CHAPTER - VI

Statistical Analysis of the Results

Introduction

"It has been observed that science could not be effectively taught unless the pupils spent a large part of their time in manipulating the apparatus and materials." It should be recognised that many pupils cannot understand without first hand experience while all pupils learn more readily under these conditions".

Also concluded that "Nevertheless the gain was not always as sometimes thought". This has led to a large body of research aimed at measuring the efficacy of practical work in school laboratories.*

(A) The Main Issues

It should be clear by now that the main objective of this study is to quantify chemistry laboratory skills henceforth referred to as CLS. In the preceeeding chapters we have identified these skills and described how appropriate laboratory skill tests can be constructed.** We have .....

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* The Teaching of Science in Secondary schools published by John Murray London. ** As mentioned earlier the tests for CLS were construded for students of class XII.

also discussed in some detail how the relevant measures can be obtained and the extent to which such measures are reliable. The next set of questions that arise naturally are the following:

a) Do chemistry practicals spread over the full academic session lead to a significant improvement in CLS.

b) Did students possess an adequate level of CLS at the start of the academic session.*

c) Are CLS related to enviornmental characteristics such as sex, type of school, type of examination, socio economic status, and out of school activities?

d) Are CLS corelated with performance in other components of the curriculum e.g. marks scored in theory test (Pandit), marks scored in chemistry theory Class XII (CBSE) and marks scored in chemistry practicals Class XII (CBSE)?

We also need to examine variations in and determinants of the acquisition of CLS. In this latter issue we must, in other words, focus on changes rather than levels of CLS of students. These can be related to the

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* It may be recalled that students have had about six years of laboratory work of one sort of the other before they join class XII.

various factors mentioned in (a) through (d). We are primarily concerned with the hypothesis that students within a given group and/or subgroups are homogeneous. In case this hypothesis is rejected we proceed to identify the sources of heterogenity as described above.

Statistical techniques used in the subsequent analysis are threefold. First, we use the well known t-test - based on sample means and standard deviations to test whether differences between the mean levels of CLS are significant for any given pair of groups. This is clearly a bilateral comparison. The second technique used is that of analysis of variance. This is similar to the t-test except that we can simultaneously compare not just two but a number of group means. The hypothesis is again one of homogeneity across different groups. This hypothesis says that all group means are the same. This test is carried out by means of the F-statistic. The third technique that proves handy is that of correlation analysis. This is used to find the extent to which different characteristics in a given sample very together. An observed coefficient of correlation between two given characteristics is subjected to Fisher's Z-test to examine whether it is significantly different from zero or not.

B) Statistical Results: Entry level Test

Let us now turn to the analysis of data derived from our experiments. We take up the Entry Level Test (ELT) first. Table 6.1 below gives us an idea of the level and dispersion of the Entry Level Test (ELT) and related variables. The Statistics used are Arithmatic means (AM) and standard deviations (SD). The data relate to three different school types and the combined sample of all schools.

Table 6.1

Means and Standard Deviations of ELT and Related Variables

Variable	Type I School		Type II School		Type III School		All Schools	
	AM	SD	AM	SD	AM	SD	AM	SD
Entry Level Test	70.28	6.95	72.60	8.16	63.66	7.37	68.77	8.37
Terminal Level test	74.12	10.88	78.24	6.48	65.31	9.37	72.46	10.52
Theory test (Pandit)	65.07	17.11	81.67	14.95	38.65	10.55	61.52	22.96
Theory Test (CBSE)	42.15	11.64	55.14	7.54	27.57	7.86	41.48	14.59
Chemistry Practical (CBSE)	21.38	3.43	28.14	1.68	25.30	2.60	25.01	3.80
Type of Examination (CBSE)	1.00	0.00	1.00	0.00	2.00	0.00	1.35	0.48
Socio-Econ. Status	2.76	1.05	1.44	0.61	3.73	1.15	2.65	1.35
Out of School activities	10.32	3.06	12.42	3.44	10.24	4.05	11.00	3.67

Similarly table 6.2 below gives the AM and SD for manipulative and cognitive scores for different school types and corresponding to the entry level test (ELT) and the terminal level tests (TLT).

