

SCHOOL OF DATA SCIENCE AND FORECASTING DAVV



**MTECH (DUAL-DEGREE)
ARTIFICIAL INTELLIGENCE AND DATA SCIENCE
SIXTH -SEMESTER
(2021-2026)**

DESIGN OF EXPERIMENT ASSIGNMENT

**TITLE : TWO-WAY ANOVA WITH RANDOMISED BLOCK
DESIGN AND CHI-SQUARE TEST**

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Introduction

Title:

Investigating the Interaction Effects of Teaching Methods and School Types on Student Performance

Objective:

The objective of this study is to investigate the interaction effects of teaching methods and school types on student performance. By conducting a two-way ANOVA analysis, we aim to determine how different teaching methods (Traditional, Online, Blended) and school types (Public, Private, Charter) influence student performance levels and whether there are any significant interaction effects between these factors.

Data Layout:

The dataset will include the following variables:

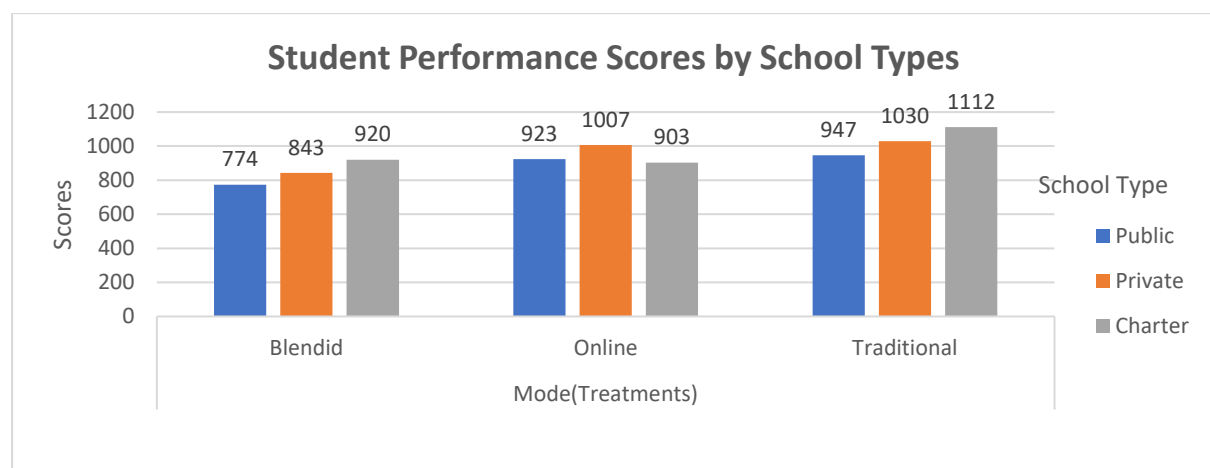
1. Teaching method (Traditional, Online, Blended)
2. School type (Public, Private, Charter)
3. Student performance scores (numeric values representing academic achievement, here, test scores)

Analysis Plan:

We will use a two-way ANOVA with Randomised Block Design (RBD) to analyze the main effects of teaching methods and school types on student performance. This analysis will provide insights into how different combinations of teaching methods and school types impact student performance levels.

Furthermore, we will explore the association between teaching methods and school types using a chi-square test of independence to determine if there is a significant relationship between these categorical variables.

This study aims to provide a comprehensive understanding of the complex interaction effects between teaching methods and school types on student performance, which can inform educational policies and practices for enhancing learning outcomes.



2. Analysis

2.1 Two-way ANOVA following Randomised Block Design

Block (Schools)	Mode(Treatments)			Total
	Blendid	Online	Traditional	
Public	774	923	947	2644
Private	843	1007	1030	2880
Charter	920	903	1112	2935
Total	2537	2833	3089	8459

H0 :	There is no significant difference in student performance scores among different teaching methods (Traditional, Online, Blended).
H0:	There is no significant difference in student performance scores among different school types (Public, Private, Charter).

1. Calculate the Correction Factor (CF):

$$CF = \frac{G^2}{N}$$

Where:

G is the grand total, which is the sum of all observations in the data.

