HOW TO CONDUCT AN EXPERIMENT IN EDUCATION

By

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I. *The Need for Experimental Research in Education*

Today, more than ever before, there is an urgent need for experimental research in education, not only because of significant changes that have taken place as a result of World War II, but also because of the dynamic nature of education and society. Several educational theories, like integration, activity curriculum, unit method and others which have been adopted and put to use in some schools need experimentation to prove their scientific validity and effectiveness.

II. *How to Define the Problem.*

The problem should be specified in detail and with precision. The major issue should first be formulated, and then this major problem should be anlayzed into its constituent specific problems. Since the way a research problem is stated oftentimes determines the type of data to be gathered and the method to be used in collecting them, it is essential that special care be taken in formulating the problem.

III. *Types of Experimental Research*

The experimental method is sometimes called *method of difference*. By this method, an experimenter notes the effect of a single variable applied to an experimental group but not to an equivalent control group. The method is governed by the law of "single variable," which requires that all variables, except the experimental factor, be held constant and that the effect of this factor, be measured.

Experimental research may be classified into two general types: (1) that which deals with individual cases or situa-

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tions; and (2) that which uses groups of subjects. The former is usually conducted in a laboratory or a specially arranged setup, in which the conditions are carefully controlled, suitable apparatus and equipment provided, and subjects studied individually.

The second type is called group experimentation which is ordinarily conducted in classrooms for the purpose of evaluating various methods of instruction. It has a distinct value in aiding teachers to choose between instructional procedures of varying effectiveness. In group experimentation, three methods are employed, namely; (1) one-group method; (2) equivalent-groups method; and (3) rotation method.

1. *One-Group Method*

When the one-group method is employed, some experimental factor or factors are applied to or subtracted from one thing, an individual, or a group; and the resulting changes are determined or measured. This method may be symbolically represented as follows:

S — (IT — EF_1 — FT — C_1) — (IT — EF_2 — FT — C_2) where

S = the experimental subject, thing, or group.

IT = initial test or status of S before EF_1 and EF_2 are, in turn, added to or subtracted from S.

EF_1 = the first experimental factor.

EF_2 = the second experimental factor.

FT = the final test or status of S after EF_1 and EF_2 have, in turn, been applied.

C_1 = the change in S produced by EF_1 and is found by computing the difference between IT and FT which immediately precede and succeed EF_1, respectively.

C_2 = the change in S effected by EF_2.

By comparing the amounts of C_1 and C_2, the relative effectiveness of EF_1 and EF_2 can be determined. If C_2 is larger than C_1 and if the significance of the difference is tested statistically by the application of "t" or critical-ratio technique and it is found to be significant, then EF_2 can be said to be more effective than EF_1. For example, if a teacher wishes to compare the effects of praising and scolding upon reading, the following steps may be followed:

a. Give the initial test (IT) in reading to measure the initial status of the group in reading.

b. Then apply EF_1, praising, to the class at the beginning of the class period.

c. Give the final test (FT) in reading at the end of the class period to find the effect of the experimental factor, praising, upon reading.

d. Compute the difference (C_1) between the initial and the final test in reading.

e. As soon as the effect of praising is worn out, assuming that the IT's are identical, apply the second experimental factor (EF_2), scolding, to the same pupils.

f. Give the final test (FT) in reading.

g. Compute the difference (C_2) produced by scolding.

h. Compare the amount and direction of C_1 with those of C_2.

i. Determine the statistical significance of the difference.

The above symbolical representation can be shortened in certain specific situations by eliminating IT, C_1, and C_2. The formula thus becomes

$$S — (EF_1 — FT) — (EF_2 — FT).$$

This formula is preferable when S is assumed to have an initial test (IT) of zero, for in this case C becomes identical in amount with FT.

The above basic formula can be indefinitely extended by lengthening the formula to provide for EF_1, EF_2, EF_3, and so on, with their corresponding C_1, C_2, C_3, etc.

Statistical computation of the one-group method is illustrated in Table I.

