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STATISTICAL ANALYSIS AND
INTERPRETATION

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STATISTICAL ANALYSIS AND INTERPRETATION

As mentioned in the previous chapters, the comparative
nature of the present study needed a thorough control of
variables to the maximum extent and thorough analysis of
the results through rather sophisticated statistics. One-to-
one matching could not be achieved due to the obvious need
of having seven treatment groups. Group matching was also
not feasible as the size of the treatment groups remained
small and differed from school to school, n being 1 in
two schools, 3 in one school, 4 in one school, 5 in five
schools, and 6 in two schools. Under these conditions, it
was decided to go for statistical control.

In the present investigation, the relative effective-
ness of programme treatments was found on the following
three criteria:

        i) Immediate posttest;

       ii) Percentage of retention; and

     iii) Time taken to finish the programme.

The level of comprehension was taken as the number of
correct answers given on the immediate posttest rather
than taking a pretest-posttest differences. As mentioned
by Lewis (1969), the pretest-posttest design has its own
disadvantage and sources of errors. The limitations of

pretest-posttest design, and the advantages of randomization are given by Lewis (1969) as follows:

> ...It is well to remind ourselves therefore
> that a pretest is not an essential ingred-
> ient in design....Often indeed a suitable
> pretest is difficult to conceive....If the
> posttest, or a parallel form of it, is also
> administered as a pretest, the element of
> artificiality would be apparent from the
> predominance of zero or near-zero scores
> that result.

> ...An equality of groups on a pre-test is no
> substitute for randomisation....The prime
> merit of randomisation is the control it
> exerts not just on one variable, but on all
> variables unrelated to the treatment(s)
> under investigation.

> ...The mere taking of the pretest might
> affect the posttest scores. A related
> possibility is that it would sensitise the
> experimental group to the treatment it
> subsequently receives. A higher posttest
> score would then be an effect of the pretest
> by treatment interaction rather than a main
> effect of the treatment itself."

The school-to-school variations were taken care through the application of the special method of covariance, called "Analysis of Covariance in Duplicate Experiments in Randomly Selected Schools" (Lindquist, 1970).

In short, the seven treatment groups were analysed in terms of the immediate posttest scores, retention scores and the time taken to finish the programme. The distribution of scores on the immediate posttest, percentage of retention and the time taken to finish the programme are given in the following pages, where

A   stands for the Linear Overt Form

B   stands for the Linear Covert Form

C.   stands for the Response Prompt Overt
     Form (Copying)

D   stands for the Response Prompt Covert
     Form (Reading)

E   stands for the Skip programme Form

F   stands for the Branching Form

G   stands for the Hybrid Form.

Distribution of Scores of the Seven Treatment Groups on the Immediate Posttest (n=46)

SCORE	A	B	C	D	E	F	G
40			1	1			
39		4	2	4	1		1
38	2	3	1	2	2	1	2
37	1	1	3	4	2	2	3
36	2	1		3	3	1	3
35	2	3	1	2	1	5	2
34	2	2		4	2	1	2
33	4	3	2	4	5	3	1
32	4	2	3	4	1	1	2
31	5	6			2	2	3
30	1	3	2	3	2	4	2
29	7	6	13	3	5	8	3
28	3	4	5	3	6	1	6
27							
26			1			1	3
25		2				1	1
24	2		3	2	2	1	1
23				1	4	1	1
22	1		1	1	1	2	2
21	2				2	2	1
20	1		3	1		2	
19	2	3	1	1	1	2	1
18		1		1	1	1	3
17	3		1	1			2
16		2			1		
15	1						1
14	1				1	1	
13			1	1			
12			1			2	
11			1				

Distribution of Scores of the Seven Treatment Groups on the Retention Test

SCORE	A	B	C	D	E	F	G
40							
39			1	1			
38	2			2			
37		1		1	1	1	2
36		2		3	1		2
35	1		1	1			2
34	2	4	2	4	1		
33	1		2	1	1	2	3
32	1	4	4	4	2	2	
31	6	4	2	4	1	2	2
30	2	4	2	4	6	6	3
29	10	7	6	4	8	4	9
28	3	5	6	4	2	8	8
27	1				1	1	
26	1		1				2
25		2			1		
24	1	1	1		4		
23			2	1	1	4	1
22	2	2	3	1	2	3	1
21	3	1	1	2	4	4	
20	6	1		1	1	3	3
19	1	4	1		3	1	1
18	1	1	5	3	1	1	
17			1	2	2		
16	1	1	1		2		1
15			2		1	2	2
14	1		1	2			1
13		1	1			1	1
12							
11				1			
10							
9						1	2
8						1	2
7		1					

Frequency Distribution of the Seven Treatment Groups in terms of the Time taken to finish (Time in Mts.)

Class intervals (mts.)	A	B	C	D	E	F	G
170 – 179				1			
160 – 169	2	2			1		1
150 – 159	1		1	1			1
140 – 149	3		3	2		1	2
130 – 139	4	2	3		4	1	1
120 – 129	5	2	10		3	3	4
110 – 119	5	4	3	2	5	8	4
100 – 109	8	6	4	2	10	9	7
90 – 99	6	6	3	12	11	5	6
80 – 89	4	6	7	8	2	2	9
70 – 79	8	12	4	3	4	10	9
60 – 669		6	6	8	4	5	1
50 – 59			2	6	1		1
40 – 49						1	
30 – 39				1	1	1	

In the table given below are shown the means of the seven treatment groups on the immediate posttest, retention test, percentage of retention and the time taken to finish.

Means Scores of the Seven Treatment Groups on Immediate Posttest, Retention test, Percentage of retention and Time

	Forms	Immediate Posttest	Retention Test	'Loss'	% of Retention	Time (in Minutes)
A.	Linear Overt Form	28.36	26.84	1.52	94.64	106.63
B.	Linear Covert Form	30.39	27.15	3.24	89.34	91.19
C.	Response Prompt Overt Form (Copying)	28.10	25.69	2.41	91.42	99.23
D.	Response Prompt Covert Form (Reading)	31.19	28.00	3.19	89.77	84.91
E.	Skip Programme Form	28.78	25.60	3.18	88.95	95.21
F.	Branching Form	27.43	25.36	2.07	92.45	91.95
G.	Hybrid Form	28.56	26.50	2.06	92.79	96.41

OBSERVATIONS

1   Of all the seven forms tried out, the Response
    Prompt Covert Form (D) seems to be relatively
    better in effectiveness, both on the immediate
    posttest and the retention test.

2   Of all the seven forms tried out, the Branching
    Form (F) seems to be relatively less effective
    both on the immediate posttest and the retention
    test.

3   When the percentage of retention is considered,
    the Response Prompt Covert Form (D) no longer
    retains its superiority; its 'loss' is 3.19
    points, next to the Linear Covert Form (B) whose
    'loss' is 3.24 points.

4   The Skip programme Form (E), though third in
    order of achievement on the immediate posttest,
    is also the one with considerable 'loss' of
    3.18 points.

5   Of all the seven forms tried out, the Linear
    Overt Form (A) requires the maximum time, while
    the Response Prompt Covert Form (D) requires the
    minimum time.

6   The Linear Covert Form (B) also requires shorter
    time, next only to the Response Prompt Covert
    Form (D) in this regard.

Comparison of the group means gives a general picture of differences, but does not tell whether the differences are significant. In order to know the statistical significance, the technique of analysis of covariance in duplicate experiment, in randomly selected schools (Lindquist, 1970) is followed. Analysis of covariance takes care of any possibility of the initial differences (for example, intelligence in the present study) influencing the final scores. This method of analysis is adopted because the groups were not matched in terms of initial scores. The method also gives a quantitative picture by revealing the levels at which these differences exist (.01 or .05 levels). The special feature of this design of duplicate experiments is that the class/school variations are also given due consideration so that the inferences cannot mask the effects of classes (i.e., classes selected from different schools).

