



Indira Gandhi National Open University
Staff Training and Research Institute of
Distance Education

MDE-415

Research For Distance Education

Block

4

DATA ANALYSIS

Unit 1 **Types of Data**

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MDE - 415: Research For Distance Education

(New Course in place of ES-315: Research For Distance Education)

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MDE-415 RESEARCH FOR DISTANCE EDUCATION

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BLOCK 4 DATA ANALYSIS

Block Introduction

There are four Units in this Block. Unit 1 explains the Types of Data. Unit 2 discusses how to test the hypotheses through statistical methods. Unit 3 introduces you to methods of writing a research report and Unit 4 describes the criteria to evaluate a research report.

In the previous Blocks, we have discussed the various tools used in collecting the data. However, data collection is only the first step. We have to analyse and interpret the data in order to make sense and draw the necessary conclusions. While analysing and interpreting the data we must apply appropriate methods/formulae/tests depending on the nature of data at hand.

In Unit 1, we have discussed (a) the quantitative data, their types, tabulation, and analysis and (b) the qualitative data and different ways of analysing such data.

In Unit 2, we have dealt with two major statistical tests – parametric, and nonparametric. Under parametric tests, we have discussed sampling distribution of means and application of various parametric tests. While discussing non-parametric tests, we focused on the application of chisquare-test in some detail.

Unit 3 is about the important issues and steps involved in preparing a research report. In the unit we have touched upon the beginning, the main body and the end part of the report.

In Unit 4, we explain the scientific ways of evaluating research. We have also developed a paradigm for assessing research reports.

In Unit 3 and 4, we have tried to present the concepts in a usual form. Hope you will be able to comprehend better with this.

The first two units will make heavy demands on you, unless you are familiar with research methodology. Hard work is necessary to deal with the enormous data collected while investigating any research problem. We hope you will enjoy working through the Units of this Block.

LET US BEGIN HERE

The Course on **Research for Distance Education** is divided into five Blocks. This is the fourth Block. It comprises four Units in all. A schematic representation of the design of Units. is given below.

Unit X

X.0 Introduction

X.I Objectives

X.2 Section 1 (Main Theme)

x.2.1 Sub-section 1 of Section 1

x.2.2 Sub-section 2 of Section 1

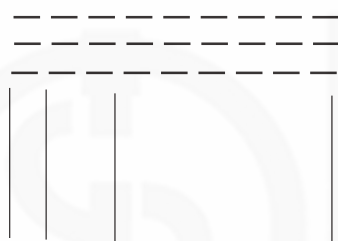
Check Your Progress

X.3 Section 2 (Main Theme)

x.3.1 Sub-section 1 of Section 2

x.3.2 Sub-section 2 of Section 2

Check Your Progress



Check Your Progress:
The Key

X.n Let Us Sum Up

As the scheme suggests, we have divided the units into sections for easy reading and better comprehension. Each section is indicated distinctly by bold capitals and each sub-section by relatively smaller but bold² upper and lower typeface. The significant divisions within sub-sections are in still smaller but bold** upper and lower typeface so as to make it easier for you to see their place within sub-sections. For purposes of uniformity, we have employed the same scheme of “partitioning” in every unit throughout the course.

We begin each unit with the section ‘Introduction’ followed by ‘Objectives’ which articulate briefly

- What we have presented in the unit, and’
- What we expect from you once you have finished working on the unit.

In the last section of each unit, under the heading, ‘Let Us Sum Up’, we summarise the whole unit for the purpose of recapitulation and ready reference.

Besides, we have given self-check exercises under the caption ‘Check Your Progress’ at a few places in each unit, and at the end of the unit “Possible answers” to the questions set in these exercises.

What, you ought to do is to go through the units and jot down important points as you read in *the space provided in the margin*. (**Broad margins in the booklet are there for you to write your notes on**). Make your notes as you work through the materials. This

will help you prepare for the examination and also help in assimilating the content. Besides, you will be able to save on time. Do use these margins. This will help you to keep track of and assimilate what you have been reading in the unit.

We hope that we have given enough space for you to work on the Check Your Progress exercises. The purpose of giving self-check exercises will be served satisfactorily if you compare your answers with the possible ones given at the end of each unit after having written your answer in the blank space. **You may be tempted to have a furtive glance at the possible answer(s)**, as soon as you come across an exercise. But we do hope that you will overcome the temptation and turn to the possible answers (which are not necessarily the best answers) only after you have written yours.

These exercises are not meant to be submitted to us for correction or evaluation. Instead, the exercises are to function as a study tool to help you keep on the right track as you read the units.

We suggest the following norms to be strictly practised while you are working through the assignments.

- Write your roll number legibly.
- Before you put anything down in words, assimilate what you have read, integrate it with what you have gathered from your experience to build your answer, and preferably prepare a concept map before starting to write it.
- Make the best use of the Block and additional reading materials by diligently working through the assignments.