Table I

COMPUTATION OF THE ONE-GROUP METHOD

One Group . . . . Two EF's . . . . One Test Type											
EF_1 (Praising)						EF_2 (Scolding)					
Pupil	IT	FT	C	x'	x'^2	Pupil	IT	FT	C	y'	y'^2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A	10	15	5	0	0	G	10	9	- 1	- 3	9
B	8	14	6	1	1	H	8	8	0	- 2	4
C	5	11	6	1	1	J	5	7	2	0	0
D	7	12	5	0	0	K	7	10	3	1	1
E	6	12	6	1	1	L	6	8	2	0	0
Sum				3	3					- 4	14

$M'_P = 5$ $\qquad\qquad$ $M'_S = 2$

$c_P = \frac{\Sigma x'}{N} = \frac{3}{5} = .60$ $\qquad\qquad$ $c_S = \frac{\Sigma y'}{N} = \frac{-4}{5} = -.80$

$\sigma_P = \sqrt{\frac{\Sigma x'^2}{N} - c^2} = \sqrt{\frac{3}{5} - (.6)^2}$ $\qquad$ $\sigma_S = \sqrt{\frac{\Sigma x'^2}{N} - c^2} = \sqrt{\frac{14}{5} - (-.8)^2}$

$= \sqrt{.6 - .36} = .49$ $\qquad\qquad$ $= \sqrt{2.8 - .64} = 1.47$

$\sigma_M = \frac{\sigma_P}{\sqrt{N}} = \frac{.49}{\sqrt{5}} = \frac{.49}{2.24} = .22$ $\qquad$ $\sigma_{M_S} = \frac{\sigma_S}{\sqrt{N}} = \frac{1.47}{\sqrt{5}} = \frac{1.47}{2.24} = .66$

$\sigma_{Diff.} = \sqrt{\sigma_{M_P}^2 + \sigma_{M_S}^2} = \sqrt{(.22)^2 + (.66)^2} = .70$

$Diff. = M_P - M_S = 5.6 - 1.2 = 4.4$

$E.C. = \frac{Diff.}{2.78 \times \sigma_{Diff.}} = \frac{4.4}{2.78 \times .70} = 2.26$

The following are the limitations of the one-group method:

a. Since there is more rapid learning at the earlier stages of learning, more gains may be shown in the first administration of the tests than in a later administration.

b. However, the practice effect of the first administration may tend to increase the scores on later administration of the same or equivalent test.

c. Since the pupils included in the experiment are older and, hence, more mentally mature in the later administration of the test than in the first, their later scores may be affected.

d. Any attitude of discouragement or confidence acquired during the first administration of the test may carry over to its later administration.

2. *Equivalent-Groups Method*

The equivalent-groups method represents an attempt to overcome the limitations of the one-group method, since two or more groups as nearly equivalent as possible in all respects are used at the same time. Under carefully controlled conditions, the experimenter tries to note the effects of the single variable applied to the experimental group but not applied to the control group. Following is a symbolical representation of the equivalent-groups method with two experimental factors (EF's) and one type of test:

$$S_1 — (IT_1 — EF_1 — FT_1 — C_1)$$

$$S_2 — (IT_1 — EF_2 — FT_1 — C_2)$$

A formula may be constructed for any number of EF's and any number of test types by extending the above formula.

The statistical computation of the equivalent-groups methods is illustrated in Table II.

The equivalent-groups methods has the following limitations.

a. Every pupil is a dynamic and complex organism, and no two pupils can be made exactly alike. Hence, the

Table II

COMPUTATION OF EQUIVALENT-GROUPS METHOD

Two Equivalent Groups ..... Two EF's ....One Type Test											
Group A – EF_1 (Praising)						Group B – EF_2 (Scolding)					
Pupil	IT	FT	C	x'	x'^2	Pupil	IT	FT	C	x'	x'^2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A	10	12	2	-1	1	F	10	11	1	-1	1
B	9	12	3	0	0	G	9	10	1	-1	1
C	8	12	4	1	1	H	8	10	2	0	0
D	7	10	3	0	0	I	7	7	0	-2	4
E	5	8	3	0	0	J	5	8	3	1	1
Sum................				0	2	Sum				-3	7

$M'_A = 3$ $\qquad\qquad$ $M'_B = 2$

$c_A = \frac{\Sigma x'}{N} = \frac{0}{5} = 0$ $\qquad\qquad$ $c_B = \frac{\Sigma x'}{N} = \frac{-3}{5} = -.6$