Analysis of Covariance in Duplicate Experiments : Analysis of the Initial Scores (Intelligence)

In the present investigation, intelligence was taken as an initial measure and the seven treatment groups were randomly formed. The size of the groups differed from school to school; but in any particular school, the seven treatment groups were equal in size.

Table No. 4.5

Totals and Means on Initial Scores (Intelligence)

(T_c on treatments)

Treatments / Schools	A	B	C	D	E	F	G	Ts	Ts²	nc	n	Ts²/n	Ts/n . Means
a	473	485	466	476	494	489	458	3341	11162281	4	28	398652.89	119.32
b	611	611	605	591	591	590	595	4194	17589636	5	35	502561.03	119.83
c	595	624	619	610	615	534	590	4196	17606416	5	35	503040.46	119.89
d	337	350	340	354	340	361	350	2421	5861241	3	21	279106.71	115.28
e	667	662	725	688	692	696	725	4855	23571025	6	42	561214.88	115.59
f	616	601	551	607	583	630	599	4187	17530969	5	35	500884.83	119.63
g	711	747	735	753	750	728	745	5169	26718561	6	42	636156.21	123.07
h	611	613	586	600	619	617	623	4269	18224361	5	35	520696.03	121.97
i	621	582	585	593	605	581	558	4135	17098225	5	35	488520.71	118.14
j	120	118	106	114	126	116	125	825	680625	1	7	97232.14	117.86
k	118	125	117	108	126	115	126	835	697225	1	7	99603.57	119.28
Total (T_t)	5480	5518	5444	5483	5541	5457	5504	38427 GT		322 N		4587669.46 $\Sigma(Ts^2/n)$	
Means	119.13	119.96	118.35	119.20	120.46	118.63	119.65						

Total of Means .. 835.38

Where,

GT stands for Grand Total
Tc stands for Class Total
The Tc of 473 in the first cell is got by adding the individual IQs. of
four students (nc in school 'a' is 4) i.e. = 120+123+117+113 = 473
Ts stands for School Total, got by adding the Tc from the seven groups
Ts(i.e. 3341 = 473+485+466+476+494+489+458.
T_t stands for treatmentwise totals.

In the following pages are given the compulation of sum of Squares for Methods, Classes and Schools and also MxS for Intelligence Scores.

Step 1: Compulation of the total and mean for each class, for each school and for each method for the initial scores (Intelligence) Table No. 4.5

Step 2: Sums of squares for M, S and C and MxS for the initial scores (Intelligence).

On the basis of the calculations shown in the table, the following computations are done:

i) $GT = 38427$; $N = 322$

$$\therefore \frac{(GT)^2}{N} = \frac{(38427)^2}{322} = 4585820.89$$

ii) **Sum of Squares for Schools**

$$\sum (Ts^2/n) = 4587669.46$$

$$\frac{(GT)^2}{N} = 4585820.89$$

S.S. for Schools: 1848.57

iii) **Sum of Squares for Methods**

$$\sum T^2m = (5480)^2+(5518)^2+(5444)^2+(5483)^2+$$
$$(5541)^2+(5457)^2+(5504)^2 = 210954695$$

$$\therefore \sum T^2m/nm =$$

$$= \frac{210954695}{46} = 4585971.63$$

$$\sum T^2m/nm = 4585971.63$$

$$\frac{(GT)^2}{N} = 4585820.89$$

S.S. for Methods   150.74

Computation of Sum of Squares for Classes for the initial scores (Intelligence)

Tc^2 on Treatments

Schools Treatment	a	b	c	d	e	f	g	h	i	j	k
A	223729	373321	354025	113569	444889	379456	5055?1	37?321	?856??	14400	13924
B	235225	373321	389376	122500	438244	361201	558009	375769	338724	13924	15625
C	217156	366025	383161	12160?	525625	303601	540225	343396	342325	11236	13689
D	226576	349281	383161	111556	473344	368449	567009	360000	351649	12996	11664
E	244036	349281	378225	115600	478864	339889	?2500	383161	366025	15876	15376
F	239121	348100	285156	130321	484416	396900	529984	380689	337561	13456	13225
G	209764	354025	348100	122500	525625	358801	555025	388129	322624	15625	15876
Totals ΣTc^2	1595607	2513354	2521204	837947	3371007	2508297	3818273	2604465	2444449	97513	99879
nc	4	5	25	3	6	5	6	5	5	1	1
$\Sigma Tc^2/nc$	398901.75	502670.80	504240.80	279282.33	561834.50	501659.40	636378.83	520893	488889.80	97513	99879

$$\Sigma \left(\Sigma Tc^2/nc\right) = 4592143.21$$

Computations

Using the value of $\sum(\Sigma Tc^2/nc)$ the sum of squares for Classes is computed as follows:

Sum of Squares for Classes

$$\sum(\Sigma Tc^2/nc) = 4592143.21$$

$$\frac{(GT)^2}{N} = \frac{4585820.89}{6322.32}$$

S.S. for Classes $\underline{\underline{6322.32}}$

The sum of Squares for MxS is computed by subtracting the S.S. values for schools and methods from that of classes:

S.S.for Classes	=	6322.32
S.S.for Schools	=	1848.57
		4473.75
S.S.for Methods	=	150.74
S.S.for MxS	=	4323.01

i) <u>Analysis of the final Scores - Immediate Posttest scores -</u>

As one of the indices of relative effectiveness, the *scores on* immediate posttest were taken as the final scores while intelligence was taken as the initial score.

The following pages illustrate the computation of Sum of Squares for Methods, Schools, Classes, and for (MxS) for the immediate posttest scores.

Totals and Means on Final Scores (Immediate Posttest Scores)

Treatments Schools	Tc on treatments A	B	C	D	E	F	G	Ts	Ts²	nc	n	Ts²/n	Means (Ts/n)
a	107	114	122	108	119	117	110	797	635209	4	28	22686.04	28.46
b	155	150	139	127	134	146	151	1002	1004004	5	35	28685.83	28.62
c	139	170	159	168	148	128	141	1053	1108809	5	35	31680.26	30.08
d	86	79	65	80	94	84	72	560	313600	3	21	14933.33	26.66
e	196	192	194	222	165	184	196	1375	1890625	6	42	45014.8	32.73
f	147	150	131	172	112	151	158	1021	1042441	5	35	29784.02	29.17
g	136	173	127	202	182	144	179	1163	1352569	6	42	32204.02	27.69
h	155	175	109	162	158	157	127	1103	1216609	5	35	34760.26	31.51
i	121	155	130	145	124	87	112	854	729316	5	35	20837.60	24.40
j	14	28	28	30	28	26	34	188	35344	1	7	5049.14	26.85
k	29	30	29	19	36	38	34	215	46225	1	7	6603.57	30.71
T_{treat}	1305	1398	1293	1435	1324	1262	1314	9331 GTy			322 N	272238.95 $\Sigma Ts^2/n$	
Means	28.36	30.39	28.10	31.19	28.78	27.43	28.56	202.81					

Where,

GT stands for Grant Total
Tc stands for Class Total
The Tc of 107 in the first cell is got by adding the individual scores of four students (nc in school 'a' is 4) i.e. = 30+33+29+15 = 107
Tc stands for School Total, got by adding the Tc from the seven groups
i.e. 797 = 107+114+122+108+119+117+110.

As a next step, the Sum of Products were computed taking intelligence as initial scores and immediate posttest scores as final scores.

The details of the computations are given in the following pages.