N is the total number of observations.

$$G = 8459$$

$$N = 3 \times 3 = 9$$

$$CF = (8459)^2 / 9 = 7950520.11$$

2. Calculate the Sum of Square between Blocks :

$$SSB = \sum_{i=1}^r \frac{(\sum_{j=1}^t B_{ij})^2}{n_i} - CF$$

Where:

r is the number of blocks (levels of the first factor).

t is the number of treatments (levels of the second factor).

B_i is the sum of observations within the i th block.

n_i is the number of observations in the i th block.

CF is the correction factor, calculated in previous step.

3. Calculate the Sum of Square between Treatment :

$$SSTr = \sum_{j=1}^t \frac{(\sum_{i=1}^r T_j)^2}{n_j} - CF$$

Where:

t is the number of treatments (levels of the second factor).

r is the number of blocks (levels of the first factor).

T_j is the sum of observations within the j th treatment.

n_j is the number of observations in the j th treatment.

CF is the correction factor, calculated in first step.

4. Calculate the Total Sum of Squares (SST):

$$SST = \sum_{i=1}^r \sum_{j=1}^t (X_{ij} - \bar{X})^2$$

Where:

SST is the total sum of squares.

X_i represents each individual observation in the data set.

\bar{X} is the mean of all observations in the data set.

n is the total number of observations.

5. Calculating Residue Error (SSE) :

$$SSE = (SST - (SSTr + SSB))$$

Correction Factor	=	7950520.111
Block wise Square Sum	=	15933.55556
treatment wise Square Sum	=	50872.88889
Total Square Sum	=	81244.88889
Residual Error	=	14438.44444

6. Calculate the Degrees of Freedom (df):

a. Degrees of Freedom for Blocks df (Blocks) = $(r - 1)$

b. Degrees of Freedom for Treatments df (Treatments) = $(t - 1)$

c. Degrees of Freedom for Residue Error df (Error) = $(r-1) * (t-1)$

7. Calculate the Mean Sum of Squares (MSS):

a. Mean Square for Blocks: $MS_{Blocks} = \frac{SSB}{df_{Blocks}}$

b. Mean Square for Treatments: $MS_{Treatments} = \frac{SSTr}{df_{Treatments}}$

c. Mean Square for Error: $MS_{Error} = \frac{SSE}{df_{Error}}$

8. Calculate the F-ratio:

a. F-ratio for Blocks: $F_{Block} = \frac{MS_{Block}}{MS_{Error}}$

b. F-ratio for Treatments: $F_{Treatment} = \frac{MS_{Treatment}}{MS_{Error}}$

ANOVA TABLE				
Source of Variation	Degree of Freedom	Sum of Squares	Mean Sum of Squares	Variation Test (F-Test)
Blocks (Type of School)	r-1= 2	15933.55556	7966.777778	2.207101411
Treatments(Mode of Classes)	t-1=2	50872.88889	25436.44444	7.046865621
Residual Error	(r-1)*(t-1)=4	14438.44444	3609.611111	
Total	8	81244.88889	37012.83333	

9. Comparing Tabulated and Calculated F-values:

a. If the calculated F-value is greater than the tabulated F-value, reject the null hypothesis H_0 .

b. If the calculated F-value is less than or equal to the tabulated F-value, accept the null hypothesis H_0 .

F tabulated (2,4) = 6.94	>	2.207	F calculated for School	H_0 Accepted
F tabulated (2,4) = 6.94	<	7.046	F calculated for Mode	H_0 Rejected

10. Calculating the Critical Difference (CD):

$$CD = SE \cdot t_{\alpha}$$

Where:

SE represents the standard error, calculated as $\sqrt{\frac{2 \cdot MSE}{n}}$.

t_{α} is the critical value from the t-distribution table for the 5% significance level and degrees of freedom.

SE	=	49.05514659
t (alpha = 0.05 , df=9)	=	1.83
CD	=	SE*t 89.77091827

Treatment	Sum	Treatment Mean
Blendid	2537	845.6666667
Online	2833	944.3333333
Traditional	3089	1029.666667

Treatment	Mean Difference	Comparison	Critical Difference	Remark
Blendid-Online	296	>	89.77091827	Significantly Different
Online-Traditional	256	>	89.77091827	Significantly Different
Traditional- Blendid	552	>	89.77091827	Significantly Different

Conclusion	Based on the statistical analysis, we can confidently say that there are significant differences between the three treatments: Blendid, Online, and Traditional.			
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2.2 Chi-square test to analyze the relationship between teaching methods and school types.