$M_A = M'_A + c_A = 3 + 0 = 3$ $\qquad\qquad$ $M_B = M'_B + c_B = 2 - .6 = 1.4$

$\sigma_A = \sqrt{\frac{\Sigma x'^2}{N} - c_A^2} = \sqrt{\frac{2}{5} - 0}$ $\qquad\qquad$ $\sigma_B = \sqrt{\frac{\Sigma x'^2}{N} - c_B^2} = \sqrt{\frac{7}{5} - (-.6)2}$

$= \sqrt{.40 - 0} = \sqrt{.40} = .63.$ $\qquad\qquad$ $= \sqrt{1.4 - .36} = \sqrt{1.04} = 1.02$

$\sigma_{M_A} = \frac{\sigma_A}{\sqrt{N}} = \frac{.63}{\sqrt{5}} = \frac{.63}{2.24}$ $\qquad$ $\sigma_{M_B} = \frac{\sigma_B}{\sqrt{N}} = \frac{1.02}{\sqrt{5}} = \frac{1.02}{2.24} = .46$

$= .28$

$\sigma_{Diff.} = \sqrt{\sigma_{M_A}^2 + \sigma_{M_B}^2} = \sqrt{(.28)^2 + (.46)^2} = .54$

$Diff. = M_A - M_B = 3.0 - 1.4 = 1.6$

$E.C. = \frac{Diff.}{2.78 \times \sigma_{diff.}} = \frac{1.6}{2.78 \times .54} = 1.07$

process of equating two or more groups is a difficult and well-nigh impossible thing to do.

b. Classroom situations and procedures are hard to control and equate.

3. *Rotation Method*

The rotation method involves the reversal of the groups at intervals, in terms of the procedures followed. This method is frequently used when parallel groups are not available or when the groups are small and there is doubt concerning the equivalence of the groups because of such factors as initiative, industry, or study habits which are very difficult, if not impossible, to control. The method attempts to overcome the shortcomings of the two other methods.

The procedure is illustrated in the diagram below with two EF's and one type of test.

$$S_1 — (IT_1 — EF_1 — FT_1 — C_1) — (IT_1 — EF_2 — FT_1 — C_2)$$

$$S_2 — (IT_1 — EF_2 — FT_1 — C_3) — (IT_1 — EF_1 — FT_1 — C_4)$$

$$EF_1 = C_1 + C_4$$

$$EF_2 = C_2 + C_3$$

A formula can be constructed for any number of EF's and any number of test types.

The statistical computation of the rotation method is shown in Table III.

On the whole, the one-group experimental method is the most convenient when some significant irrelevant factors will not invalidate the experiment. The equivalent-groups method is peculiarly free from influences of disturbing irrelevant factors. The only difficulty encountered in this method is the selection of the groups which are genuinely equivalent, especially when the number of pupils composing each group is small.

Due to the practical difficulty at times of establishing this equivalence, the rotation method is frequently used. Reversing the order of application of EF's permits each EF to

Table III

COMPUTATION OF ROTATION METHOD

Two Groups ....Two EF's .... One Test Type

Group A - EF_1 (Praising)						Group B - EF_2 (Scolding)					
Pupil	IT_1	FT_1	C_1	x'	x'^2	Pupil	IT_1	FT_1	C_2	x'	x'^2
A	10	12	2	-1	1	F	12	13	1	-1	1
B	9	12	3	0	0	G	10	12	2	0	0
C	8	13	5	2	4	H	9	10	1	-1	1
D	7	10	3	0	0	I	8	10	2	0	0
E	5	9	4	1	1	J	6	7	1	-1	1
Sum				2	6	Sum				-3	3

Group A - EF_2 (Scolding)						Group B - EF_1 (Praising)					
Pupil	IT_1	FT_1	C_3	x'	x'^2	Pupil	IT_1	FT_1	C_4	x'	x'^2
C	13	13	0	-1	1	F	13	15	2	0	0
A	12	13	1	0	0	G	12	16	4	2	4
B	12	14	2	1	1	H	10	12	2	0	0
D	10	11	1	0	0	I	10	10	0	-2	4
E	9	8	-1	-2	4	J	7	10	3	1	1
Sum..................				-2	6	Sum.................				1	9