Step 1: Computation of the total and mean for each class, for each school and for each method, for the final scores (immediate posttest)   Table No. 4.7

Step 2: Computation of Sum of Squares for M, S and C and MxS for the final Scores (Immediate posttest)

On the basis of the calculations shown in the table, the following computations are done:

i) i)   GT = 9331;   N=322

Therefore, $\dfrac{(GT)^2}{N} = \dfrac{(9331)^2}{322} = 270396.15$

ii) Sum of Squares for Schools

$$\sum (Ts^2/n) \quad = \quad 272238.95$$

$$\dfrac{(GT)^2}{N} \quad = \quad 270396.15$$

S.S.for Schools=   1842.80

iii) Sum of Squares for Methods

$$\sum T_m^2 \quad = \quad (1305)^2 + (1398)^2 + (1293)^2 + (1435)^2 +$$
$$(1324)^2 + (1262)^2 + (1314)^2 = 12460719$$

$$\sum T^2m/nm = \dfrac{12460719}{46} = 270885.19$$

$$\sum T^2m/nm = 270885.19$$

$$\dfrac{(GT)^2}{N} = 270396.15$$

S.S.for Methods =   489.04

Computation of Sum of Squares for classes for the final scores

(Immediate Posttest)

Schools Treat-ment	a	b	c	d	e	f	g	h	i	j	k
A.	11449	24025	19321	7396	38416	21609	24336	24025	14641	196	841
B.	12996	22500	28900	6241	37636	22500	29929	30625	18225	784	900
C.	14884	19321	25281	4225	37636	17161	16129	28561	16900	784	841
D.	11664	16129	28224	6400	49284	29584	40804	26244	21025	900	361
E.	14161	17956	21904	8336	35721	12544	33124	24964	15376	784	1296
F.	13689	21316	16384	7056	33856	22801	20736	24649	7569	676	1444
G.	12100	22801	19881	5184	38416	24964	32041	16129	12544	1156	1156
Totals											
Totals ΣT_c^2	90943	144048	159895	45338	270965	151163	197099	175197	106280	5280	6839
nc	4	5	5	3	6	5	6	5	5	1	1
$\Sigma T_c^2/nc$	22735.75	28809.60	31979	15112.66	45160.83	30232.60	32849.83	35039.40	21256	5280	6839

$$\Sigma(\Sigma T_c^2/nc) = 275294.67$$

Computations

Using the value of $\Sigma(\Sigma Tc^2/nc)$, the sum of squares

for classes is computed as follows:

Sum of Square for Classes

$\Sigma (\Sigma Tc^2/nc)$	$=$	275294.67
$(GT)^2/N$	$=$	270396.15
S.S. for classes	$=$	4898.52

The sum of squares for MxS is computed by subtracting

the S.S. values for schools and methods from that of classes,

as shown below:

S.S. for Classes	$=$	4898.52
S.S. for Schools	$=$	1842.80
		3055.72
S.S. for Methods	$=$	489.04
S.S. for MxS		2566.68

Step 3: Computation of Sum of Products for Methods,Schools and Classes
(Intelligence and Immediate Posttest)

Grand Total of IQ, that is, (GT_x) $=$ 38427

Grand Mean of Immediate
Posttest , (GM_y) $=$ 28.98

$\therefore (GT_x).(GM_y)$ $=$ (38427) x (28.98)

$=$ 1113614.46

Sum of Products for Methods

Sum of Products for methods is computated using the treatmentwise IQ totals and the treatmentwise immediate posttest means as follows:

$$\Sigma_M(T_x.M_y) = (T_{Ax}).(M_{Ay}) + (T_{Bx}).(M_{By}) + (T_{Gx}).(M_{Gy})$$

$$
\begin{aligned}
= \quad &(5480).(28.36) + (5518).(30.39) + \\
&(5444).(28.10) + (5483).(31.19) + \\
&(5541).(28.78) + (5457).(27.43) + \\
&(5504).(28.56) = 1113445.72
\end{aligned}
$$

$\Sigma \ M(T_x.M_y)$	= 1113445.72
$(GTx).(GMy)$	= 1113614.46
Sum of Products for Methods	−168.74

Sum of Products for Schools

Sum of Products for Schools is computed using the schoolwise IQ totals and the Schoolwise immediate posttest means as follows:

$$\Sigma_s(T_x.M_y) = (T_{ax}).(M_{ay}) + (T_{bx}).(M_{by}) + \ldots$$

$$\ldots (T_{kx}).(M_{ky})$$

$$
\begin{aligned}
= \quad &(3341).(28.46) + (4194).(28.62) + \\
&(4196).(30.08) + (2421).(26.66) + \\
&(4855).(32.73) + (4187).(29.17) + \\
&(5169).(27.69) + (4269).(31.51) + \\
&(4135).(24.40) + (825).(26.85) + \\
&(835) \ .(30.71) = 1113249.52
\end{aligned}
$$

$\Sigma_s(Tx.My)$	= 1113249.52
$_s(GTx).(GMy)$	= 1113614.46
Sum of Products for Schools	−364.94

Sum of Products for Classes

Sum of Products for Classes is computed using the schoolwise IQ totals and the schoolwise immediate posttest means as follows:

Method A $= \Sigma_A(Tcx).(Mcy) = (Tcax).(Mcay) + (Tcbx).(Mcby) + \ldots\ldots +(Tckx).(Mcky)$

$= (473).(2675) + (611).(31) + (595).(27.8) + (337).(28.66) + (667).(32.66) + (616).(29.4) + (711).(26) + (611).(31) + (621).(24.2) +(120).(14) + (118).(29)$

$= \underline{155244.99}$

Method B $= (485).(28.5) + (611).(30) + (624).(34) + (350).(26.33) + (622).(32.33) + (601).(30) + (747).(28.83) + (613).(35) + (582).(27) + (118).(28) + (125).(30)$

$= \underline{167775.47}$

Method C $= (466).(30.5) + (605).(27.8) + (619).(31.8) + (349).(21.66) + (725).(32.33) + (551).(26.2) + (735).(21.16) + (586).(33.8) + (585).(26) +(106).(28) +(117).(29)$

$= \underline{153081.39}$

Method D $= (476).(27) + (591).(25.4) + (619).(33.6) + (334).(26.66) + (688).(37) + (607).(34.4) + (753).(33.66) + (600).(32.4) + (593).(29) + (144).(30) + (108).(19)$

$= \underline{171358.02}$

Method E $= (494).(29.75) + (591).(26.8) + (615).(29.6) + (340).(31.33) + (692).(31.5) + (583).(22.4) + (750).(30.33) + (619).(31.6) + (605).(24.8) + (126).(28) +(126).(36)$

$= \underline{159624.60}$

Method F = $(489).(29.25) + (590).(29.2) + (534).(256) + (361).(28) + (696).(30.66) +$

$(630).(30.2) + (728).(24) + (617).(31.4) + (581).(17.4) + (116).(26) +$

$(115).(38) = \underline{150016.21}$

Method G = $(458).(27.5) + (595).(30.2) + (590).(28.2) + (350).(24) + (725).(32.66) +$

$(599).(31.6) + (745).(29.83) + (623).(25.4) + (568).(22.4) + (125).(34) +$

$(126).(34) = \underline{157513.65}$

$\Sigma(\Sigma(Tcx).(Mcy))$ = $155244.99 + 167775.47 + 153081.39 + 171358.02 + 159624.60 +$

$150016.21 + 157513.65 = 1114614.33$

$\Sigma(\Sigma(Tcx).(Mcy))$ = 1114614.33

GTx.GMy = 1113614.46

Sum Products for Classes = 999.87
=======

Step 4: **Computation of Sum of Products for MxS (Intelligence and Immediate Post test)**

Sum of Products for MxS is computed as below:

Sum of Products for Classes	= 999.87
Sum of Products for Schools	—(-364.94)
	1364.81
Sum of Products for Methods	—(-168.74)
Sum of Products for MxS	1533.55
	=========

Step 5: **Computation of M+(MxS)**

	Σx^2	Σxy	Σy^2
M	150.74	-168.74	489.0 4
MxS	4323.01	1533.55	2566.68
M+(MxS)	4473.75	1364.81	3055.72

Step 6: **Adjusted Sum of Squares for MxS**

$$\Sigma y^2 - \frac{(\Sigma xy)^2}{\Sigma x^2} \quad \text{(for MxS)}$$

$$= 2566.68 - \frac{(1533.55)^2}{4323.01} = 2022.67$$

Step 7: **Adjusted Sum of Squares for M+(MxS)**

$$\Sigma y^2 - \frac{(\Sigma xy)^2}{\Sigma x^2} \quad \text{(for M+(MxS))}$$

$$= 3055.72 - \frac{(1364.81)^2}{4473.75} = 2639.36$$

Step 8: **Reduced Sum of Squares for M**

This is obtained by substracting Step 6 from Step 7.

$$= 2639.36 - 2022.67 = 616.69$$

Step 9: **Reduced METHODS Variance**

$$\text{Reduced Methods Variance} = \frac{\text{reduced Sum of squares for M}}{\text{df for M}}$$

$$= \frac{616.69}{6} = \underline{102.78}$$

Step 10: **Adjusted MxS (error) Variance**

Adjusted MxS Variance =

$$\frac{\text{Adjusted sum of Squares for MxS}}{\text{d.f. for adjusted MxS}}$$

$$= \frac{2022.67}{59} = \underline{34.28}$$

Step 11: **Computation of F**

$$F = \frac{\text{Reduced Methods Variance}}{\text{Adjusted MxS Variance}} = \frac{102.78}{34.28}$$

$$= \underline{2.99}$$

F is significant at .05 level.