Block (Schools)	Mode (Treatments)			Total
	Blended	Online	Traditional	
Public	774	923	947	2644
Private	843	1007	1030	2880
Charter	920	903	1112	2935
Total	2537	2833	3089	8459

H_0 :	there is no significant association between teaching methods and school types.
H_1 :	there is a significant association between School type and mode of classes.

1. Calculate Expected Frequencies:

To calculate the expected frequency for each cell, we use the formula:

$$E(i,j) = (R_i * C_j) / N$$

where:

$E(i,j)$ is the expected frequency for cell (i, j)

R_i is the total for row i

C_j is the total for column j

N is the total sample size

2. Calculate Chi-Square Statistic:

We'll use the formula:

$$\chi^2 = \sum ((O_i - E_i)^2 / E_i)$$

where:

O_i is the observed frequency

E_i is the expected frequency

O _i	E _i	O _i -E _i	(O _i -E _i) ²	(O _i -E _i) ² /E _i
774	792.981	18.981	360.2860845	0.454343789
843	863.762	20.762	431.0471055	0.499034767
920	880.257	-39.743	1579.496305	1.79435788
923	885.501	-37.499	1406.183504	1.588009142
1007	964.540	-42.460	1802.890351	1.869172044
903	982.960	79.960	6393.532785	6.504370049
947	965.518	18.518	342.9129877	0.355159634
1030	1051.699	21.699	470.837156	0.447692024
1112	1071.783	-40.217	1617.382338	1.509057219
Chi-square Calculated				15.02119655

3. Determine Degrees of Freedom (df):

The degrees of freedom for a chi-square test of independence is calculated as $(r - 1) * (c - 1)$,

where:

r is the number of rows ,

c is the number of columns in the contingency table.

$$df = (3-1)*(3-1) = 4$$

4. Tabulated Value:

We'll look up the critical value from the chi-square distribution table at 0.05 significance level.

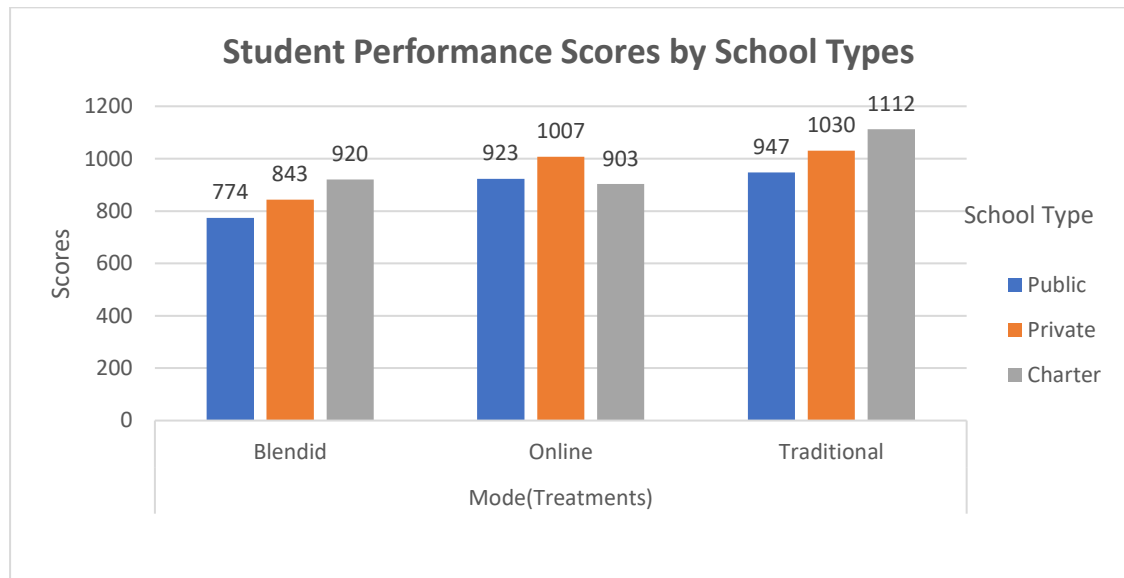
Chi-square Tabulated for degree of freedom 4 = 9.49