$M'_{A_p} = 3; \quad c_{A_p} = \frac{\Sigma x'}{N} = \frac{2}{5} = .4$

$M'_{B_S} = 2; \quad c_{B_S} = \frac{\Sigma x'}{N} = \frac{-3}{5} = -.6$

$M_{A_p} \equiv M' + c = 3 + .4 = 3.4$

$M_{B_S} = M' + c = 2 + -.6 = 1.4$

$M'_{A_S} = 1; \quad c_{A_S} = \frac{\Sigma x'}{N} = \frac{-2}{5} = -.4$

$M'_{B_S} = 2; \quad c_{B_p} = \frac{\Sigma x'}{N} = \frac{1}{5} = .2$

Table III (continued)

$$M_{A_S} = M' + c = 1 - .4 = .6$$

$$\sigma_{A_P} = \sqrt{\frac{\Sigma x'^2}{N} - c^2} = \sqrt{\frac{6}{5} - (.4)^2}$$

$$= \sqrt{1.2 - .16} = \sqrt{1.04} = 1.02$$

$$\sigma_{A_S} = \sqrt{\frac{\Sigma x'^2}{N} - c^2} = \sqrt{\frac{6}{5} - (-.4)^2}$$

$$= \sqrt{1.2 - .16} = \sqrt{1.04} = 1.02$$

$$\sigma_{M_{A_P}} = \frac{\sigma_{A_P}}{\sqrt{N}} = \frac{1.02}{\sqrt{5}} = \frac{1.02}{2.24} = .46$$

$$\sigma_{M_{A_S}} = \frac{\sigma_{A_S}}{\sqrt{N}} = \frac{1.02}{\sqrt{5}} = \frac{1.02}{2.24} = .46$$

$$M_{B_P} = M' + c = 2 + .2 = 2.2$$

$$\sigma_{B_S} = \sqrt{\frac{\Sigma x^2}{N} - c^2} = \sqrt{\frac{3}{5} - (-.6)^2}$$

$$= \sqrt{.6 - .36} = \sqrt{.24} = .49$$

$$\sigma_{B_P} = \sqrt{\frac{\Sigma x'^2}{N} - c^2} = \sqrt{\frac{9}{5} - (.2)^2}$$

$$= \sqrt{1.8 - .04} = \sqrt{1.76} = 1.33$$

$$\sigma_{M_{B_S}} = \frac{\sigma_{B_S}}{\sqrt{N}} = \frac{.49}{\sqrt{5}} = \frac{.49}{2.24} = .22$$

$$\sigma_{M_{B_P}} = \frac{\sigma_{B_P}}{\sqrt{N}} = \frac{1.33}{\sqrt{5}} = \frac{1.33}{2.24} = .59$$

$$M_P = M_{A_P} + M_{B_P} = 3.4 + 2.2 = 5.6$$

$$M_S = M_{B_S} + M_{A_S} = 1.4 + .6 = 2.0$$

$$\sigma_{S_{diff.}} = \sqrt{\sigma^2_{M_{A_P}} + \sigma^2_{M_{B_S}} + \sigma^2_{M_{A_S}} + \sigma^2_{M_{B_P}}}$$

$$= \sqrt{(.46)^2 + (.22)^2 + (.46)^2 + (.59)^2} = .91$$

$$D = M_P - M_S = 5.6 - 2.0 = 3.6$$

$$B.C. = \frac{D}{2.78 \times \sigma_{diff.}} = \frac{3.6}{2.78 \times .91} = 1.42$$

get the advantage or disadvantage of a carry-over from the other. The rotation method is also valuable in eliminating special irrelevant factors, such as teaching skill and difference in ability of the groups.

IV. *The Selection of Schools, Classes, Pupils, Teachers, Units of Instruction, and Tests*

1. *Selection of Schools*

In the selection of schools which are to participate in the experiment, the types of community in which they are found should be taken into consideration. The communities should be more or less equivalent in socio-economic status, homogeneity of population, and other conditions. For instance, a school in a fishing community should be matched with a school in another fishing community. The home conditions in these communities should be more or less equivalent in social, economic, and educational levels, if equivalent groups are to be obtained and used for the experiment. The communities should be representative.

The schools to be included in the experiment should be representative in character and should be appropriate to the experimental factor or factors. To be representative, 50 per cent of the sample should come from the average, 25 per cent from the best, and 25 per cent from the poorest. They should be equivalent in school facilities, equipment, school control, and management.