The table in the following page shows the analysis of Covariance and the F calculated for the immediate posttest, taking intelligence as the initial score.

Table No. 4.9

Analysis of Covariance of the Immediate Posttest
Scores for the Seven Treatment Groups (Taking
Intelligence as the Initial Score)

	$\sum x^2$	$\sum xy$	$\sum y^2$	S.S.	df	F	Significance
M	150.74	-168.74	489.04	616.69 (reduced S.S.)	6	2.99	Significant at .05 level
MxS	4323.01	1533.55	2566.68	2022.67 (adjusted S.S.)	59		
M+(MxS)	4473.75	1364.81	3055.72	2639.36 (adjusted S.S.)			

OBSERVATIONS

It can be seen that the overall differences between
the seven treatment means are significant at .05 level.
As the differences among the schools have been statisti-
cally controlled by 'analysis of covariance in duplicate
experiments in randomly selected schools', (Lindquist,
1970) it can be inferred that the differences among the
treatment groups are true differences and are neither due
to initial differences in intelligence which are indicated
by the negative value of the sum of products for methods
as -168.74, nor due to school to school variations.

Hence we can safely reject the null hypothesis, and
can attribute the differences to the variations in the
effectiveness of the programme forms.

Analysis of covariance does not tell us which one
treatment is significantly different from others. In such
cases, the analysis can further be continued using other
derived techniques. The Least Significant Difference (LSD)
Test is one such technique using a pooled error variance
computed in the analysis of covariance.

The formula for LSD is:

$$LSD = \sqrt{\frac{2 \ MSW}{n}} \quad \text{with df} = 59$$

where MSW = error variance

$\qquad$ n = no. of subjects in each

$\qquad\qquad$ treatment group (46).

$$LSD \text{ at } 5\% = t \ 0.5 \ x\sqrt{\frac{2MSW}{n}}$$

$$= (2.00) \ x\sqrt{\frac{2x34.28}{46}} = 2.4414$$

$$LSD \text{ at } 1\% = t \ 0.1 \ x\sqrt{\frac{2MSW}{n}}$$

$$= (2.66) \ x\sqrt{\frac{2x34.28}{46}} = 3.24706$$

Table No. 4.10

Significance of Difference between Means of any Two Treatments on the Immediate Posttest (Using the technique of L.S.D.)

Treatments	Difference between Means	Significance
A & B	2.03	Not significant
A & C	0.26	Not significant
A & D	2.83	Significant at .05 level
A & E	0.42	Not significant
A & F	0.93	Not significant
A & G	0.20	Not significant
B & C	2.29	Not significant
B & D	0.80	Not significant
B & E	1.61	Not significant
B & F	2.96	Significant at .05 level
B & G	1.83	Not significant
C & D	3.09	Significant at .05 level
C & E	0.68	Not significant
C & F	0.67	Not significant
C & G	0.46	Not significant
D & E	2.41	Not significant
D & F	3.76	Significant at .01 level
D & G	2.63	Significant at .05 level
E & F	1.35	Not significant
E & G	0.22	Not significant
F & G	1.13	Not significant

OBSERVATIONS

i) The differences between the following forms
   are significant at .01 level

   - The Response Prompt Covert Form
     (Form D) and the Branching Form
     (Form F)

ii) The differences between the following forms
    are significant at .05 level

    - The Response Prompt Covert Form
      (Form D) and the Linear Overt Form
      (Form A)

    - The Response Prompt Covert Form
      (Form D) and the Response Prompt
      Overt Form (Form C)

    - The Response Prompt Covert Form
      (Form D) and the Hybrid Form
      (Form G)

    - The Branching Form (Form F) and
      the Linear Covert Form (Form B).

In short, the differences between the Response Prompt
Covert Form and four other forms are significant.

ii)   Analysis of the Final Scores - Percentage

of Retention

In the following pages are given the

analysis of covariance using the percentage of

retention as the final score and intelligence

as the initial score. The details of the

computation include the Sum of Squares for

Methods, Classes, Schools and MxS. The Sum

of Products are computed as before and the

F value is deduced.

The details of the computation involved the

following steps:

Step 1.   Computation of the totals and means for

each class, for each school, and for each

method for the final scores (percentage

of retention)   Table No. 4.11

TABLE NO. 4.11

Totals and Means on Final Scores - Percentage of Retention

Treatment Schools	A	B	C	D	E	F	G	Ts	Ts²	nc	n	Ts²/n	Means Ts/n
a	393.94	362.11	352.12	302.35	357.74	396.97	313.05	2478.28	6141871.75		28	219352.55	86.51
b	453.55	398.15	386.19	492.80	375.14	380.55	487.92	2984.30	8906046.49		35	254458.47	85.26
c	428.75	401.88	445.52	364.36	400.03	389.74	382.21	2812.49	7910100.00		35	226002.85	80.35
d	237.76	257.58	300.00	293.64	248.80	296.67	300.00	1934.45	3742096.89		21	178195.08	92.11
e	513.33	513.54	556.98	531.75	499.16	503.17	557.36	3675.29	13507756.58		42	321613.25	87.50
f	457.15	462.72	458.74	465.73	454.26	441.89	419.27	3139.76	9858092.85		35	281659.79	89.70
g	560.92	555.61	568.42	530.38	580.48	555.65	580.16	3931.82	15459208.51		42	368076.39	93.61
h	477.02	434.25	411.02	453.91	386.12	364.79	411.11	2938.22	8633136.76		35	246661.05	83.94
i	450.08	455.74	458.74	484.66	500.00	472.41	449.71	3275.24	10727197.05		35	306491.34	93.57
j	100.00	100.00	64.29	100.00	57.14	100.00	97.06	618.49	382529.88		7	54647.12	88.35
k	100.00	93.33	55.17	57.89	91.67	97.37	100.00	595.43	354536.89		7	50648.12	85.06
T treat	4173.40	4037.91	4037.19	4077.67	3960.54	3999.21	4097.85	28383.77 GT				2507806.02 $\Sigma(Ts^2/n)$	
Mean	90.72	87.78	87.76	88.64	86.09	86.93	89.08	617.00					

Where,

GT stands for Grand Total
Tc stands for Class Total
The Tc of 393.94 in the first cell is got by adding the individual
percentages of retention of four students (nc in school 'a' is 4)
i.e., 393.94 = 100+93.94+100+100.
Tg stands for School Total, got by adding the Tc from seven groups
i.e. 2478.28 = 393.94+362.11+352.12+257.74+396.97+313.05

Step 2: <u>Computation of the Sum of Squares for M, S
and C and MxS for the final Scores (Per-
centage of retention)</u>

