Chapter 15

Analysis of Data

A prime responsibility of the educational researcher is that of being able to make either a probability or logical inference covering the tenability of his testable hypothesis. The acceptance or rejection of these hypotheses will ultimately determine what contribution the study makes to the scientific' development of a particular area. This is especially tried in the analysis for interpretation of data.

The analysis and interpretation of data represent the application of deductive and inductive logic to the research process. The data are often classified by division into, subgroups, and are then analyzed and synthesized in such a way that hypothesis may be verified or rejected. The final result may be a new principle or generalization. Data are examined in terms of comparison between the more homogeneous segments within the group any by comparison with some outside criteria.

Analysis of data includes comparison of the outcomes of the various treatments upon the several groups and the making of a decision as to the achievement of the goals of research. Data relevant to each hypothesis must be assembled in quantitative form and tested to determine whether or not there is a significant difference in the results obtained from the controlled groups. Usually the analysis develops as a comparison between groups however, sometimes the type of data obtainable tends itself better to the existing differences by contrast or by summing up.

It is virtually impossible to complete a scientific analysis without using some form of statistical processing. This may involve depicting differences by complicated inferential statistics such as the analysis of variance, and analysis of covariance technique.

Each statistical method is based upon its own or specific assumptions regarding the sample, population and research conditions. Unless these factors are considered in advance the researcher may find that it is impossible to make valid comparison for purpose of inferences.

NEED FOR ANALYSIS OF DATA OR TREATMENT OF DATA

After administering and scoring research tools scripts, data collected and organized. The collected data are known as 'raw data.' The raw data are meaningless unless certain statistical treatment is given to them. Analysis of data means to make the raw data meaningful or to draw some results from the data after the proper treatment. The 'null hypotheses' are tested with the help of analysis data so to obtain some significant results. Thus, the analysis of data serves the following main functions:

1. To make the raw data meaningful,
2. To test null hypothesis,
3. To obtain the significant results,
4. To draw some inferences or make generalization, and
5. To estimate parameters.

There are two approaches which are employed in analysis of data: Parametric analysis of data and non-parametric analysis of data. The details of these approaches have been discussed in this chapter.

SELECTING THE LEVEL OF DATA

If we are working with variables which do have a quantitative aspect we can use the data collecting process of measurement. In this process we attempt to achieve some quantitative estimate of the variable or, more realistically of the amount of the variable which each of our research subject has. We can aspire to four different levels of measurement – Nominal, Ordinal, Interval and Ratio–and these are listed from the weakest level (nominal) to the strongest level (ratio).

Here is seldom any question In labelling nominal data for nonquantitative data are typically obvious to researcher and reader alike. However, for quantitative data, the distinction between ordinal and interval or ratio data is a critical one and moreover, one which different researchers see differently. Some research specialists or guides advise as a general principle in planning data analysis that the researcher considers the data ordinal, unless he can specifically identify a rationale other than the assignment of consecutive digits to consider them interval data. This rationale may be purely intellectual and based on the processes involved in selecting the various points one scale, or the rationale may be empirical and based on the data collected during pilot work from which the final instrument was derived. But there should be some specific set of reasons or data which can be cited when the researcher departs from treating his numerical data as ordinal data.

ANALYSIS OF DATA

Analysis of data means studying the tabulated material in order to determine inherent facts or meanings. It involves breaking down existing complex factors into simpler parts and putting the parts together in new arrangements for the purpose of interpretation.

A plan of analysis can and should be prepared in advance before the actual collection of material. A preliminary analysis on the skeleton plan should as the investigation proceeds, develop into a complete final analysis enlarged and reworked as and when necessary. This process requires an alert, flexible and open mind. Caution is necessary at every step. In case where a plan of analysis has not been made beforehand. Good. Barr and Scates suggest four helpful modes to get started on analysing the gathered data:

(*i*) To think in terms of significant tables that the data permit.

(*ii*) To examine carefully the statement of the problem and the earlier analysis and to study the original records of the data.

(*iii*) To get away from the data and to think about the problem in layman's terms.

(*iv*) To attack the data by making various simple statistical calculations.

In the general process of analysis of research data, statistical method has contributed a great deal. Simple statistical calculation finds a place in almost any research study dealing with large or even small groups of individuals, while complex statistical computations form the basis of many types of research. It may not be out of place, therefore to enumerate some statistical methods of analysis used in educational research.

STATISTICAL ANALYSIS OF DATA

Statistics is the body of mathematical techniques or processes for gathering, describing orgainising and interpreting numerical data. Since research often yields such quantitative data, statistics is a basic tool of measurement and research. The research worker who uses statistics is concerned with more than the manipulation of data, statistical methods goes back to fundamental purposes of analysis. Research in education may deal with two types of statistical data application.

1. Descriptive Statistical Analysis, and
2. Inferential Statistical Analysis.

1. Descriptive Statistical Analysis

Descriptive statistical analysis is concerned with numerical description of a particular group observed and any similarity to those outside the group can not be taken for granted. The data describe one group and that one group only.

Much simple educational research involves descriptive statistics and provides valuable information about the nature of a particular group or class.

2. Inferential Statistical Analysis

Inferential statistical analysis involves the process of sampling, the selection for study of a small group that is assumed to be related to the large group from which it is drawn. The small group is known as the sample; the large group, the population or universe, A statistics is a measure based on a sample. A statistic computed from a sample may be used to estimate a parameter, the corresponding value in the population which it is selected.

DESCRIPTIVE DATA ANALYSIS

Data collected from tests and experiments often have little meaning or significance until they have been classified or rearranged in a systematic way. This procedure leads to the organisation of materials into few heads.

(*i*) Determination of range of the interval between the largest and smallest scores.