2. *Selection of Classes*

The classes should be appropriate to the experiment and to the experimental factor or factors. The facilities and equipment should be equivalent. The environment should not introduce irrelevant factors that might invalidate the results of the experiment.

The classes should be representative. They must represent the poorest, average, and the best classes in the grades. Draw the sample in such a way that 50 per cent are from the average; 25 per cent from the poorest; and 25 per cent from the best. Samples can also be drawn at random from the registers of pupils.

3. *Selection of Experimental Subjects*

Pupils should be selected on the following bases: (a) appropriateness to the experimental factors; (b) appropriateness to the tests; (c) appropriateness to the experimental method; (d) representativeness as to age, sex, grade, and intelligence by random selection; (e) adequacy of sampling so as to secure reliability of results; and (f) availability throughout the period of the experiment.

4. *Selection of Teachers*

The teachers who are to participate in the experiment should be equated on the basis of their educational attainment, experience, teaching ability, classroom management, personality traits, health, sex, and socio-economic status.

5. *Selection of Units of Instruction*

The units of instruction should be selected and equated on the basis of difficulty and interest. The selection of the method to be used in teaching should be based upon appropriateness of the unit to be covered.

6. *Selection of Tests*

The tests to be used should include an intelligence test to measure the potential mental ability of the pupils to do school work, and such achievement tests as reading, arithmetic, language, and the like. Needless to say, these tests should be selected on the basis of their validity, reliability, objectivity, availability of norms, and ease of administration and scoring.

V. *Conducting the Experiment*

After everything is set for the experiment, the initial test should be administered and the papers should be scored immediately. The groups may, however, be equated after the experiment to avoid the reduction of the number of experimental pupils due to disturbing factors, such as absence, transfers, etc.

After the initial test or tests have been given, apply the experimental factor or factors to the group or groups.

1. *The Control of Experimental Conditions*

During the experimental period, the most common irrelevant factors should be controlled, namely: (a) the bias of the experimenter; (b) the bias of the assistants; (c) the bias in teaching skills; (d) the bias of the subject matter; (e) the bias of the subjects or pupils; (f) the bias of the physical conditions of the rooms; and (g) the bias of the time allowance. If the results of the experiment are to be valid, each of the above-mentioned sources of error should be eliminated or controlled.

The following are suggestions for controlling these sources of error:

a. *Errors Due to Bias of the Experimenter.* Maintain a neutral, impartial, and scientific attitude towards the EF's to be used in the experiment. Accuracy of measurement is of paramount importance.

b. *Errors Due to Bias of Assistants.* Keep the assistants ignorant of the purpose of the experiment and provide detailed written instructions for them to follow. This applies specially to experimental research which is usually conducted in the laboratory.

c. *Errors Due to Bias in Teaching Skill.* To avoid this error, equate the skill of the teachers assigned to each EF. This equating is based upon pre-experimental measurement of each teacher's efficiency or skill in the particular experimental trait. The teachers can also be equated by means of objective tests or judgment of competent supervisors. Generally, superior teachers will be favorable to each EF.

d. *Errors Due to Bias of Subject matter.* To avoid this error, teach equivalent or the same subject matter for S_1 and S_2 and use the same method or technique of instruction.

e. *Errors Due to Bias of Subjects or Pupils.* Keep the pupils ignorant of the nature of the EF and, if possible, of the fact that an experiment is in progress.

f. *Errors Due to Bias of Physical Conditions of the Rooms.* Check the general physical environmental conditions, such as temperature, lighting, humidity, and the like, and see to it that differences are limited and equated.

g. *Errors Due to Bias in Time Allowance.* Secure the maximum effects of the experimental factors and reduce to a minimum the effects of disturbing factors. The teaching and studying time for each EF should be equated. Groups should be placed under identical length of time.

2. *Equating the Subjects or Pupils*

The most convenient basis for equating the subjects is the initial status of the experimental trait under investigation. However, delayed equating is preferred to early equating to avoid the elimination of paired subjects when certain pupils selected for the experimental group are absent or transferred at the time when the EF is given. Waste of efforts will be avoided because it is difficult to segregate the selected pupils for the purpose of applying the EF and FT alone.