On the basis of the values shown in the table,
the following computations are made:

i) GT = 28383.77; N = 322

Therefore $(GT)^2/N = \dfrac{(28383.77)^2}{322} = 2501982.60$

ii) <u>Sum of Squares for Schools</u>

$\sum (Ts^2/n)$ = 2507806.02

$(GT)^2/N$ = 2501982.60

S.S. for
. Schools   5823.42

iii) <u>Sum of Squares for Methods</u>

$\sum T^2m = (4173.40)^2 + (4037.91)^2 + (4037.19)^2 +$

$(4077.67)^2 + (3960.54)^2 + (3999.21)^2 +$

$(4097.85)^2 = 115120212.76$

$\therefore \sum T^2m/nm = \dfrac{115120212.76}{46} = 2502613.32$

$\sum T^2m/nm$ = 2502613.32

$(GT)^2/N$ = 2501982.60

S.S. for
Methods   630.72

TABLE NO.4.12

Computation of Sum of Squares for Classes for the final scores

Percentage of Retention

Schools Treatment	a	b	c	d	e	f	g	h	i	j	k
A	155188.72	205707.30	183826.56	56529.81	263507.68	208986.12	314631.24	227548.08	203382.96	10000.00	10000.00
B	131123.65	158523.42	161507.53	66347.45	263723.33	214109.79	308702.4?	188573.06	210442.38	10000.00	8710.48
C	123908.49	149142.71	198403.07	90000.00	310226.72	192492.78	323101.29	168937.44	?1??.38	4?3.20	3043.72
D	91415.52	242851.84	132758.20	86224.44	282758.06	216904.43	281515.13	206034.28	234895.31	10000.00	3351.25
E	127977.90	148332.81	160024.00	61901.44	249160.70	206352.14	336957.03	142088.65	250000.00	3264.97	8403.38
F	157585.18	144818.30	151897.26	88013.08	253180.04	195266.77	308746.92	133071.74	223171.20	10000.00	9480.91
G	98000.30	238065.92	146084.48	90000.00	310650.16	175787.33	336585.62	169011.43	202239.08	9420.64	10000.00
Totals ΣTc^2	885279.76	1287442.60	1134586.10	539016.22	193?09.69	1409899.36	2210239.70	1242264.68	1524573.31	56818.81	52989.74
nc	4	5	5	3	6	5	6	5	5	1	1
$\Sigma Tc^2/nc$	221319.94	257488.52	226?17.22	179672.07	322201.11	281979.87	368?73.28	248452.93	306914.66	56818.81	52989.74

$$\Sigma\left(\Sigma Tc^2/nc\right) = 2523128.15$$

Using the value of $\sum(\sum Tc^2/nc)$, the sum of
Squares for Classes is computed as below:

Sum of Squares for Classes

$\sum(\sum Tc^2/nc)$ = 2523128.15

$\dfrac{(GT)^2}{N}$ = 2501982.60

21145.55

The sum of squares for MxS is computed by sub-
tracting the S.S. values for Schools and Methods
from that of Classes.

S.S.for Classes = 21145.55

S.S.for Schools = 5823.42

15322.13

S.S.for Methods = 630.72

S.S.for MxS = 14691.41

Step 3: Computation of Sum of Products for Methods,
Schools and Classes (Intelligence and Percentage
of retention)

Grand Total of IQ (GTx) = 38427

Grant Mean Percentage
of Retention (GM_z) = 88.14

$\therefore (GT_x).(GM_z)$ = 38427 x 88.14 = 3386955.78

Sum of Products for Methods

Sum of Products for methods is computed using
the treatmentwise Intelligence totals and the
treatmentwise mean percentage of retention as follows:

$$\Sigma'_M(T_x.M_z) = (T_{Ax}).(M_{Az}) + (T_{Bx}).(M_{Bz}) + \ldots$$

$$\ldots\ldots (T_{Gx}).(M_{Gz})$$

$$
\begin{aligned}
&= (5480).(90.72) + (5518).(87.78) + \\
&\quad (5444).(87.76) + (5483).(88.64) + \\
&\quad (5541).(86.09) + (5457).(86.93) + \\
&\quad (5504).(89.08) = 3386992.22
\end{aligned}
$$

$$\Sigma'_M(T_x.M_z) \qquad = 3386992.22$$

$$GT_x.\ GM_z \qquad = 3386955.78$$

Sum of Products
for Methods $\qquad \underline{\underline{36.44}}$

Sum of Products for Schools

Sum of Products for Schools is computed using the school-wise Intelligence totals and the schoolwise *percentage of retention* immediate post-test means as follows:

$$\Sigma'_s(T_x.M_z) = (T_{ax}).(M_{az}) + (T_{bx}).(M_{bz}) + \ldots$$

$$\ldots (T_{kx}).(M_{kz})$$

$$
\begin{aligned}
&= (3341).(88.51) + (4194).(85.26) + \\
&\quad (4196).(80.35) + (2421).(92.11) + \\
&\quad (4855).(87.5) + (4187).(89.7) + \\
&\quad (5169).(93.61) + (4269).(83.94) + \\
&\quad (4135).(93.57) + (825).(88.35) + \\
&\quad (835).(85.06) = 3386861.41
\end{aligned}
$$

$$\Sigma'_s(T_x.M_z) \quad = 3386861.41$$

$$(GT_x).(GM_z) \quad = 3386955.78$$

Sum of Pro-
ducts for $\qquad \underline{\underline{94.37}}$
Schools

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Sum of Products for Classes (Intelligence and Percentage of retention)

Sum of Products for Classes is computed using the schoolwise Intelligence totals and the schoolwise mean percentage of retention.

Method A $= \sum_A (T_{cx}).(M_{cz}) = (T_{cax}).(M_{eaz}) + (T_{cbx}).(M_{cbz}) + \ldots + (T_{ckx}).(M_{ckz})$

$$= (473).(98.49) + (595).(85.75) + (337).(79.25) + (667).(85.55) +$$
$$(611).(90.71) + (611).(95.4) + (621).(90.19) + (120).(100) +$$
$$(616).(91.43) + (711).(93.48) +$$
$$(118).(100) = \underline{497682.48}$$

Method B $=$ $(485).(90.52) + (624).(80.37) + (350).(85.86) + (662).(85.59) +$
$$(611).(79.63) + (613).(86.85) + (582).(91.74) + (118).(100) +$$
$$(601).(92.54) + (747).(92.6) +$$
$$(125).(93.33) = \underline{484305.31}$$

Method C $=$ $(466).(88.03) + (619).(89.10) + (349).(100) + (725).(92.83) +$
$$(605).(77.23) + (586).(82.20) + (585).(91.74) + (106).(64.29) +$$
$$(551).(87.74) + (735).(94.74) +$$
$$(117).(55.17) = \underline{478186.15}$$

Method D $=$ $(476).(75.58) + (612).(72.87) + (334).(97.88) + (688).(88.62) +$
$$(591).(98.56) + (600).(90.78) + (593).(96.03) + (114).(100) +$$
$$(607).(93.14) + (753).(88.43) +$$
$$(108).(57.89) = \underline{485717.43}$$

Method E $= (494).(89.43) + (591).(77.02) + (615).(80) + (340).(82.93) + (692).(83.19) + (583).(90.85) + (750).(96.74) + (619).(77.22) + (605).(100) + (126).(57.14) + (126).(91.67) = \underline{477230.71}$

Method F $= (489).(99.24) + (590).(76.11) + (534).(77.94) + (361).(98.89) + (696).(83.86) + (630).(88.37) + (728).(92.6) + (617).(72.95) + (581).(94.48) + (116).(100) + (115).(97.37) = \underline{474905.55}$

Method G $= (458).(78.26) + (595).(97.58) + (590).(76.44) + (350).(100) + (725).(92.89) + (599).(83.85) + (745).(96.69) + (623).(82.22) + (568).(89.94) + (125).(97.06) + (126).(100) = 490649.71$

$$\sum_i \left(\sum (T_{cx}).(M_{cz}) \right) = 497682.48 + 484305.31 + 478186.15 + 485717.43 + 477230.71 + 474905.55 + 490649.71 = 33,88,677.34$$

$$\sum_i \left(\sum (T_{cx}).(M_{cz}) \right) = 3388677.34$$

$GT_x . GM_z = 3386955.78$

Sum of Products for Classes $= \underline{\underline{1721.56}}$

Step 4: **Computation of Sum of Products for MxS (Intelligence and Percentage of retention)**