(*ii*) Decision as to the number and size of the group to be used in classification. Class interval is therefore, helpful for grouping the data in suitable units and the number and size of these class intervals will depend upon the range of scores and the kinds of measures with which one is dealing. The number of class intervals which a given range will yield can be determined approximately by dividing the range by the interval tentatively chosen.

Most commonly used methods of analysis data statistically are:

1. Calculating frequency distribution usually in percentages of items under study.
2. Testing data for normality of distribution skewness and kurtosis.
3. Calculating percentiles and percentile ranks.
4. Calculating measures of central tendency-mean, median and mode and establishing norms.
5. Calculating measures of dispersion-standard deviation mean deviation, quartile deviation and range.
6. Calculating measures of relationship-coefficient of correlation, Reliability and validity by the Rank-difference and Product moment methods.

7. Graphical presentation of data-Frequency polygon curve, Histogram, Cumulative frequency polygon and Ogive etc.

While analyzing their data investigations usually make use of as many of the above simple statistical devices as necessary for the purpose of their study.

INFERENTIAL DATA ANALYSIS

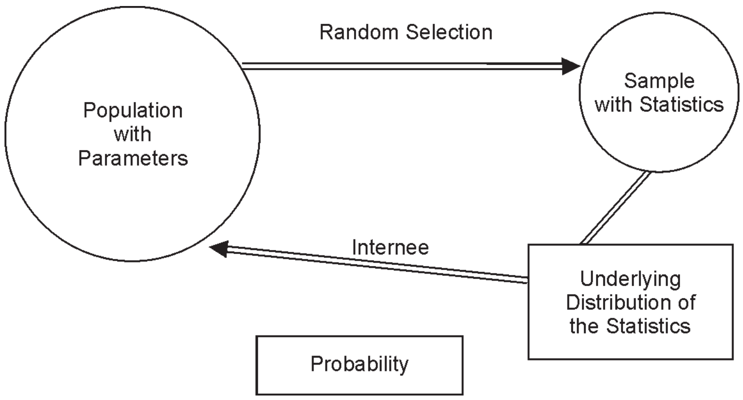
The primary purpose of research is to discover principles' that have universal application. But to study a whole population in order to arrive at generalization would be impracticable if not impossible.

A measured value based upon sample data is statistic. A population value estimated from a statistic is a parameter. A sample is a small proportion of a population selected for analysis. By observing the sample, certain inferences may be made about the population. Samples are not selected haphazardly, but are chosen in a deliberate way so that the influence of chance or probability can be estimated. Several types of sampling procedures are described each one is particularly appropriate in a given set of circumstances.

INFERENCE FROM STATISTICS TO PARAMETERS

The basic ideas of inference are to estimate the parameters with the help of sample statistics which play an extremely important role in educational research. These basic ideals of which the concept of underlying distribution is a part, comprise the foundation for testing hypotheses using statistical techniques.

The chain of reasoning from statistics to parameters is a part of what we call inferential statistics. The inference is from the statistics to the parameters. This chain of reasoning has been illustrated with help of the following diagram:



(*a*) We have a population and want to make decisions about measures of the population namely parameters.

(*b*) We have a random sample and compute measures of the sample which are termed as statistics.

(*c*) The statistics are used to estimate parameters with sample fluctuation.

(*d*) We have to obtain the sample statistics which are the facts that we have to infer back to the parameters in the light of the underlying distribution and probability.

We have a population and we want to know something about the descriptive measures of this population, namely the parameters. It is desirable or impossible to measure the entire population, so a random sample is selected from the population. The descriptive measures of the sample are known as statistics and the statistics can be determined. Since the sample is a random sample, we know that the statistics can be employed to estimate the population parameters within fluctuation due to sampling. It is at this point that the underlying distribution of the statistics comes in. If we know the underlying distributions we know how the statistics behaves. The appropriate underlying distribution for a specific statistics has been determined for us by mathematical theory and has been tabulated in table form. Underlying distributions are commonly theoretical distributions.

The parameters are never known for certain unless the entire population is measured and then there is no inference. We look at the statistics and their underlying distributions and from them we reason to tenable conclusions about the parameters.

SELECTING THE STATISTICS

As he plans the analysis of the data the researcher should consider two sections of the research report in which statistics will be relevant. The first of these is the section in which the data producing sample is described and in which may also be compared to the selected sample and to the population. In describing the sample, the basic descriptive statistics of the summary frequency distribution and the appropriate measures of central tendency and variability serve to provide the reader with some insight into the nature of the respondents. Researches are interested in the usual demographic characteristics such as gender, age, occupation and educational level, but in addition anyone project will suggest other descriptive variables about which data should be collected.

Provided the data are available, the researcher should also employ inferential statistics such as Chi-square or the t-test to determine whether or not his data producing sample differs from his selected sample or population by selecting which analysis he will prefer at his early stage, the researcher structures the kinds of data he will need to produce about the population and can incorporate the search for these data into his data gathering plan.

The second section of the report in which statistical procedures plays role is in the reporting of research results. The selection of these procedures should be well structured by this point if the researcher has stated specific hypotheses and research questions. The necessity to test the hypothesis provides guidance to statistical procedures at the general level, with the decision as to the level of data available providing the key to which specific procedures are to employ. Thus, hypothesis which refers to the expected a relationship between two variables, immediately indicates the need for a correctional analysis. Once the researcher decides that the two variables will yield ordinal data, for example, he can move directly to the specification of the rank order correlation.

The specification of statistical analysis at this stage of the research also enables the researcher to estimate his data analysis cost in both time and money and make whatever arrangements are necessary to reserve time on data-processing facilities.