The groups participating in the experiment employing the equivalent-groups methods should be equivalent. Equivalence of groups means that they have like means and like variability. Like means and like variability imply that for every subject in one group there should be an equivalent subject in the group or in every other group, if more than two groups are involved. But it is not absolutely necessary that there be an equivalent number of subjects in each group.

In pairing or equating the groups, observe the following steps: (a) Arrange the pupils in the experimental group (S_1) in the order of the magnitude of their scores in the IT. The same should be done with the pupils in the control group (S_2). (b) Eliminate from subsequent computations all the pupils in one group who could not be paired with an equivalent pupil in the other group.

The technique of pairing is illustrated in Table IV in which the Philippine Mental Ability Test scores are used as a basis.

The computation of the figures in Table IV is as shown below it.

Table IV illustrates like means and like variability. The procedure for equating groups on the basis of point scores on initial tests, etc. is identical.

The equating of groups can be improved by pairing subjects who are alike in mental and chronological age.

Groups may be equated on the basis of more than one test or trait. This requires a composite of the scores on the various tests or traits. If this device is used, it is more convenient to use the composite of the initial scores on all the experimental tests.

The procedure for computing a composite score is illustrated in Table V. Column 1 gives the identification number of each pupil. Columns 2, 5 and 8 show the test scores of each pupil in reading, arithmetic, and language, respectively. Columns 11, 12 and 13 show the weighed scores of each pupil, and column 14, the composite scores. Under columns 2, 5 and 8 are shown the standard deviation of the three series of scores.

The computations of the figures are shown below Table V.

To give equal weight to each test and to make the variability of each test equivalent, the multipliers were selected as follows:

Any one of the standard deviations can be used as the basis.

The following are the steps in the computation of the figures in Table V:

1. Compute the arithmetic mean of columns 2, 5, and 8. (Please see Formula 1, page 105)

2. Determine the deviation of each score from the corresponding means in columns 2, 5, and 8. (Formula 3)

Table IV

EQUATING GROUPS BY MENTAL ABILITY TEST SCORES[1]

Experimental Group (S_1)				Control Group (S_2)			
Pupil	Mental Test: Score (X)	x'	x'^2	Pupil	Mental Test: Score (X)	x'	x'^2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2	45.5	3.0	9.00	4	46.0	6.0	36.00
3	45.0	2.5	6.25	2	45.0	5.0	25.00
4	44.5	2.0	4.00	3	44.0	4.0	14.00
6	42.5	0.0	0.00	7	41.5	1.5	2.25
5	39.5	-3.0	9.00	5	40.0	0.0	0.00
Sum		4.5	28.25			16.5	79.25
Mean	43.4				43.3		
σ_{dist}	2.2				2.23		

[1]Data were taken from B.P.S. Form 14-A, Experimental and Control Classes in the Iloilo Vernacular Experiment, April, 1951.

$M'_{s_1} = 42.5$ $\qquad$ $M'_{s_2} = 40$

$c_{s_1} = \frac{\Sigma x'}{N} = \frac{4.5}{5} = .9$ $\qquad$ $c_{s_2} = \frac{\Sigma x'}{N} = \frac{16.5}{5} = 3.3$

$M_{s_1} = M'_{s_1} + c_{s_1} = 42.5 + .9 = 43.4$ $\qquad$ $M_{s_2} = M'_{s_2} + c_{s_2} = 40 + 3.3 = 43.3$

$$\sigma_{s_1} = \sqrt{\frac{\Sigma x'^2}{N} - c^2_{s_1}} = \sqrt{\frac{28.25}{5} - (.9)^2} = \sqrt{5.65 - .81} = \sqrt{4.84} = 2.2$$

$$\sigma_{s_2} = \sqrt{\frac{\Sigma x'^2}{N} - c^2_{s_2}} = \sqrt{\frac{79.25}{5} - (3.3)^2} = \sqrt{15.85 - 10.89} = \sqrt{4.94} = 2.23$$

3. Square every deviation in columns 3, 6, and 9.

4. Add the squared deviations in columns 4, 7, and 10. (Σx^2, Σy^2, and Σz^2, respectively.)

5. Find the square root of the sum of the squared deviations in columns 4, 7, and 10 divided by the number of cases, which is the standard deviation. (Formula 5)

6. Select multipliers for each standard deviation in columns 2, 5, and 8 to give equal weight to each test.

7. Multiply each score in columns 2, 5, and 8 by the selected multipliers 2.35, 2, and 1, respectively. The results are the weighted scores in columns 11, 12, and 13, respectively.