Sum of Products for MxS is computed as below:

Sum of Products for Classes	=	1721.56
Sum of Products for Schools	=	$\underline{(-94.37)}$
		1815.93
Sum of Products for Methods	=	$\underline{-36.44}$
Sum of Products for MxS	=	$\underline{\underline{1779.49}}$

Step 5: **Computation of M+(MxS)**

	$\sum x^2$	$\sum xz$	$\sum z^2$
M	150.74	−36.44	630.72
MxS	4323.01	1779.49	14691.41
M+(MxS)	$\underline{\underline{4473.75}}$	$\underline{\underline{1743.05}}$	$\underline{\underline{15322.13}}$

Step 6: **Adjusted Sum of Squares for MxS**

$$\sum z^2 - \frac{(\sum xz)^2}{\sum x^2} \quad \text{(for MxS)}$$

$$14691.41 - \frac{(1779.49)^2}{4323.01} = \underline{\underline{13958.92}}$$

Step 7: **Adjusted Sum of Squares for M+(MxS)**

$$\sum z^2 - \frac{(\sum xz)^2}{\sum x^2} \quad \text{(for M+(MxS))}$$

$$= 15322.13 - \frac{(1743.05)^2}{4473.75} = \underline{\underline{14643.01}}$$

Step 8: __Reduced Sum of Squares for M__

This is obtained by subtracting step 6 from step 7.

$$= 14643.01 - 13958.92 = \underline{\underline{684.90}}$$

Step 9: __Reduced METHODS Variance__

Reduced Methods Variance $= \dfrac{\text{Reduced Sum of Squares for M}}{\text{df for M}}$

$$= \frac{684.09}{6} = \underline{\underline{114.01}}$$

Step 10: __Adjusted (MxS) error variance__

$$= \frac{\text{Adjusted sum of squares for M}}{\text{df for adjusted MxS}}$$

$$= \frac{13958.92}{59}$$

$$= \underline{\underline{236.59}}$$

Step 11: __Computation of F__

$$F = \frac{\text{Reduced Methods Variance}}{\text{Adjusted MxS Variance}}$$

$$= \frac{114.01}{236.59}$$

$$= \underline{\underline{0.48}}$$

F is not significant

The table in the following page shows the analysis of covariance and the F calculated for the percentage of retention, taking intelligence as the initial score.

Analysis of Covariance of the Percentage of Retention
Scores for the Seven Treatment Groups (Taking Intelli-
gence as the Initial Score)

	$\sum x^2$	$\sum xz$	$\sum z^2$	S.S.	df	F	Significance
M	150.74	-36.44	630.72	684.09 (reduced S.S.)	6		
						0.48	Not significant
MxS	4323.01	1779.49	14691.41	13958.92 (adjusted S.S.)	59		
M+(MxS)	4473.75	1743.05	15322.13	14643.01 (adjusted S.S.)			

OBSERVATIONS

It can be seen that the overall differences between the seven treatment means are not significant even at .05 level. As the differences among the schools have been statistically controlled by the design used, and as school variations are also controlled, it can be safely inferred that there are no true differences among the treatments in terms of the percentage retained.

Hence the null hypothesis isretained indicating that the programme forms do not differ statistically in terms of the percentage of retention.

LSD is also calculated using the formula:

$$\sqrt{\frac{2MSW}{n}} \quad \text{with df 59 as done earlier}$$

$$\text{LSD at } 5\% = t \ 0.5 \ x \ \sqrt{\frac{2MSW}{n}}$$

$$= 2.00 \ x \ \sqrt{\frac{2 \ x \ 236.59}{46}}$$

$$= 6.4144$$

$$\text{LSD at } 1\% = t \ 0.1 \ x \sqrt{\frac{2MSW}{n}}$$

$$= 2.66 \ x \ \sqrt{\frac{2 \ x \ 236.59}{46}}$$

$$= 8.53115$$

Significance of Difference Between Means of any Two Treatments on the Percentage of Retention (Using the technique of L.S.D.)

Treatment	Difference between Means	Significance
A & B	5.30	Not significant
A & C	3.22	Not significant
A & D	4.87	Not significant
A & E	5.69	Not significant
A & F	2.19	Not significant
A & G	1.85	Not significant
B & C	2.08	Not significant
B & D	0.43	Not significant
B & E	0.39	Not significant
B & F	3.11	Not significant
B & G	3.45	Not significant
C & D	1.65	Not significant
C & E	2.47	Not significant
C & F	1.03	Not significant
C & G	1.37	Not significant
D & E	0.82	Not significant
D & F	2.68	Not significant
D & G	3.02	Not significant
E & F	3.50	Not significant
E & G	3.84	Not significant
F & G	0.34	Not significant

From the table for L.S.D., it is seen that the differences between any two treatments are not significant as for as the percentage of retention is concerned. Thus, whatever differences existed on the immediate posttest disappeared after six weeks.

As the differences between the means of the seven treatment groups are not significant, the Null hypothesis is retained.

Analysis of the Final Scores –
Time taken to finish the programme

The effectiveness of a programme form is also judged in terms of the time taken by the seven treatment groups. The time (in minutes) taken by each individual pupil was noted down to calculate the average time taken by each class, by each school and by each treatment group.

The following pages show the computation of the Sum of Squares and Sum of Products for Methods, Schools and MxS.

Step 1: Computation of the total and mean for each class, for each school and for each method, for final score (Time taken to finish) – Table No. 4.15

Totals and Means on Final Scores – Time taken to finish the Programme

Tc on treatments

Treatment Schools	A	B	C	D	E	F	G	Ts	Ts²	nc	n	Ts²/n	Means Ts/n
a	615	595	570	620	545	490	585	4020	16160400	4	28	577157.14	143.57
b	555	495	520	440	525	465	510	3510	12320100	5	35	352002.85	100.28
c	520	420	515	390	470	425	390	3130	9796000	5	35	279911.42	99.42
d	250	235	197	180	185	175	250	1470	2160900	3	21	102900.00	70.00
e	510	405	595	370	650	620	560	3770	14212900	6	42	338402.38	89.76
f	615	480	590	455	515	550	465	3670	13468900	5	35	384325.71	104.85
g	520	415	380	371	395	460	570	3111	9678321	6	42	230436.21	74.07
h	545	450	465	455	395	340	415	3065	9394225	5	35	268406.42	87.57
i	500	525	545	470	505	540	500	3585	12852225	5	35	367206.42	102.42
j	115	100	85	90	110	100	115	715	511225	1	7	73032.14	102.14
k	100	75	105	65	85	65	75	570	324900	1	7	46414.28	81.42
T_{treat}	4905	4195	4565	3906	4380	4230	4435	30616 GT_t			322 N	3020694.97 $\sum(Ts^2/n)$	
Mean	106.63	91.19	99.23	84.91	95.21	91.95	96.41		665.53				

Where,

GT stands for Grant Total
Tc stands for Class Total
The Tc of 615 in the first cell is got by adding the individual 'times' of four students (nc in school 'a' is 4)
i.e. = 615 = 145+165+145+160
Ts stands for School Total, got by adding the Tc from the seven groups.
i.e. 4020 = 615+595+570+620+545+490+585

Step 2:   Computation of the Sum of Squares for M, S
and C and MxS for final scores (Time)

On the basis of the calculations shown in the
table, the following computations are done:

i)   GT = 30616;   N = 322

   Therefore $\dfrac{(GT)^2}{N} = \dfrac{(30616)^2}{322} = 2910992.09$

ii)   Sum of squares for schools

   $\sum_i (Ts^2/n)$ =   3020694.97

   $\dfrac{(GT)^2}{N}$ = $\dfrac{2910992.09}{109702.88}$

   S.S. for
   Schools   =   109702.88

iii)   Sum of Squares for Methods

   $\sum_i T^2{}_m$ = $(4905)^2 + (4195)^2 + (3906)^2 + (4380)^2 + (4230)^2 + (4435)^2$