The elementary and special statistical techniques of analsysis are as follows:

Elementary Statistical Techniques of Analysis

Most commonly used statistical techniques of analysis data are:

1. Calculating frequency of distribution in percentages of items under study.
2. Testing data for normality of distribution Skewness Kurtosis and mode.
3. Calculating percentiles and percentile ranks.
4. Calculating measures of central tendency-Mean, Median and Mode and establishing Norms.
5. Calculating measures of dispersion-Standard deviation, Mean deviation, quartile deviation and range.
6. Calculating measures of relationship-Coefficients of Correlation, Reliability by the Rank difference and Product moment method.
7. Graphical presentation of data-Frequency polygon curve, Histogram, Cumulative frequency polygon and Ogive, etc.

While analysis their data investigator usually makes use of as many of the above simple statistical devices as necessary for the purpose for their study. There are some other complicated devices of statistical analysis listed below which researcher use in particular experimental or complex casual-comparative studies and investigations.

Special Statistical Techniques of Analysis

The following are the special statistical techniques of analysis:

1. Test of students '*t*' and analysis of variance for testing significance of differences between statistics especially between Means.
2. Chi-square test for testing null hypothesis.
3. Calculation of Biserial '*r*' and Tetrachoric '*r*' for finding out relationship between different phenomena in complex situations.
4. Calculation of partial and multiple correlation and of Bivariate and Multivariate Regression Equations for findings out casual relationship between various phenomena involved in a situation.
5. Factorial Analysis for the purpose of analysing the composition of certain complex phenomena.
6. Analysis of co-variance for estimating the true effect of the treatment after adjusting the initial effect.

PLANNING FOR DATA ANALYSIS

The next aspect of the data analysis plan is to scan the data gathering instruments in the context of data analysis. During the process of selecting a method and technique and developing an instrument, the researcher is usually so oriented to content and procedure that he ignores the relatively minor issues in instrument development, such as whether or not their is a place for the respondent to indicate his name, age, class, or any other data that will be required for data analysis. After the data are collected and about to be analyzed it is often too late to capture this information. Thus, it is at this point of planning the data analysis that the researcher can profitability refer to the list below of characteristics of the data gathering instrument that will expedite data analysis.

1. There should be a place for name, school, class, age, sex or any other classifying information the researcher will need in data analysis.

2. Every item should be numbered, and every option within an item should be separately numbered or lettered, for case of data analysis.
3. Options should not overlap on structured questions, that is, if one option is 5-10, the next should begin with 11.
4. It is preferable to have options circled rather than checked. This expedites the analysis of data and also eliminates the possibility that the check below means 'high school' to some respondents rather than 'College' as the researcher intended.
5. The order in which items appear on an instrument reflect the priority of information sought. The researcher must recognize that respondents and observers tire and if they do the items which appear late in the instrument are answered less carefully or omitted entirely.

The order of the items has been planned with the processing of data in mind. If two pieces of data are to be analyzed simultaneously, this analysis can be expedited considerably if they are physically close together on the instrument. If some sub-analysis within the instrument is planned, such as computing the number of items correct on a sub-test or the number of positive responses on an interest inventory, the layout of the instrument should consider the placement of those items on each sub-test.

The instrument should provide the respondent with a way of indicating inability or unwillingness to answer a question, record an observation, or respond to a measure.

The possibility of pre-coding instruments, or printing them on different colour paper as an aid to data analysis should be considered. Instrument used in the pre-and-post administration of any technique should be easily distinguishable and so impossible to confuse.

CONSIDERATIONS FOR STATISTICAL ANALYSIS

There are various statistical techniques for analysing data. To choose an appropriate technique of statistical analysis in the challenging task to a research worker. It has two main functions:

1. Interpretation of results, and
2. Presentation of data.

The major types of tests are employed for analysing data so as to interpret the results. There are:

(A) Parametric statistics or tests, and

(B) Non-parametric statistics or tests.

A researcher has to select either of these approaches for analysing his own research data. The following are the criteria for choosing an appropriate statistical approach.

(A) Considerations for Parametric Statistics

This type of statistical analysis may be employed effectively in the following conditions:

1. Probability or representative sample has been employed in the investigation.
2. Variables of the study can be qualified at interval scale.
3. Specific assumptions are fulfilled. The obtained data are normally distributed or not free distribution.
4. The population of the study has been clearly defined.
5. Objectives of the research study.

Under this approach the following statistical techniques are employed :

(*a*) To study the descriptive relationship of two or more variables:

a_1 – Pearson's product moment method of correlation (two variables)

a_2 – Multiple correlation (more than two variables)

a_3 – Partial correlation (more than two variables)

a_4 – Factor analysis-extracting factors or estimating psychological or factorial validity of tests.

(*b*) To analyse the functional relationship of the variables:

b_1 – Main effect of two treatments '*t*' test

b_2 – Main effect of more than two treatments *F*-test

b_3 – Interaction effect of two or more variables-Two or more ways analysis variance techniques

b_4 – Gain or loss of more than two treatments-Analysis of covariance and correlated '*t*' test.

(B) Considerations for Non-parameteric Statistics

This type of statistical analysis may be used effectively in the following situations:

1. When non-probability sample is selected in the research study.
2. The variables of the study are quantified at any level of measurement, mainly, nominal and ordinal scale. It may be in the discrete form.
3. No assumption is required for this approach.
4. Free distribution of data, may be skewed or may be normally distributed.
5. Objectives of the study.

In this approach the following statistical techniques are generally used :

(*a*) To study the relationship of two or more variables:

a_1 – Spearman Rho correlation in small sample not in large sample for two variables. Data are available at ordinal or internal scale.

a_2 – x^2 and contingency correlation. It is used when two or more variables are taken. The data may be nominal or ordinal scale or interval scale.

a_3 – Analysis variance.