Table 6.2

Means and Standard Deviations of Scores Corresponding to ELT & TLT

Variable	Type I School		Type II School		Type III School		All Schools	
	AM	SD	AM	SD	AM	SD	AM	SD
Manipulative Score (ELT)	35.40	3.05	33.14	4.63	32.62	4.63	33.68	4.36
Cognitive score (ELT)	34.88	6.52	39.46	6.77	31.04	6.32	35.09	7.36
Manipulative (TLT)	35.81	3.31	38.40	2.69	34.54	3.73	36.24	3.63
Cognitive score (TLT)	38.31	11.22	39.83	6.28	30.77	9.24	36.21	9.84

Tables 6.3 through 6.5 overleaf give the results of comparisons of the mean values of ELT in different universes. These comparisons are based on the t-test. The observed t-values is given for each case along with the inference.

Table 6.3

t-Test for Binary Comparisons between schools (ELT)

Comparison	d.f.	t-value	Inference
1. Between schools of Type I and II	68	-1.28	Not significant
2. Between schools of Type II and III	71	4.92	Significant at 1%
3. Between Schools of Type I and II	69	3.89	Significant at 1%

It is obvious from table 6.3 that while school type III differs from both school types I and II, the two types I and II do not differ from each other significantly. Thus, school type III stands apart from the other two. This is also clear from table 6.1 in which (row 1) the mean ELT in school type III is much lower than the means for the other two types. This difference is a clear indication of the diversity in the student quality in-take, for whatever reasons, between type III on the one hand and types I & II on the other.

Table 6.4

t-Test for Binary comparison between sexes (ELT)

Comparison	d.f.	t-value	Inference
1. Within school of type I	32	3.07	Significant at 1%
2. Within school of Type II	34	-1.51	Not significant

Table 6.4 shows that inter sex differences (i.e. between boys and girls) are significant in type I school but not in type II school.

Table 6.5

t-Test for Binary Comparison of Sexes in Schools of Type I & II (ELT)

Comparison	D.F.	t-value	Inference
1. Between Boys	47	0.51	Not significant
2. Between Girls	19	-3.60	Significant at 1%

Finally, table 6.5 shows that if school types I & II are compared sexwise boys do not turn out to be significantly different from each other in the two types of schools. On the contrary girls do differ significantly between the two school types. One should here hear in mind that in the four groups the mean ELT scores are as follows.

Table 6.6

Mean scores of Boys & Girls in ELT of Type I & Type II Schools

	School Type I	School Type II
Boys	72.24	71.17
Girls	64.83	75.46

Thus, the low ELT score of girls in type I school is the source of heterogeneity.

Let us now consider the question of inter-group differences in order to examine whether groups - defined by different characteristics are homogeneous or not, as far as ELT is concerned. The groups examined are sex, school type, type of examination, socio-economic status and out of school activities. The hypothesis of homegeneity is tested by means of analysis of variance using the F-statistic.*

Table 6.7 gives the within and between sums of squares, degrees of freedom and the F value in each case. The last column of this table also gives the inference drawn.

Table 6.7

Analysis of variance for ELT

Variable	Between and within sums of squares	D.F*	F	Inference
1. Sex	1188 731968	1 105	1.705	Not Significant
2. School type	156992 586996	2 104	13.908	Significant at 1%
3. Examination type	147600 596288	1 105	25.99	Significant at 1%
4. Socio-economic status	127344 1045088	5 101	2.062	Not Significant
5. Out of school activities	57408 686560	5 101	1.689	Not significant

* Notice that since there are only two classifications for sex and examination type the analysis of variance is equivalent to simple t-test. This because for one d.f. the F statistic is just equal to the squared value of t-statistic.

F-values reported in table 6.7 show that entry level test performance is not significantly different across sex, socio-economic status and out of school activities. It is however significantly different between the three school types and between the two examination types. These results can be interpreted as implying that the different socio-economic stratifications are mirrored by the types of schools. Most other differences do not by themselves matter much. It is the school system which acts as a filter process and gives rise to varying achievements in chemistry laboratory skills by different school groups.