      =   134499636

   $\sum T^2m/nm$ = $\dfrac{134499636}{46}$ =   2923905.13

   $\sum T^2m/nm$ =   2923905.13
   $(GT)^2/N$ =   2910992.09

      S.S. for   12913.04
      Methods

Computation of Sum of Squares for Classes for Final Scores

(Time taken to finish the programme)

Tc^2 on Treatments

Schools Treatment	a	b	c	d	e	f	g	h	i	j	k
A	378225	308025	270400	62500	324900	378225	270400	297025	250000	13225	10000
B	354025	245025	176400	55225	164025	230400	172225	202500	275625	10000	5625
C	324900	270400	265225	39025	354025	348100	144400	216225	297025	7225	11025
D	384400	193600	152100	32400	136900	207025	127641	207025	220900	8100	4225
E	297025	275625	220900	34225	422500	265225	156025	156025	255025	12100	7225
F	240100	216225	180625	30625	384400	302500	211600	115600	291600	10000	4225
G	342225	260100	152100	62500	313600	216225	324900	172225	250000	13225	5625
Total ΣTc^2	2320900	1769000	1417750	315500	2100350	1947700	1417191	1366625	1840175	73875	47950
nc	4	5	5	3	6	5	6	5	5	1	1
$\Sigma Tc^2/nc$	590225	353800	283550	105166.66	350058.33	389540	236198.50	273325	368035	73875	47950

$$\Sigma(\Sigma Tc^2/nc) = 3061723.49$$

Computations

Using the value of $\sum(\sum Tc^2/nc)$, the sum of squares for classes is computed as follows:

Sum of Squares for Classes

$$\sum(\sum Tc^2/nc) \ = \ 3061723.49$$

$$(GT)^2/N \ = \ 2910992.09$$

S.S. for $\underline{\underline{150731.40}}$
Classes

The sum of squares for MxS is computed by subtracting the S.S. values for schools and methods from that of classes.

S.S. for Classes	=	150731.40
S.S. for Schools	=	109702.88
		41028.52
S.S. for Methods	=	12913.04
S.S. for MxS	≠	$\underline{\underline{28115.48}}$

Step 3: Computation of Sum of Products for Methods, Schools and Classes (Intelligence and Time)

Grand Total of IQ, that is, $(GT_x) = 38427$

Grand Mean Time, that is, $(GM_t) = 95.08$

$\therefore \ (GTx).(GM_t) \ = \ 38427 \times 95.08 = 3653639.16$

Sum of Products for Methods

Sum of products for methods is computed using the treatmentwise Intelligence totals and the treatmentwise mean time, as follows:

$$\sum{}_M(T_{\dot x} \cdot M_t) = (T_{Ax}) \cdot (M_{At}) + (T_{Bx}) \cdot (M_{Bt}) + \ldots$$
$$\ldots \quad (T_{Gx}) \cdot (M_{Gt})$$

$$= (5480) \cdot (106.63) + (5518) \cdot (91.19) +$$
$$(5444) \cdot (99.23) + (5483) \cdot (84.91) +$$
$$(5541) \cdot (95.21) + (5457) \cdot (91.95) +$$
$$(5504) \cdot (96.41) = 3653258.87$$

$$\sum{}_M(T_{x} \cdot M_t) = 3653258.87$$

$$GT_x \cdot GM_t = 3653639.16$$

Sum of	-380.29
Products	$======$
for Methods	

Sum of Products for Schools

Sum of Products for Schools is computed using the schoolwise Intelligence totals and the schoolwise meantime as follows:

$$\sum{}_s(T_x \cdot M_t) = (T_{ax}) \cdot (M_{at}) + (T_{bx}) \cdot (M_{bt}) + \ldots$$
$$+ (T_{kx}) \cdot (M_{kt})$$

$$= (3341) \cdot (143.57) + (4194) \cdot (100.28) +$$
$$(4196) \cdot (89.42) + (2421) \cdot (70.0) +$$
$$(4855) \cdot (89.76) + (4187) \cdot (104.85) +$$
$$(5169) \cdot (74.07) + (4269) \cdot (87.57) +$$
$$(4135) \cdot (102.42) + (825) \cdot (102.14) +$$
$$(835) \cdot (81.42) = 3652171.82$$

$$\sum{}_s(T_x \cdot M_t) = 3652171.82$$

$$(GT_x) \cdot (GM_t) = 3653639.16$$

Sum of Products	-1467.34
for Schools	$========$

Sum of Products for Classes

Sum of Products for Classes is computed using the schoolwise Intelligence totals and the schoolwise meantime.

Method A : $\sum A(T_{cx}).(M_{ct}) = (T_{cax}).(M_{cat}) + (T_{cbx}).(M_{cbt}) + ...+(T_{ckx}).(M_{ckt})$

$= (473).(153.75) + (611).(111) + (595).(104) + (337).(83.33) + (667).(95) +$
$(616).(123) + (711).(86.66) + (611).(109) + (621).(100) + (120).(115) +$
$(118).(100) = \underline{585554.22}$

Method B :

$(485).(148.75) + (611).(99) + (624).(84) + (350).(78.33) + (662).(67.5) +$
$(601).(96.0) + (747).(69.17) + (613).(90.0) + (582).(105.0) + (118).(100.0) +$
$(125).(75.0) = \underline{503970.24}$

Method C :

$(466).(142.5) + (605).(104) + (619).(103.0) + (349).(65.0) + (725).(99.17) +$
$(551).(118.0) + (735).(63.33) + (586).(93.0) + (585).(109.0) + (106).(85.0) +$
$(117).(105.0) = \underline{538788.80}$

Method D :

$(476).(155.0) + (511).(88.0) + (619).(78.0) + (334).(60.0) + (688).(61.66) +$
$(607).(91.0) + (753).(61.83) + (600).(91.0) + (593).(94.0) + (114).(90.0) +$
$(108).(65.0) = \underline{465949.07}$

Method E :
$$= (494).(136.25) + (591).(105.0) + (615).(94.0) + (340).(61.66) + (692).(108.33) +$$
$$(583).(103.0) + (750).(65.83) + (619).(79.0) + (605).(101.0) + (126).(110.0) +$$
$$(126).(85.0) = \underline{527098.76}$$

Method F :
$$= (489).(122.5) + (590).(93.0) + (534).(85.) + (361).(58.33) + (696).(103.33) +$$
$$(630).(110.0) + (728).(76.66) + (617).(68.0) + (581).(108.0) + (116).(100) +$$
$$(115).(65.0) = \underline{502024.79}$$

Method G :
$$= (458).(146.25) + (595).(102.0) + (590).(78.0) + (350).(83.33) + (725).(93.33) +$$
$$(599).(93.0) + (745).(95.0) + (623).(83.0) + (568).(100.0) + (125).(115.0) +$$
$$(126).(75.0) = \underline{529338.25}$$

$$\sum \left(\sum (T_{cx}).(M_{ct}) \right) = 585554.22 + 503970.24 + 538788.80 + 465949.07 + 527098.76 +$$
$$502024.79 + 529338.25 = 3652724.13$$

$$\sum \left(\sum (T_{cx}).(M_{ct}) \right) = 3652724.13$$

$$(GT_x).(GM_t) = 3653639.16$$

$$\text{Sum of Products} = \underline{\underline{-915.03}}$$
$$\text{for Classes}$$

Step 4: Computation of Sum of Products for MxS (Intelligence and Time)

Sum of Products for MxS is computed as below:

Sum of Products for Classes   =   −915.03

Sum of Products for Schools   =   −(−1467.34)
                                    ─────────────
                                          522.31

Sum of Products for Methods   =   −(−380.29)
                                    ─────────────
Sum of Products for MxS   =   932.60

Step 5: Computation of M÷(MxS)

	$\sum x^2$	$\sum xt$	$\sum t^2$
M	150.74	−380.29	12913.04
MxS	4323.01	932.60	28115.48
M÷(MxS)	4473.75	552.31	41028.52