(*b*) To analyse the difference between two or more groups:

b_1 – Median test for small test.

b_2 – x^2 test for large sample also for small sample.

b_3 – Run test and *U*-test when data are on ordinal scale.

b_4 – Sign test.

BASIS FOR SELECTING A STATISTICAL TECHNIQUES

The main basis for selecting an appropriate statistical test is the nature of data and number of variables included in the investigation. In the behavioural science researches: nominal, ordinal and interval types of data are commonly used. The table provides the basis for selecting a statistical test apart from the above considerations.

Commonly used Measures of Association for Different Types of Variables

Measure of Association to Use	*Nature of Variables Involved*	*Restrictions, Assumptions, or Comments*
Pearson product- moment correlation.	2 continuous variables	Linear relationship interval or ratio scales
Rank-order correlation or Kendall's tau	2 continuous variables	Ordinal scales
Tetrachoric correlation	2 continuous variables both of which have been dichotomized	Normal bivariate distribution of the two variables
Correlation ration (Eta coefficient)	1 continuous variable 1 variable, either continuous or a discrete set of categories	Non-linear relationship
Intraclass correlation	1 continuous variable 1 variable, a discreate set of categories	Intent is to ascertain degree of similarity within groups interval or ratio scale
Biserial correlation	1 continuous variable 1 continuous variable which has been dichotomized	Interval or ratio scale
Point biserial correlation	1 continuous variable 1 true dichotomy	Interval or ratio scale
Fourfold point correlation (phi-coefficient)	2 true dichotomies	Nominal or ordinal scale
contingency coefficient	2 sets of unordered categories	Nominal scale
Mahalanobis D2 (from linear discriminant function) or multiple biserial correlation	1 set of unordered categories 1 or more variable of any sort	Intent is to determine degree of similarity among the group on basis of several measures
Partial correlation	3 or more continuous variable	Intent is to find to degree of relationship between any two with the effects of the others held constant
Multiple correlation (from multiple regression)	3 or more continuous variables	Intent is to determine predictability of one variable on basis of several others linear relationships
Kendall’s coefficient or concordance	3 or more continuous variables	Intent is to determine the overall amount of agreement ordinal scale
Intraclass correlation	3 or more continuous variables	Estimates average of inter-correlation between pairs.

PRESENTATION OF DATA

The presentation of data is an important aspect of analysing of data. The purpose of presentation of data is to highlight the results and to make data or results more illustrative. The visual presentation of data or results is simple and easy to understand. The graphical and pictorial presentation provide the geometrical image of data. It enables us to comprehend the essential features of the frequency distribution. It also helps in observing the assumptions of the statistical analysis applied for the treatment of data. The presentation of data serves the following functions:

Basic for Selecting a Statistical Test Types and Number of Independent Variables

			Interval		*Ordinal*		*Nominal*	
			1	More than 1	1	More than 1	1	More than 1
DEPENDENT VARIABLES		0		Factor Analysis	Transformation of Scale			
		1	Correlat-ion	Multiple Correlat-ion			Analysis of Variance (or t-test)	Analysis of Variance
		More than 1	Multiple Correlat-ion					
		0	Transformation of Scale			Coefficient of concord-ance (W)		
		1			Spearman Correlat-ion Kendall's Tau (τ)	Sign test, median test U-test Kruskal-Wallis		Friedman's two-way analysis of variance
		More than 1						
		0						Chi-square
		1	Analysis of Variance		Sign test, Meidan test U-test Kurskal Wallis		Phi-Coeff. (f) Fisher exact test Chi-square	
		More than 1	Analysis of Variance		Friedma's two-way analysis of variance			

1. Visual or pictorial presentation of data
2. Makes the data to comprehend easily
3. Helps in understanding the nature of the distribution of data
4. The assumptions of statistical analysis can also be observed.

Generally the following types graphical presentation are attempted in behavioural researches:

(*a*) Bar diagrams and Histogram
(*b*) Graphical presentation
(*c*) Polygons and curve or Cumulative frequency curve
(*d*) Pie diagrams.

A. Parametric Tests

The parametric tests are the tests of the most powerful type and should be used if their basic assumptions are based upon the nature of the population values and the way that sample have been selected:

1. The observations are independent. The selection of one case is in no way dependent upon the selection of any other case,
2. The population values are normally distributed or, if not, the nature of their distribution is known.
3. The population values have equal variances or the ratio of their variances is known.
4. The variables measured are expressed in interval or ratio scales. Nominal or ordinal do not qualify.

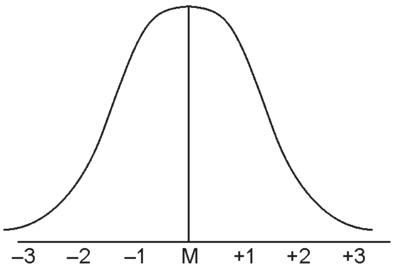


Fig. Normal curve of distribution of Individual scores

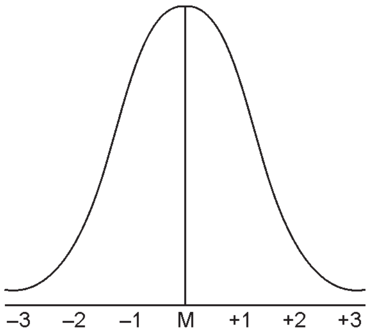


Fig. Normal curve of distribution of sample means

THE CENTRAL LIMIT THEOREM

If a number of equal-sized large samples are selected at random from an infinite population.

1. The means of the samples will be normally distributed.
2. The mean of the sample means will approximate the mean of the population or parameters.