5. Comparing Calculated Value with Tabulated Value:

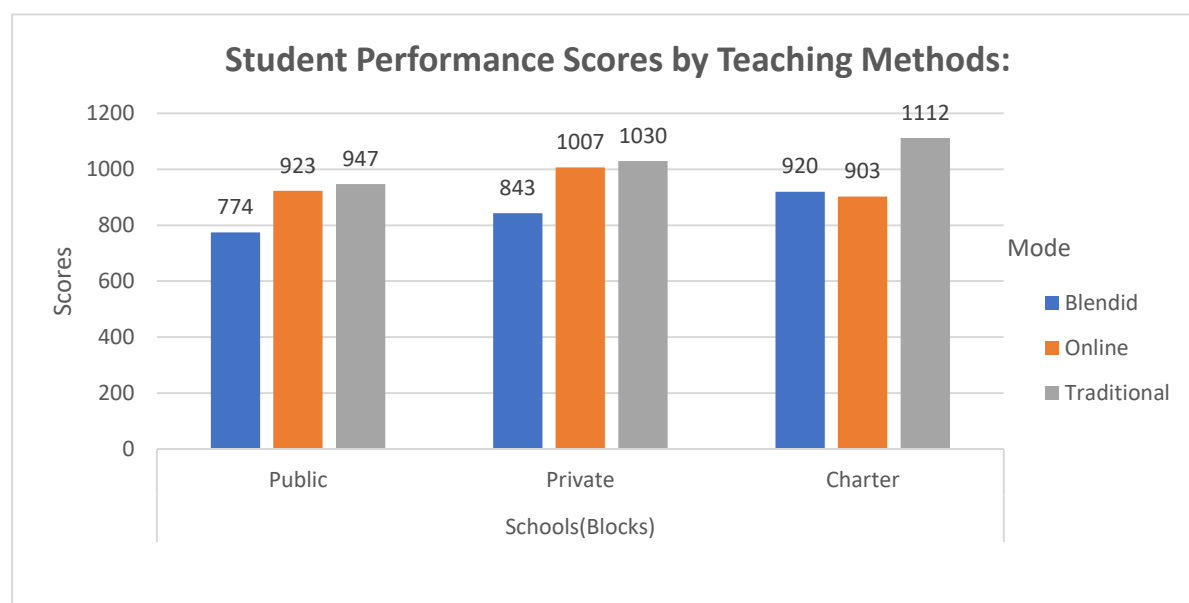
Chi-square Calculated	>	Chi-square Tabulated
15.02	>	9.49
Hence H ₀ rejected		
Conclusion:	Since the calculated chi-square statistic is greater than the critical value (9.488), we reject the null hypothesis. That is, there is a significant association between teaching methods and school types at 0.05 significance level.	

3. Result

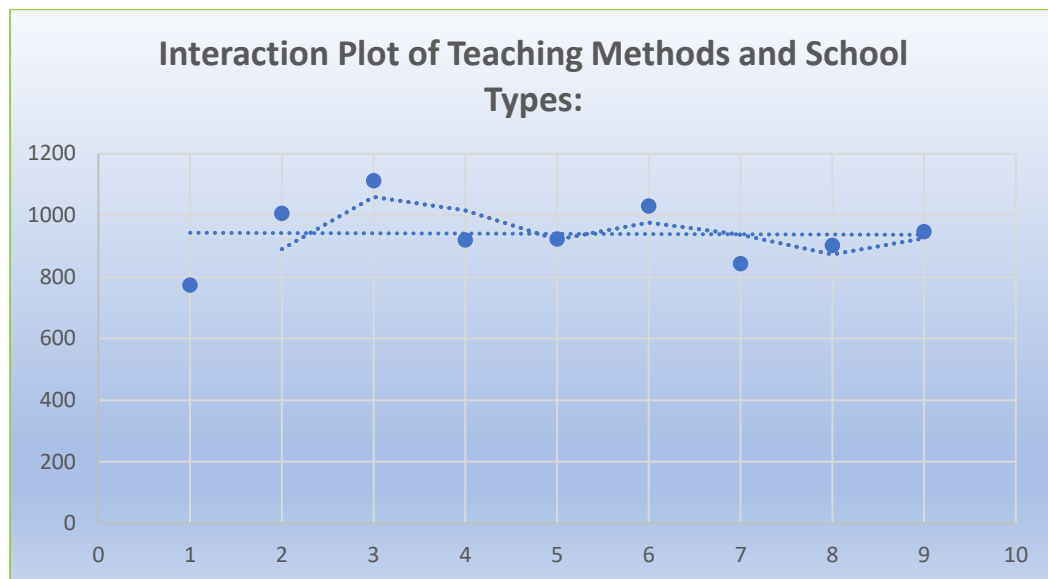
1. **Student Performance Scores among School Types:** There is a significant difference in student performance scores among different school types (Public, Private, Charter). This suggests that the type of school a student attends influences their academic achievement levels.