8. Add the weighted scores of each pupil to get the composite score in column 14.

VII. *Statistical Treatment of Results*

A. **One-group method**

In Table I is shown the computation for any one-group experiment contrasting two EF's, Praising (P) and Scolding (S), and employing only one type of test. In computing the experimental coefficient,[1] observe the following steps:

1. Compute the mean of the changes (C's) made by the two experimental factors. (Formula 1)

2. Compute the standard deviation of the changes made by the experimental factors. (Formula 6)

3. Compute the standard error of the means. (Formula 7)

4. Find the standard error of the difference between the two experimental factors. (Formula 9)

5. Compare the means of the two experimental factors. This will give the difference between the two means (D). (Formula 8)

6. Divide the difference between the two means (D) by its standard error (ódiff.) multiplied by the constant 2.78.

Table V

COMPUTATION OF A COMPOSITE SCORE WHERE EACH TEST RECEIVES EQUAL WEIGHT[1]

Pupil	Reading			Arithmetic			Language			Weighted Scores			Composite
	X	x	x^2	Y	y	y^2	Z	z	z^2	Read.	Arith.	Lang.	Score
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	41	-7.40	54.76	68	+1.8	3.24	41	+0.6	0.36	96.35	136	41	273.35
2	54	+5.60	31.36	76	+9.8	96.04	63	+22.6	510.76	126.90	152	63	341.90
3	41	-7.40	54.76	67	-0.8	.64	25	-15.4	96.35	96.35	134	25	255.35
4	49	+0.60	0.36	68	+1.8	3.24	51	+10.6	115.15	115.15	136	51	302.15
5	57	+8.60	73.96	52	-14.2	201.64	22	-18.4	133.95	133.95	104	22	259.95
Sum	242	0	215.2	331	0	304.80	202	0	1199.20				
Mean	48.4			66.20			40.40						
Standard Deviation	6.6			7.8			15.5						
Multiplier	2.35			2			1						

[1] Original scores were taken from B. P. S. Form 14-A, Experimental and Control Classes on the Iloilo Vernacular Experiment, April, 1951.

R = Reading A = Arithmetic L = Language

$M_R = \frac{\Sigma X}{N} = \frac{242}{5} = 48.00$ $M_A = \frac{\Sigma Y}{N} = \frac{331}{5} = 66.20$ $M_L = \frac{\Sigma Z}{N} = \frac{202}{5} = 40.40$

$\sigma_R = \sqrt{\frac{\Sigma x^2}{N}} = \sqrt{\frac{215.20}{5}} = 6.6$ $\sigma_A = \sqrt{\frac{\Sigma y^2}{N}} = \sqrt{\frac{304.8}{5}} = 7.8$ $\sigma_L = \sqrt{\frac{\Sigma z^2}{N}} = \sqrt{\frac{1,199.20}{5}} = 15.5$

LIST OF SYMBOLS USED

N = Number of cases

M = Obtained mean

M' = Guessed or assumed mean

c = Correction

X = One variable

Y = Another variable

x = Deviation of X score from the obtained mean (M_x)

x' = Deviation of X score from the guessed mean (M'_x)

y = Deviation of Y score from the obtained mean (M_y)

y' = Deviation of Y score from the guessed mean (M'_y)

$\sigma_{dist.}$ = Standard deviation of the distribution

σ_M = Standard error of the obtained mean

$\sigma_{Diff.}$ = Standard error of the difference between two obtained means

E.C. = Experimental Coefficient

S_1 = Group 1

S_2 = Group 2

IT = Initial test

FT = Final test

EF = Experimental Factor

C = Change

LIST OF FORMULAS USED

(1) $M = M' + c$

(2) $x = X - M$

(3) $x' = X - M'$

(4) $c = \frac{\Sigma x'}{N}$

(5) $\sigma_{dist} = \sqrt{\frac{\Sigma x^2}{N}}$

(6) $\sigma_{dist.} = \sqrt{\frac{x'}{N} - c^2}$

(7) $\sigma_M = \frac{\sigma_{dist.}}{N}$

(8) $Diff. = M_1 - M_2$

(9) $\sigma_{Diff.} = \sqrt{\sigma_{M_1} + \sigma_{M_2}}$

(10) $E.C. = \frac{Diff}{2.78 \times \sigma_{Diff.}}$

The result will be the Experimental Coefficient (E.C.) (Formula 10).