To strengthen our results further we can now turn to the observed coefficients of correlation between ELT and certain selected characteristics within each school as also in all schools put together. These are given in table 6.8 below*.

Table 6.8

Coefficients of correlation between ELT and other variables in Different Schools

School → / Variable ↓	Type I (n=34)	Type II (n=36)	Type III (n=37)	All Schools (n=107)
1	2	3	4	5
1. Terminal Level Test	0.3196**	0.5736**	0.6835**	0.6078**
2. Theory Test (Pandit)	0.1075	0.0658	0.2596	0.4269**
3. Theory Test (CBSE)	0.2502	0.3396*	0.3782*	0.4065**
4. Chemistry practical (CBSE)	0.0462	0.0074	0.2234	0.1138

1	2	3	4	5
5. Type of Examination*	-	-	-	-0.4455**
6. Socio-economic status	0.2010	0.2246	-0.0491	-0.2442**
7. Out of School Activites	-0.0264	0.2618	-0.3654**	0.0464

* Cannot be calculated for individual schools because all students undergo only one type of examination.

The calculated coefficients of correlation are significantly large with regard to the terminal level test (TLT). They are positive for each schools as well as for all schools put together. This implies that in all cases students with higher ELT score tend to also have a higher TLT score and vice versa. One thing to note is that the linear relationship between ELT and TLT is the strongest in school type III. It is second strongest in school type II and relatively the weakest in school type I.

Figures in table 6.8 show that the relationship between ELT and almost all other variables (excluding TLT) is weak.

Note that n stands for the sample size * shows that it is significant at 5% only. ** on top of a calculated value of the co-efficient of correlation denotes significant at 1%. Unmarked values are not at all significant.

Almost none of the correlation coefficients within each school are significantly different from zero. However, in all cases (except chemistry practicals score and out ofschool activities) the coefficients of correlation are significant. This apparent paradox is easy to explain. It seems to us that the schools are implicitly ranked and this ranking is reflected in terms of the variables we are looking at. But there is a fair degree of randomness - i.e. lack of systematic relaionship between various variables in any given school. Thus the observed linear relationship between ELT and variables such as theory test only reflect the inter school diversity. Between ELT and theory test (CBSE) the relationship is significant in school types II & III and in the combined sample. Similarly, the relationship between ELT and out ofschool activities is significant (and negative) only for school type III All other ccefficients of correlation as stated earlier, fail tobe significant.

Turning to the calculated coefficients for the combined sample we observe that the relationship between ELT and TLT is positive and fairly strong. This means, as in case of the individual schools, that students with high ELT tend to have high TLT also. Similarly, those who have a better ELT score tend to perform relatively better in theory tests (CBSE As well as Pandit). However no systematic relationship is discernable between ELT and either out of

school activities or chemistry practicals. On the contrary the relationship between ELT and examination type as well as socio-economic status is inverse. What do these results imply? With regard to examination type this means that, since there are only two types ofexamination, ELT score is higher for examination type I (All India Higher Secondary) and lower for type II (Delhi Board).

With regard to socioeconomic status, since numbering of status is in a decreasing order (i.e. the highest is assigned No.1 the second highest No.2 and so on) negative correlation implies that students coming from parents of better socioeconomic status have a higher ELT. While this is quite expected the coefficient of correlation is not sufficiently large, though significant. This calls for some explanation.

Notice first that the two variables (ELT and socio-economic status) at the school level are positively related in case of school types I and II but negatively in case of school type III. This is indicated by ranking of the three schools in terms of means. It is this phenomenon that leads to a marginally significant correlation in the combined sample.

The type II school is the strongest in socio-economic status with a homogeneous character. The next strongest in socioeconomic status is the type I school. It is also

a bit more heterogeneous than Type II school. Type III school is the weakest in socioeconomic status and also the most heterogeneous.

Some of the other findings relating to the ELT and socioeconomic status are as follows. First, there is an inverse relationship between occupational hierarchy and performance in CLS - Class XI (ELT). This implies, for example, that a technicians' child is not doing as well as a specialists' child. Second, there is a social stratification between the schools. Third, students coming from higher income groups perform better in CLS Class XI (ELT). However, student's whose fathers are better educated do not tend to perform better. In contrast, students with educated mothers do perform better in CLS Class XI (ELT). Thus performance improves with mother's education but not with father's education.