If we selected a number of samples of 100 teachers from the population of teachers in Meerut, the mean ages of the samples, would not be identical. A few would be relatively high, a few relatively low, but most of them would tend to cluster around their own mean. The variation of these sample means is due to what is known as sampling error. The term does not suggest any fault in the sampling process. It merely identifies the chance variations that are inevitable when, a number of randomly selected sample means are computed.

Standard Error of the Mean or SE_{Mn}

The means of randomly selected samples, which are normally distributed, have their own standard deviation known as the standard deviation or standard error of the mean. The standard error of mean of a sample is computed from the formula:

$$SE_{Mn} \quad \text{or} \quad \sigma M = \frac{S}{\sqrt{N}}$$

Where,

Se_{Mn} = Standard error of mean

S = Standard deviation of sample scores

N = Size of the sample

The standard error of sample means has a smaller value than the standard deviation of the individual scores. This is understandable because in computing the means which are middle score values. The following figures illustrate this relationship.

Note the differences between the range and standard deviation of individual scores and those of sample means.

From the formula $SE_M = S/\sqrt{N}$, it is apparent that as the size of the sample increases, the standard error of means decreases. As the sample N approaches infinity the mean approaches the population and the standard error of mean approaches zero.

$$SE_{Mn} = \frac{S}{\sqrt{N}} = 0$$

As N is reduced in size and approaches one, the standard error of the mean approaches the value of the standard deviation of the individual scores.

$$SE_{Mn} = \frac{S}{\sqrt{N}} = \frac{S}{1} = S$$

This analysis suggests that, other factors being equal statistical inferences based upon small samples have larger margins of error than those based upon larger samples.

The value of the true mean of an infinite population is not known, for it cannot be calculated. But a particular mean calculated from a randomly selected sample can be related to the population mean in the following way. Approximately:

68 per cent of sample means will lie within a range of ± one SE_{Mn} of the population mean.

95 per cent of sample means will lie within ± 1.96 SE_{Mn} of the population -mean.

99 per cent of sample means will lie within ± 2.58 SE_{Mn} of the population mean.

The Standard Error of the Difference between Two Sample Means

The standard error of difference between two independent sample means may be calculated by the following formula:

$$SE_{(M_1-M_2)} = \sqrt{\left(\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}\right)}$$

N_1 = number of cases in first sample
N_2 = number of cases in second sample
S_1 = standard deviation of first sample
S_2 = S.D. of second sample.

CRITICAL RATIO (CR OR Z)

Using this value we may calculate the statistical significance of the differences between an experimental and a control means, if the experimental sample group and the control sample group are randomly selected from the same population. When the size of samples is large (more than 30) we may calculate what is known as the critical ratio, (CR) a ratio of the difference between experimental and control means (numerator), and the standard error of the difference between the two means (denominator).

$$CR = \frac{M_1 - M_2}{\sqrt{\left(\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}\right)}}$$

At this point an example might be helpful. Let us assume that an experiment is set up to compare the effectiveness of two methods of teaching reading. Two groups are randomly selected from the same population, one designated as the experimental group is taught by the initial teaching alphabet approach, while the other is taught by the traditional alphabet method. At the end of the year a standardized reading test is administered and the mean scores for each group are computed. The effectiveness of the experimental group method as compared with the effectiveness of the control group method is the issue, with the end of year mean scores of each group, the basis of comparison.

A mere quantitative superiority of the experimental group mean score over the control group mean score is not conclusive proof of its superiority. Since we know that means drawn from same population are not necessarily identical, any difference could possibly be attributed to sampling error. The difference must be greater than that reasonably attributed to sampling error to be statistically significant.

NULL HYPOTHESIS

A null hypothesis states that there is no significant difference between two or more parameters. It is concerned with a judgement as to whether apparent differences are real differences or whether they merely result from sampling error.

The experimenter formulates a null hypothesis, a no difference hypothesis. What he hypothesizes, is that any apparent difference between the mean achievement of the two sample group at the end of the experiment is simply the result of sampling error, as explained by the central limit theorem.

If the difference between the mean achievement of the experimental group and control group is too great to attribute to the normal fluctuations that result from sampling error, he may refute or reject the null hypothesis, saying, in effect, that it is not true that the apparent difference is merely the result of sampling error. These means no longer behave as two random sample means from the same population. Something has happened to, or affected, the experimental group in such a way that it behaves like a sample from a different or changed population. Thus, the researcher may conclude the experimental treatment not sampling error accounted for the difference in performance. The experimenter is using a statistical test to discount chance or sampling error as a variable.

If the difference between means was not great enough to reject the null hypothesis, the researcher accepts it. He concludes that there was no significant difference and that the sampling error probably' explained the apparent difference.