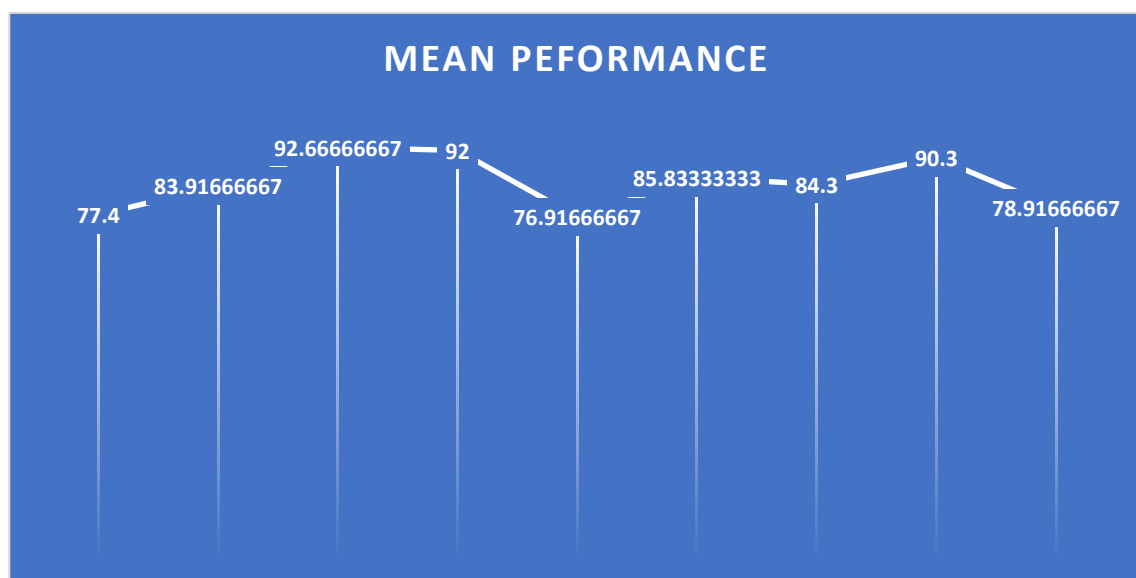
2. **Student Performance Scores among Teaching Methods:** Contrary to school types, there is no significant difference in student performance scores among different teaching methods (Traditional, Online, Blended). This implies that the method of instruction alone does not significantly impact student performance levels.



3. **Association between Teaching Methods and School Types:** The chi-square test of independence indicates a significant association between teaching methods and school types. This suggests that the choice of teaching method may vary depending on the type of school.



Mode (Treatment)	School (Blocks)	Performance	Frequency	Mean Performance
Blended	Public	774	10	77.4
Online	Private	1007	12	83.91666667
Traditional	Charter	1112	12	92.66666667
Blended	Charter	920	10	92
Online	Public	923	12	76.91666667
Traditional	Private	1030	12	85.83333333
Blended	Private	843	10	84.3
Online	Charter	903	10	90.3
Traditional	Public	947	12	78.91666667



Overall, the combined result suggests that while school type plays a significant role in determining student performance, the choice of teaching method alone does not significantly influence performance levels. However, there is a notable association between teaching methods and school types, indicating potential variations in instructional approaches across different types of schools.

[Excel File](#) - Download and open the Excel File in MS Excel