Before closing this section let us now consider the relationship between manipulative and cognitive scores in ELT and TLT. The coefficients of correlation between different relevant scores are given in table 6.9 overleaf. This pertain to each of the three school types as well as to the combined sample.

Table 6.9

Coefficients of Correlation between Manipulative and Cognitive Scores

Schools → / Variable ↓	School Type I (n=34)	Type II (n=36)	Type III (n=37)	All Schools (n=107)
1. Manipulative score (ELT) and cognitive score (ELT)	-0.0885	0.0094	-0.1398	-0.0463
2. Manipulative score (ELT) and Manipulative score (TLT)	-0.4322**	0.0729	-0.0842	0.0725
3. Cognitive score (ELT) and cognitive score (TLT)	0.1598	0.3210*	0.3656*	0.3909**

n denotes the sample size.

From the available figures we see that there is no systematic relationship between the two scores for ELT - either at the school level or in the combined sample. None of the coefficients is significantly different from zero even at 10 percent level. Thus ability with manipulative skills is not accompanied generally by ability with cognitive skills in CLS. This means that some students are good at one set of skills and others are good at the other type of skills. A haphazard distribution of mean values across the three schools indicates the same phenomenon.

The relationship between manipulative skills indicated by ELT and TLT is significant only for school type I. Further, the relationship is inverse. This implies that students with better manipulative skills in class XI show relatively poorer manipulative skills in class XII. This is only a relative and not an absolute phenomenon. Probably students with poorer skills show a faster improvement over the year though all students may generally be improving. The combined sample consisting of all schools shows no such systematic behaviour.

Finally, the relationship between cognitive scores corresponding to ELT and TLT is significant in school Types II and III as well as in the combined sample. The relationship for all schools individually and combined is positive, at varying levels of significance. This shows that students tend to improve their cognitive skills uniformly all across the different types of schools.

(C) Statistical Results: Terminal Level Test

Let us now consider the terminal level test (TLT). Table 6.10 overleaf gives us the level and dispersion of the Terminal level test (TLT) and related variables. The Airthmatic means (AM and standard deviations (SD) given relate to the three different school types and the combined sample of all schools.

Table 6.10

Means and standard deviations of TLT and related variables

Variable	Type I school		Type II School		Type III School		All Schools	
	AM	SD	AM	SD	AM	SD	AM	SD
Terminal level test	74.12	10.88	78.24	6.48	65.31	9.37	72.46	10.
Entry level Test	70.28	6.95	72.60	8.16	63.66	7.37	68.77	8.
Theory test(Pandit)	65.07	17.11	81.67	14.95	38.65	10.55	61.52	22.
Theory test(CBSE)	42.15	11.64	55.14	7.54	27.57	7.86	41.48	14.
Chemistry Practical (CBSE)	21.38	3.43	28.14	1.68	25.30	2.60	25.01	3.
Type of Examination (CBSE)	1.00	0.00	1.00	0.00	2.00	0.00	1.35	0.
Socio Economic Status	2.76	1.05	1.44	0.61	3.73	1.15	2.65	1.
Out of school activities	10.32	3.06	12.42	3.44	10.24	4.05	11.00	3.

Table 6.11 gives the AM and SD for manipulative and cognitive scores for different school types and corresponding to the Terminal level test (TLT) and the Entry level test (ELT)

Table 6.11

Means and standar deviations of scores corresponding to ELT and TLT

Variable	Type I School		Type II School		Type III School		All Schools	
	AM	SD	AM	SD	AM	SD	AM	SD
Manipulative score (TLT)	35.81	3.31	38.40	2.69	34.54	3.73	36.24	3.63
Cognitive score (TLT)	38.31	11.12	39.83	6.28	30.77	9.24	36.21	9.84
Manipulative score (ELT)	35.40	3.05	33.14	4.63	32.62	4.73	33.68	4.36
Cognitive score (ELT)	34.88	6.52	39.46	6.77	31.04	6.32	35.09	7.36

Table 6.12 through 6.14 below give the results of comparisons of the mean values of TLT between different groups. These comparisons are based on the "t" test which are given for each case along with the inference.