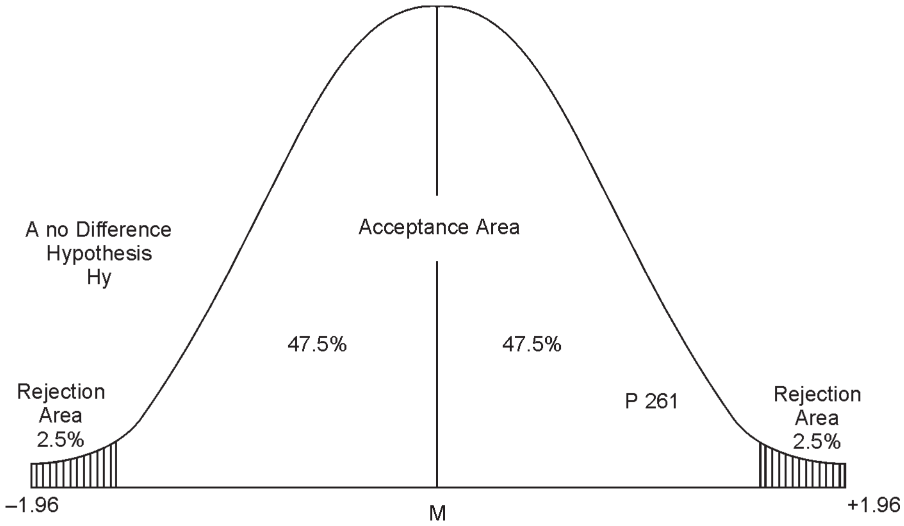
THE LEVEL OF SIGNIFICANCE

The rejection or acceptance of a null hypothesis is based upon some level of significance as a criterion. In psychological and educational circle the 5 per cent level of significance (.05) is often accepted as a standard for rejection. Rejecting the null hypothesis at the 5 per cent level indicates that a difference in means as large as that found between the experimental and control group means would not likely have resulted from sampling error in more than 5 out of 100 replication of the experiment. This suggests 95 per cent likelihood or probability that the difference was due to the experimental variable. A more rigorous test of significant is the 1 per cent level (.01).

When the samples are large (more than 30) the critical ratio is expressed as Z, or probability, score. If the critical ratio value exceeds 2.58, we may conclude that the difference between means is significant at the 1 per cent level. If the critical ratio value is greater than 1.96 but less than 2.58, we may conclude that the difference between means is significant at 5 per cent, but not at 1 per cent level. If the critical ratio is less than 1.96 the null hypothesis must be accepted at the 5 per cent level. .

TWO-TAILED OR NO DIFFERENCE TESTS

If a null hypothesis was established that there was no significant difference between the mean I.Q. scores of basketball letter winners and boys who did not participate, we would be' concerned only with a difference. We would not be concerned with the superiority of the letter winner group or that of the non- letter group. In such a case we apply a two tailed test.



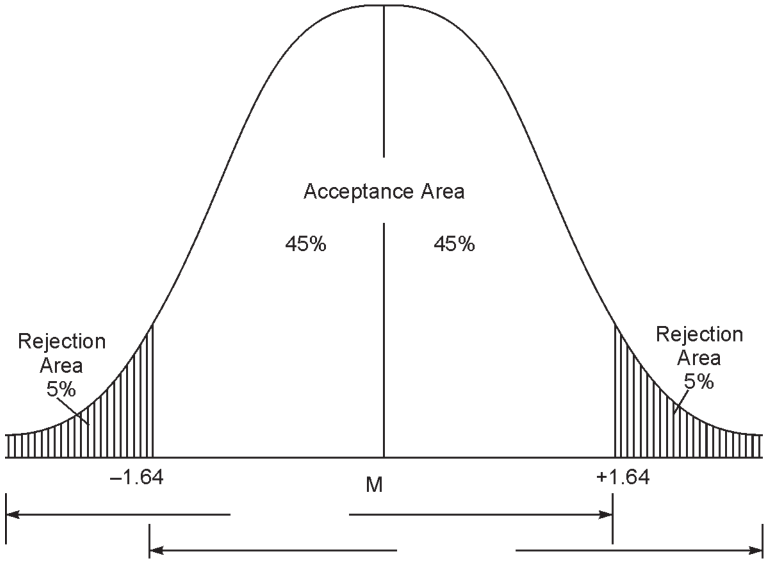
A two Tailed Test at the .05 Level

ONE TAILED OR DIRECTIONAL TEST

If we changed the null hypothesis to indicate a test of superiority of a particular group it might be started.

1. Athletes do not have lower I a mean scores than non athletes. or
2. Athletes do not have higher I a mean scores than non athletes.

Each null hypothesis indicates a direction of difference we are concerned with either higher or lower a mean for athlete group. When the researcher is interested in a direction of difference between groups, he uses a one tailed test. It can be noted that when 5 per cent rejection area is at one end or at the other end of the curve, it is not necessary to go out as far on the sigma scale to reach the 5 percent area of rejection.



A one tailed Test at the 0.5 Level

SIGMA VALUE THAT MUST BE EXCEEDED FOR REJECTION OF HYPOTHESIS

The sigma value exceeds, these table values for the rejection of null hypothesis.

Test	*Level of .05*	*Significance .01*
One tailed Test	1.64	2.33
Two tailed Test	1.96	2.58
Probability	.95	.99

THE SIGNIFICANCE OF *R*

To test the significance of a coefficient of correlation we may establish the null hypothesis that $r = 0$ and that any value of r, other than 0, is the possible result of sampling error. We assume that the sample r is one of a number of random samples. To use the z value and the probability table the r is converted into z value by the formula.

$$z = r\sqrt{N-1}$$

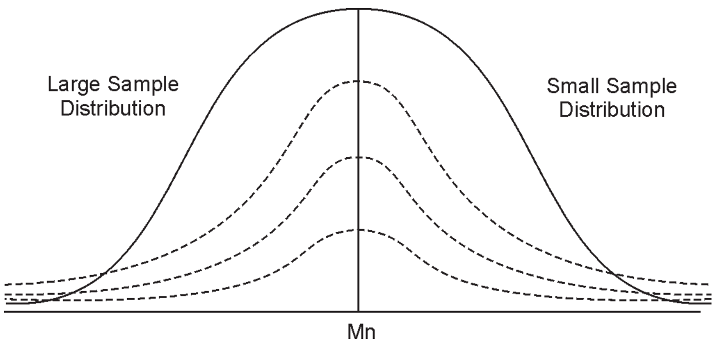
If z value exceeds the table value the hypothesis is rejected and if not then the hypothesis is accepted.