Step 6: Adjusted Sum of Squares for MxS

$$\sum t^2 - \frac{(\sum xt)^2}{\sum x^2} \qquad \ldots \text{ (for MxS)}$$

$$28115.48 - \frac{(932.60)^2}{4323.01} = 27914.30$$

Step 7: Adjusted Sum of Squares for M÷(MxS)

$$\sum t^2 - \frac{(\sum xt)^2}{\sum x^2} \qquad \ldots \text{ (for M÷(MxS)}$$

$$41028.52 - \frac{(552.31)^2}{4473.75} = 40960.34$$

Step 8: Reduced Sum of Squares for M

This is obtained by subtracting step 6 from step 7.

$$= 40960.34 - 27914.30 = \underline{\underline{13046.04}}$$

Step 9: Reduced METHODS Variance

Reduced Methods Variance $= \dfrac{\text{Reduced sum of squares for M}}{\text{d.f. for M}}$

$$= \dfrac{13046.04}{6}$$

$$= \underline{\underline{2174.34}}$$

Step 10: Adjusted MxS (error) Variance

Adjusted MxS (error) Variance $= \dfrac{\text{Adjusted Sum of Squares for MxS}}{\text{d.f. for adjusted MxS}}$

$$= \dfrac{27914.30}{59} = \underline{\underline{473.12}}$$

Step 11: Computation of F

$$F = \dfrac{\text{Reduced Methods Variance}}{\text{Adjusted MxS Variance}}$$

$$= \dfrac{2174.34}{473.12} = \underline{\underline{4.59}}$$

F is significant at 1% level.

Table No. 4.17

Analysis of Covariance of the Time (in Minutes) Required by the Seven Treatment Groups to finish the Programme (Taking intelligence as the Initial Score)

	$\sum x^2$	$\sum XT$	$\sum T^2$	S.S.	df	F	Significance
M	150.74	-380.29	12913.04	13046.04 (reduced S.S.)	6	4.59	Significant at .01 level
MxS	4323.01	932.60	28115.48	27914.30 (adjusted S.S.)	59		
M+(MxS)	4473.75	552.31	41028.52	40960.34 (adjusted S.S.)			

OBSERVATION

It can be seen that the overall differences between the time taken by the seven treatment groups are significant at .01 level. As the differences among the schools have been statistically controlled by 'analysis of covariance in duplicate experiments in randomly selected schools' (Lindquist, 1970) it can be inferred that the differences among the treatment groups are true differences, neither due to initial differences in intelligence which are indicated by the negative value of the sum of products for method as -380.29, nor due to school to school variations.

Hence we can safely reject the null hypothesis and can attribute the differences to the variations in effectiveness of the programme forms.

LSD is also calculated using the formula

$\sqrt{\dfrac{2MSW}{n}}$ with df 59 as done for the immediate posttest and for the percentage of retention.

LSD at 5% $= t.05 \times \sqrt{2x\dfrac{473.12}{46}}$

$= 2.00 \times \sqrt{2x\dfrac{473.12}{46}} = 9.070$

LSD at 1% $= t._{01} \times \sqrt{\dfrac{2MSW}{n}}$

$= 2.66 \times \sqrt{2x\dfrac{473.12}{46}} = \underline{12.0631}$

$= \underline{12.0631}$

The table below shows the significance of difference between any two means (L.S.D.).

Significance of Difference between Means of Any Two Treatments on the Time taken to finish the programme (Using the technique of L.S.D.)

Treatments	Difference between Means	Significance
A & B	15.44	Significant at .01 level
A & C	7.40	Not significant
A & D	21.72	Significant at .01 level
A & E	11.42	Significant at .05 level
A & F	14.68	Significant at .01 level
A & G	10.22	Significant at .05 level
B & C	8.04	Not significant
B & D	6.28	Not significant
B & E	4.02	Not significant
B & F	0.76	Not significant
B & G	5.22	Not significant
C & D	14.32	Significant at .01 level
C & E	4.02	Not significant
C & F	7.28	Not significant
C & G	2.82	Not significant
D & E	10.30	Significant at .05 level
D & F	7.04	Not significant
D & G	11.50	Significant at .05 level
E & F	3.26	Not significant
E & G	1.20	Not significant
F & G	4.46	Not significant

OBSERVATIONS ON TIME

    i) The differences between the following forms
       are significant at .01 level

- The Linear Overt Form (Form A) and
  the Linear Covert Form (Form B)

- The Linear Overt Form (Form A) and
  the Response Prompt Covert Form (Form D)

- The Linear Overt Form (Form A) and
  the Branching Form (Form F)

- The Response Prompt Covert Form
  (Form D) and the Response Prompt
  Overt Form (Form C)

    ii) The differences between the following are
       significant at .05 level

- The Linear Overt Form (Form A) and the
  Skip programme Form (Form E)

- The Linear Overt Form (Form A) and the
  Hybrid Form (Form G)

- The Response Prompt Covert Form
  (Form D) and the Skip programme Form
  (Form E).

- The Response Prompt Covert Form
  (Form D) and the Hybrid Form (Form G)

    The results of the present study do not support the
superiority of the overt response mode both in terms of
immediate posttest and time as shown in the following
summary table. Holland (1960) asserts that only
covert responses suitably reinforced are learned and

that the students must 'write' the programme. The results
have shown that the Response Prompt Covert Form, in which
the correct responsesare already given,is significantly
better than other forms both on the immediate posttest
and the time taken to finish the programme. The F value
for the immediate posttest is significant at .05 level, and
for the time taken, it is significant at .01 level. But
the differences on the percentage of retention are not
significant.

In Shah's study (1970), the pupils responded either
overtly or covertly, Each group was further divided into
a group making constructed responses and a group reading
the frames with answers already filled in. Significance
differences were found on the immediate test scores but
not on the retention scores. The covert response prompt
group showed an appreciable time saving, and the results
have shown that covert responding is at least as effective,
if not more, as overt responding from the viewpoint both
of immediate and delayed test scores. In the present study,
however, the relatively better effectiveness of the
Response Prompt Covert Form in comparison with the Linear
Overt Form is seen (significant at .05 level).

Leith and Guhman (1966) asserted that "being aware of
the answer before making a try does not necessarily lead
to poor learning'. The results of the present study

Table showing the Results of Different Statistical Analyses on the Three Criteria of Effectiveness

Criteria of Effectiveness	Analysis of Covariance		Significance of Differences Between Any Two Means (LSD Test)*	
	F	Significance	Significant at .05 level	Significant at .01 level
A) Immediate Posttest	2.99	Significant at .05 level	i) Response Prompt Covert(D) and Linear Overt (A)	i) Response Prompt Covert(D) and Branching (F)
			ii) Linear Covert (B) and Branching (F)	
			iii) Response Prompt Covert(D) and Response Prompt Overt (C)	
			iv) Response Prompt Covert(D) and Hybrid (G)	
B) Percentage of Retention	0.48	Not significant	Nil	Nil
C) Time (in minutes) required to finish	4.59	Significant at .01 level	i) Skip Programme (E) and Linear Overt (A)	i) Linear Covert (B) and Linear Overt (A)
			ii) Hybrid (G) and Linear Overt (A)	ii) Response Prompt Covert (D) and Linear Overt (A)
			iii) Response Prompt Covert(D) and Skip Programme (E)	iii) Branching (F) and Linear Overt (A)
			iv) Response Prompt Covert(D) and Hybrid (G)	iv) Response Prompt Covert (D) and Response Prompt Overt (C)

*In LSD Columns, the relatively more effective forms are written first, e.g., A - i) Response Prompt Covert (D) is relatively more effective than the Linear Overt (A).

supports this contention. Skinner's emphasis on overt
and active responding does not seen to be tenable after
surveying the results of many studies including the present
one.

In the Indian context, the effectiveness of Response
Prompt Covert Responding has much significance. It is
often alleged that programmes prove to be costly. Experts
advocate the use of separate answer sheets in order to
bring down the cost. As the Response Prompt Covert mode
does not require even the answer sheet or big margins for
responses etc., it is less expensive and time saving also.
Also, it frees one from the alleged fears of 'cheating'.

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