Table 6.12

t-test for Binary Comparisons Between Schools (TLT)

Comparison	d.f.	t-value	Inference
1. Between Schools of Type I and II.	68	-1.94	significant at 1%
2. Between schools of Type II and III	71	6.84	significant at 1%
3. Between Schools of type I and III	69	3.66	significant at 1%

Table 6.12 shows that while school type III differs from both school types I and II. The two types of schools I and II do not differ from each other very sharply. Thus school type III is distinct from the other two. This is also clear from table 6.10 in which (row I) the mean of TLT in school type III is much lower than the means for the other two types. This difference is a clear indication of the diversity in the students' achievements between type III on the one hand and type I & II, on the other hand. Similar pattern was observed regarding ELT (Table 6.3). This means that the initial differences persist and even widen slightly.

Table 6.13

t-test for Binary comparison Between Sexes (TLT)

Comparison	d.f.	t-value	Inference
1. Within school of Type I	32	0.32	Not significant
2. Within school of Type II	34	-2.13	Significant at 5%

The table 6.13 shows that inter-sex differences in TLT (i.e. between boys and girls) are significant in type II school but in type I school. This is important in so far as the corresponding comparison for ELT is totally different while in school type I ~~xx~~ the inter sex differences get reduced these increase in school type II.

Table 6.14

t-test for comparison of Sexes in schools of Type I & II(TLT)

Comparison	d.f.	t-value	Inference
1. Between Boys	47	-0.86	Not significant
2. Between Girls	19	-2.18	Significant at 5%

Table 6.14 shows that if school types I & II are compared by sexes, boys do not turn out to be significantly different from each other in the two types of schools. On the contrary girls do differ significantly between the two school types. This result is in line with the one for ELT, except that the level of significance has altered. For the four groups the mean TLT scores are as follows:

Table 6.15

Mean scores of Boys & Girls in TLT of Type I & Type II schools

Sex	School Type I	School Type II
Boys	74.48	76.69
Girls	73.11	81.33

This shows the score of girls in Type II school is substantially higher than the remaining three groups. This explains the results in tables 6.13 and 6.14.

Let us now consider the question of inter group differences collectively in order to see if groups - defined by diferent characterstics are homogenous as far as TLT is concerned. For this we consider sex, type of school, type of examination, socio-economic status and out of school activities. The hypothesis of homogenity is tested by carrying out analysis of variance* and the related F-statistic.

Table 6.16 overleaf gives the two relevant sums of squares, degrees of freedom and the F-value in each case. The last column of this table gives the inference drawn.

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*As explained earlier the analysis of variance is equivalent to simple "t" test in case of sex and examination type because in both cases we have only one d.f. for between group sums of squares.

Table 6.16

Analysis of Variance for TLT

Variable	Between and within sum of squares	D.F.	F-Value	Inference
1. Sex	74816 1097472	1 105	7.158	Significant at 1%
2. School type	318544 853872	2 104	19.399	Significant at 1%
3. Examination type	288896 883472	1 105	34.355	Significant at 1%
4. Socio-Economic Status	127344 1045088	5 101	2.461	Significant at 5%
5. Out of school Activities	49952 1122448	5 101	0.899	Not significant

F-values reported in table 6.16 show that the means of Terminal level test performance are not significantly different from each other in case of out of school activities. They are however significantly different between groups corresponding to sex, three types of schools, types of examinations and socio-economic status. These results are considerably different from the corresponding results for ELT. However, as in case of ELT the most prominent heterogeneity is visible in case of school type and examination type. Other differences namely sex and socioeconomic status are significant but not to the same extent. These results imply

that the rate of improvement might vary significantly across sex and socioeconomic conditions. But the basic line of division is defined by the school type, examination type being a natural consequence. This is exactly as we had found to be the case for ELT.

To examine these issues further let us now consider the observed coefficients of correlation between TLT and some other selected characterstics within each school and also in all schools put together. These are given in table 6.17 below.