PRACTICAL SIGNIFICANCE

It is also important to note that a finding that is statistically significant may not be a measure of its usefulness in making a practical decision. A test of significance merely indicates there is a genuine relationship, that r is not O. Statistical significance indicates the probability that the finding did not result from sampling error.

STUDENT'S DISTRIBUTION '*t*'

When small samples, fewer than 30 observations in number, are involved, the *t*-test is used to determine the statistical significance. The concept of small sample sizes was developed by Gosset. Gosset determined that the distribution curves of small samples were somewhat different from the normal curve. Small sample distributions were observed to be higher at the mean and higher at the tails or ends of distribution.



Distribution of Large and Small sample means

Gosset's distribution, carefully calculated for small samples, is partially reproduced in t-table. The values necessary for rejection of a null hypothesis are higher for small samples at a given level of significance. As the sample size increases, the 't' values approaches the size 'z' values of the normal probability table. To find the appropriate value necessary for rejection of the null hypothesis the number of degrees of freedom should be calculated.

For the test of significance of the difference between two means the number of degrees of freedom would be:

$$(N_1 - 1) + (N_2 - 1) = N_1 + N_2 - 2$$

For a test of significance of a small sample coefficient of correlation the number of degrees of freedom would be $(N - 2)$.

Many '*t*' tables list values at various degrees of freedom for rejection of the null hypothesis at .05 and the .01 level of significance.

To compute *t*-value for the significance of the difference between two means, when *N* is fewer than 30, the formula is :

$$t = \frac{(M_1 - M_2)}{\sqrt{\frac{(N_1 - 1)S_1^2 + (N_2 - 1)S_2^2}{N_1 + N_2 - 2}}\sqrt{\frac{1}{N_1} + \frac{1}{N_2}}}$$

ANALYSIS OF VARIANCE (F) ANOVA TEST

The analysis of variance is a convenient way to determine whether the means of more than two random samples are too different to attribute to sampling error.

It would be possible to use a number of '*t*' test to determine the significance of the difference five means, two at a time, but it would involve ten separate tests. The number of the necessary pair wise comparisons of '*N*' things is determined by the formula:

$$\frac{N(N-1)}{2}$$

An analysis of variance would make this determination possible with a single test, rather than ten.

The question raised by the analysis of variance is whether the sample means differ from their own sample means (within group variance).

If the variation of sample means from the grand mean is greater enough than the variance of the individual scores from their sample means, the samples are different enough to reject a null hypothesis or sampling error explanation. If the among groups variance is not substantially greater than the within group variance, the samples are not significantly different and probably behave as random samples from the same population.

$$F = \frac{\text{Variance among groups}}{\text{Variance within groups}}$$

The significance of the '*f* 'ratio is found in '*f* 'tables which indicate the values necessary to reject the null hypothesis at the .05 or the .01 levels.

ANALYSIS OF COVARIANCE

The analysis of covariance represents an extension of analysis of variance, particularly useful when it has not been possible to compare randomly selected samples, a common situation is classroom experiments using available samples.

In such cases a pre-test is administered to each group before the application of the experimental variables. At the end of experimental period a post-test is administered and the gain evaluated by a test of covariance.

B. NON-PARAMETRIC TESTS

Non-parametric, or distribution free tests are used when the nature of the population distribution is not known or when the data are expressed as nominal or ordinal measures. The variables in a non-parametric tests are usually presented in rank order or discrete values. Discrete data could represent such classifications as high, medium or low, urban or rural or male or female, counting number in each category.

Non-parametric Statistics for the Behavioural Sciences Sidney Siegel

There are many types of non-parametric tests which are most frequently used in the educational research studies. The basis for selecting the non-parametric statistics has been given in the following table:

Level of Measurement		Non-parametric Statistical Test				Non-parametric Measures of Correlation
	One Sample Case	Two Sample Case		K-Sample Cause		
		Related Sample	Independent Sample	Related Sample	Independent Sample	
Nominal	Binominal test x^2-one sample test	McNemar test for the significance of changes	Fisher exact probability test x^2-test for two independent samples	Cochran q test	x^2 test for independent samples	Contingency coefficient: c
Ordinal	Kolmogrov Smirnov One-sample test	Sign test Wilcoxon matched pairs signed ranks test	Meidan test, Mann-Whitney u-test	Friedman Two-way analysis of variance	Extension of meidan test	Spearman rank correlation coefficients; rs
	One-sample runs test		Kolmogro Smirnov two-sample test Wald-Walfowitz runs test Moss test of extreme reactions		Krushkal-Wallis one-way analysis of variance	Kendall rank correlation coefficient; r Kendall partial rank correlation coefficient t_{xyx} Kendall coefficient of concordance W
Interval		Walsh test Randomizat-ion test for matched	Randomizat-ion test for two independent samples			

CHI-SQUARE TEST (χ^2)

The Chi-square test applies only to discrete data (discrete variables are those expressed in frequency counts). The test is based upon the concept of independence the idea is that one variable is not affected by, or related to another.

For example, in a test in which 90 individuals are given a blindfold test in order to determine their selection of the mildest of three brands of cigarettes, the results could be interpreted by the Chi-square test.

If there were no significant differences preference we would expect the individual to choose brand. A, brand B or brand C in about equal proportion. On the basis of a null hypothesis any variation could possibly be attributed to sampling error. We would hypothesize that the choices were independent, or not related to any factor other than probability.

The test would provide a method of testing the difference between actual preferences and choices based upon a probability assumption.

The Chi-square formula:

$$\chi^2 = \Sigma \left[\frac{(f_0 - f_e)^2}{f_e} \right]$$

The differences in preference are greater than would likely result from sampling error.

