Step 7 :- Mean Squares

$MS_A = SS_A / df_A = 75.71/1 = 75.71$

$MS_B = 3.41/1 = 3.41$

$MS_{AB} = 0/1 = 0$

$MS_E = 67.39/8 = 22.18$

Step 8 :- F-Ratios

$$F_A = \frac{MS_A}{MS_B} = \frac{75.71}{22.18} = 3.37$$

$$F_B = \frac{MS_B}{MS_E} = \frac{3.41}{22.18} = 0.15$$

$$F_{AB} = \frac{0}{22.18} = 0$$

Step 9 :- From Table $\alpha = 0.05$

- Teaching Method :- $F(1,8) = 3.37$ - Not Significant
- Gender :- $F(1,8) = 0.15$
- $F_{A\,critical} = 10.13$ - Not Significant
- $F_{B\,critical} = 10.13$

Interaction/F_{AB} = None

No Significant effects found.

$F_{calculated} > F_{critical}$ (From F-table), then Reject H_0 → the factor has Significant effect

$F_{calculated} \leq F_{critical}$, the fail to Reject H_0 → No Significant effect

Conclusion :-

We fail to reject the null hypothesis

* Teaching Method has no significant effect
* Gender has no significant effect
* There is no Interaction effect.