Table 6.17

Coefficients of correlation between TLT and other Variable in different schools

School → / Varidable ↓	Type I (n=34)	Type II (n=36)	Type III (n=37)	All Schools (n=107)
1	2	3	4	5
1. Entry Level Test	0.3196*	0.5136**	0.6835**	0.6078**
2. Theory test (Pandit)	0.0002	-0.0283	0.3000*	0.4458**
3. Theory test (CBSE)	0.0195	-0.3220*	0.0832	0.3879**
4. Chemistry Practical (CBSE)	-0.0829	0.0562	0.2717	0.1246

1	2	3	4	5
5. Type of Examination*	-	-	-	-0.4964**
6. Socio-Economic states	0.2660	0.0634	0.1140	-0.2512**
7. Out of school activities	0.0861	0.1794	-0.2295	0.0924

The extent and nature of correlation between ELT and TLT has been discussed earlier in this chapter and need not be repeated. For the remaining variables figures intable 6.17 show that the relationship between TLT andalmost all of them is very weak. Almost none of the correlation coefficients within each schools are significantly different from zero. However, in all cases (except chemistry practicalscore (CBSE) and out of school activities) the coefficients of correlation are significant. These results are fairly similar to those we got for ELT (Table 6.8) earlier. Looking at all the results ...

* Coefficient of correlation for type of examination cannot becalculated for individual schools because all students undergo only one type of examination. n stands for thesample size ** on the top of a calculated value of the coefficient of correlation denotes significant at 1% and * denotes significance at 5% .

together it appears that the ranking of schools is reflected in the variables we are looking at. But there is a fair degree of randomness i.e. lack of systematic relationship between variables in any given school. Thus the observed linear relationship between TLT and variables such as theory test reflect the inter-school diversity more than anything else. Between TLT and theory test (CBSE) the relationship is significant in school type II and in the combined sample. Similarly the relationship between TLT and theory test (Pandit) is significant only for school type III. All other coefficients of correlation as stated earlier fail to be significant.

Turning to the calculated coefficients for the combined sample we have already seen that the relationship between TLT and ELT is positive and fairly strong. This means that students with high TLT tend to have high ELT also. This is true for each individual school also. Also, those who have better TLT score tend to perform relatively better in theory test (Pandit & CBSE).

However no systematic relationship seems to hold between TLT and either chemistry practicals or out of school activities even for the combined sample. On the contrary the relationship between TLT and examination type and socio-economic status is inverse. Since there are only two types of examinations a higher TLT score

is associated with examination type I (All India higher secondary examination) than with examination type II (Delhi board examination). As explained in the context of ELT in our earlier discussion the present results imply that students coming from parents of better socio-economic status have higher TLT score. However, notice that the coefficients of correlation is significant but not too large. This is because the relationship between the two variables is almost negligible in case of school types II as well as III. It is only for the school type I that the coefficient of correlation is of a reasonable magnitude.

A comparison with results pertaining to ELT shows that the correlation between TLT and socio-economic status is much lower than between ELT and socio-economic status in school type II.

Some other findings in this context are quite similar to those mentioned for ELT. These relate to occupational hierarchy, stratification between schools, income of parents, mother's education etc.

To conclude we shall now consider the relationship between manipulative and cognitive scores in TLT & ELT. The coefficients of correlation between different relevant scores are given in table 6.18 overleaf. These partain to each of the three school types as well as the combined sample.

Table 6.18

Coefficients of correlation between Manipulative and cognitive scores for TLT

Schools	Coefficients of Correlation
Type I	-0.2208
Type II	-0.1394
Type III	-0.1667
All Schools combined	0.0096

The estimated coefficients of correlation shows that there is no systematic relationship between the two scores for TLT (manipulative and cognitive) either at the individual school level or in the combined sample. None of the coefficients is significantly different from zero even at 10% level. Thus higher (or lower) competence with manipulative skills are not accompanied generally by higher (or lower) competence with cognitive skills in chemistry laboratory skills. This means that some students are good at one set of skills and others are good at the other type of skills. This phenomenon is also corroborated by the patternless-ness of mean values of the two skills across the three schools. These results are in total agreement with those for ELT (table 6.9) discussed earlier.