Spearman Rank Order Coefficient of Correlation (ρ-Rho)

The Spearman rank order coefficient of correlation is a useful non-parametric test. The data are expressed in ranks rather than as scores. The test is useful when the number of ranked pairs is fewer than thirty and when there are few ties in rank.

$$\rho = 1 - \frac{6\Sigma d^2}{N(N_2 - 1)}$$

To test the significance of p (a one tailed test) we may use the '1' table (students distribution) for null hypothesis rejection values. The number of degrees of freedom is (N – 2).

The ρ (rho) is converted to a t value by the formula

$$t_\rho = \frac{\rho\sqrt{(N-2)}}{\sqrt{(1-\rho^2)}}$$

If the '1' value exceeds the table value the hypothesis is rejected. If the '1' value fails to exceed the table values at the .01 and .05 levels of significance, the hypothesis that P = a must be accepted.

THE SIGN TEST

The sign test is sometimes used to evaluate the effect of a type of treatment in a before-after experiment. The sign test is based on the following assumptions;

1. The direction, not the amount of change in scores units is noted.
2. Cases in which there were no changes are disregarded.
3. The probabilities of a gain or loss are equal (P =.5). The sign test uses the principles of the standard error of a dichotomous variable; deriving a Z-score by the formula:

$$Z = \frac{O - NP}{\sqrt{NP(1-\rho)}}$$

where 0 = +ve changes

N = + and –ve changes

P =.5 (equal probability of a gain or loss)

If Z value exceeds the table value the null hypothesis is rejected and if not exceeded then the null hypothesis is accepted.

How to Make Analysis Objective

An investigator-analysis the tabulated material with a view to determining inherent facts or meanings. He breaks down existing complex factors into simpler parts and puts the parts together in new arrangement for the purpose of interpretation. The investigators make analysis objective by:

1. Picking out the essential elements in a problematic situation.
2. Separating similarities from dissimilarities.
3. Giving special attention to exceptions.
4. Arranging data on gently.
5. Making judgements on adequate data.
6. Making his sense of logic on sound principles.
7. Being inventive in the matter of techniques.
8. Disregarding personal attachment to a hypothesis.
9. Having good mathematical ability.
10. Studying data from as many angles as possible to find out new and newer facts.

SIGNIFICANCE

However valid, reliable and adequate the data may be, if they do not serve any worthwhile purpose unless they are carefully edited, systematical classified and tabulated, scientifically analyzed, intelligently interpreted and rationally concluded.

Barr and others point out, "Analysis is an important phase of the classification and summation of data into a summary."

According to A. Wolfe, "The discovery of order in the phenomena of nature, not withstanding their complexity and apparent confusion is rendered possible by the process of analysis and synthesis which are foundation stone of all scientific methods."

The types of statistical analysis of the data obtained in a research work are limited to the nature of data or to the type of scale of measurement one obtains by the process of quantification. The four scales investigated are: nominal, ordinal, equal interval, and ratio. Non-parametric statistics may be used to analysed data measured by the nominal or ordinal scale. Data measured by either the equal-interval or the ratio scale may be analysed by either non-parametric or parametric methods. Parametric statistics or tests are preferred if all the parametric assumptions are fully met and provided the researcher has great competence in the use of inferential statistics.

REVIEWING ASSUMPTIONS AND LIMITATIONS

In the final aspect of data analysis plan is for the researcher to look back over all the decisions and choices that have been made to identify two things: the final set of assumptions required for the project to be sensible and the limitations to the conclusions which will hold if the current plans for the project are implemented. In identifying both assumptions and limitations the researcher is concerned with those aspects of the research process over which he has no control or about which he has no information. This includes aspects of the potential respondents, such as why some agreed to participate and others did not, or why after agreeing to participate some failed to complete the data gathering instrument, as well as the frankness of the base who did complete it. It may include aspects of the research approach, such as the availability of data in the historical approach, or the comparability of survey sites in the comparative survey, and often includes aspects of the research method such as the relevance of the time periods selected for observation or whether or not rapport was established in an interview.

Any controlled aspect which the researcher considers critical for the research to make sense must be stated as an assumption. Thus, the frankness of the respondents, the comparability of survey sites, the relevance of observation time periods in most projects would be considered assumptions because it makes no sense to report data from respondent who cannot be considered frank, or to do comparative study in sites or considered comparable, or to report observation data obtained during time periods which can not be considered relevant for the problem under study.

Those controlled aspects which are not critical may be stated as limitations to the conclusions. Thus, a researcher may decide that he can live with the fact that his historical project is limited to sources available.

Having stated the assumptions and limitations, and researcher should scan them as a total set and review them with one thought in mind, the impact on the audience to whom his research is directed. He must appraise the effect of his assumptions and limitations on the acceptance and implementation of his research findings and must be willing, even at this late stage, to revise or expand his research plans if one or more assumptions or limitations seem likely to damage the significance of the research too greatly. The researcher must build into the research atleast an overview of the materials of major significance in other languages. The research planning the comparative survey may conclude that simply saying he assumes that the several argument, and so decide to incorporate into his data gathering plan specific efforts to obtain data to verify comparability.

EXERCISES

1. Explain the phrase ‘Analysis of Data’ or ‘Treatment of Data’. Indicate the need and importance of data analysis.
2. Differentiate between descriptive statistical analysis and inferential statistical analysis.
3. Distinguish between parametric statistics and non-parametric statistics. Indicate their uses in different types of data or researches.
4. Describe the role of statistics and parameters in analysing the data. Illustrate your answer with suitable example.
5. What are the statistical technique which are commonly used in educational research?
6. Enumerate the important considerations for statistical analysis with special references to parametric statistics and non-parametric statistics.
7. Indicate the basis for selecting a statistical technique in analysing data for educational research.