In the computation of the standard error of the mean for Tables I, II, and III, the $\sqrt{N} - 3$ should have been employed as the denominator because the number of cases was below 10, but the $\sqrt{N}$ was used for the sake of illustrating the computation of the standard error of the mean in a normal distribution with 30 or more cases.

B. **Equivalent-groups method**

In the statistical treatment of the data in the equivalent-groups method, observe the following steps:

1. Arrange the pupils in the experimental group in the order of the size of their IT scores.

2. Compare the initial and final scores of each pupil in the Experimental Group to find how much change has been made by the experimental factor.

3. Find the mean of the changes (C's) made in the Experimental Group. (Formula 1)

4. Find the standard deviation of the distribution of changes in the Experimental Group. (Formula 6)

5. Find the standard error of the mean of the Experimental Group. (Formula 7)

6. Proceed in the same way (Steps 1 to 5) in treating the scores in the Control Group.

7. Compare the mean in the Experimental Group with the mean in the Control Group. This will give the difference between the two means, (D). (Formula 8)

8. Find the standard error of the difference between the two means. (Formula 9)

9. Divide the difference (D) by its standard error multiplied by the constant 2.78. The result will be the Experimental Coefficient. (Formula 10)

The above steps are illustrated in the computation of the data in Table II.

C. Rotation Method

The computation of the experimental coefficient (E.C.) in the simplest type of rotation experiment, namely, two groups which may or may not be equivalent, two EF'S and one test type, is illustrated by Table III.

In the computation of the mean, standard deviation, standard error of the mean, standard error of the difference and the Experimental Coefficient in Table III, follow the same procedures as given for the One-Group and for the Equivalent-Groups Method.

VII. *Interpretation of Experimental Results*

In interpreting the results of an experiment, it is always necessary to inquire into the reliability of the obtained difference between the two obtained means. Is the difference stable? Will it stay as it is, if the experiment is repeated under the same experimental conditions? What are the chances that it will stay the same? If the experiment is repeated under the same experimental conditions, will it be obliterated or will it be reversed? These questions can be answered by examining the size of the Experimental Coefficient.

The experimental coefficients (EC) in Tables I, II, and III need interpretation. An experimental coefficient of 1.0 means that we can be practically certain that the true difference between the results of the two experimental factors is somewhere above zero, and, according to Table VI, the chances are 369 to 1 that it will remain as it is. An EC of 0.5 means that we can be certain only half of the time that the true difference is above zero, and the chances are only 11 to 1 that it will remain as it is. If the EC is 2.0, we can be doubly sure that the true difference is above zero.

The primary concern of the experimenter is to know whether the obtained superiority of one EF over another is sufficiently reliable for him to make conclusions that the true difference, if known, would continue to favor the same EF. For instance, in Table I the experimental coefficient of 2.26 indicates 2.26 times practical certainty that the true difference is above zero, and that it would continue to favor EF_1. As to the experimental coefficient of 1.07 in Table II we can be practically certain that the true difference between the two experimental factors is above zero; the EC of 1.42 in Table III shows 1.42 times practical certainty that the true difference is above zero and that the chances are 20,000 to 1 that it will remain as it is. So when the EC is less than 1.0, the experimenter should state that one of his EF's is *probably* more effective than the other.

The following table of chances, as computed by McCall, gives the approximate chances for different sizes of the Experimental Coefficient.

Table VI

HOW TO CONVERT AN EXPERIMENTAL COEFFICIENT INTO A STATEMENT OF CHANCES[1]

Experimental Coefficient	Approximate Chances
.1	1.6 to 1
.2	2.5 to 1
.3	3.9 to 1
.4	6.5 to 1
.5	11 to 1
.6	20 to 1
.7	38 to 1
.8	75 to 1
.9	160 to 1
1.0	369 to 1
1.1	930 to 1
1.2	2,350 to 1
1.3	6,700 to 1
1.4	20,000 to 1
1.5	65,000 to 1

[1] William A. McCall. *How to Experiment in Education.* New York: The Macmillan Co., 1923, p. 155.

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