Mail us

At the end of this Block, we have provided a feedback questionnaire. Please fill it after you complete this Block and send it to us. Your feedback shall be highly useful for future revision and maintenance of the course. Also please take note of the time you devote to studying this Block. May be, you complete this block after 4-5 sittings. But for every sitting kindly note the time separately so that you can categorically say how much time you took to read this Block. You can send the feedback form by post or you can email the same to: mparhar@ignou.ac.in. In the email, please mark in the subject area - FOR COURSE COORDINATOR-MDE-415. You may also contact us for any difficulties related to the programme in general and MDE-415 in particular.

UNIT 1 TYPES OF DATA

Structure

- 1.0 Introduction
- 1.1 Objectives
- 1.2 Types of Data: Quantitative and Qualitative
- 1.3 Quantitative Data
 - 1.3.1 Types of Quantitative Data
 - 1.3.2 Tabulation and Organisation of Quantitative Data
 - A. Frequency Distribution
 - B. Cumulative Frequency Distribution
 - 1.3.3 Graphical Presentation of Quantitative Data
 - 1.3.4 Analysis of Quantitative Data
 - A. Measures of Central Tendency
 - B. Measures of Variability
 - C. Measures of Relative Position
 - D. Measures of Relationship
- 1.4 Qualitative Data
 - 1.4.1 Organisation of Qualitative Data
 - 1.4.2 Analysis of Qualitative Data
 - A. Content Analysis
 - B. Inductive Analysis
 - C. Logical Analysis
- 1.5 Let Us Sum Up
- 1.6 Glossary
- 1.7 Check Your Progress: The Key

1.0 INTRODUCTION

In Block 3, we dealt with the nature of various tools used in the collection of data. These data are mostly expressed in quantified terms. However, quantitative data may not be available in certain cases. In such a situation, the researcher has to consider the phenomenon as a whole without breaking it down into measurable or quantifiable components. Indeed, he/she should be familiar not only with the two types of data – quantitative and qualitative, but also with the process of classifying data, graphical representation and the various methods of data analysis.

The aim of this Unit is to make you understand the nature of quantitative and qualitative data, the procedures for classifying and tabulating quantitative data, presenting them graphically, and the various methods used in data analysis.

1.1 OBJECTIVES

After the completion of this Unit, you should be able to:

- Define quantitative and qualitative data,
- Prepare various types of graphs and tables for presenting data,
- Compute measures of central tendency, variance, standard deviation, measures of relative position and measures of relationships, and
- Describe various methods used for analysing qualitative data.

1.2 TYPES OF DATA: QUANTITATIVE AND QUALITATIVE

The data collected through the administration of various types of tools on the selected samples are of two types - **qualitative** and **quantitative**. In **quantitative data**, numerical values are assigned to the characteristics or properties of objects or events, according to logically accepted rules. It is a process wherein a number system like figures, ratings or scores is imposed on empirical data. However, when the researcher takes into consideration the phenomenon as a whole and does not attempt to analyse it in measurable or quantifiable terms, the approach becomes '**qualitative**'. Generally, in educational and behavioural sciences, both types of data, (i) quantitative and (ii) qualitative, are recognised. We will look at the characteristics of both in the following sections. Section 1.3 deals with quantitative data, their types, tabulation, frequency distribution and cumulative frequency distributions, the need to represent data graphically, the various types of graphs, and the methods of analysing quantitative data, viz., measures of central tendency, variability, relative positions and relationship. In section 1.4, we shall briefly discuss qualitative data and their analysis with reference to content analysis, logical analysis and inductive analysis. The application of various parametric and non-parametric tests is discussed in more detail in Unit 2 of this Block.

1.3 QUANTITATIVE DATA

Quantitative data describe an empirical event or phenomenon in a numerical system with the help of different scales of measurement: **nominal**, **ordinal**, **interval** or **ratio**.

Nominal scales of measurement are used when a set of objects among two or more categories is to be differentiated on the basis of certain clearly known characteristics. For example, we may assign individuals categories such as sex (male and female), nationality (French and Indian), level (school and higher), education (formal and non-formal), etc.

The **ordinal scales** of measurement correspond to quantitative classification of a set of objects done with the help of ranking on a continuum. For example, we may rank students according to their height from the lowest to the highest. The **interval scale** of measurement is based on equal units of measurement.

It includes how much or how little of a given characteristic or attribute is present. For example, the difference in the amount of an attribute possessed by individuals with test

scores of 60 and 61 is assumed to be equivalent to that between individuals with scores of 50 and 51. **Ratio scale** is the highest level of measurement. Since this scale assumes the existence of absolute zero, this type of measurement is almost non-existent in educational and psychological measurement. Thus, quantitative data are expressed in nominal, ordinal, interval and ratio scales of measurement.

1.3.1 Types of Quantitative Data

Quantitative data may be classified into two categories:

- (i) **Parametric** and
- (ii) **Non-parametric**

Parametric data are obtained by applying interval or ratio scales of measurement. Scores of the tests of ability, achievement, attitude, interest, values, personality etc. are examples of interval scales of measurement. In the study of reaction time we use ratio scale. In this type of experiment, the zero point in the absolute sense is known and it makes sense to look at the ratio of the time taken to respond in different treatment situations.

Non-parametric data are either counted or ranked. In counted data, we make use of the nominal scale. Each individual can be a member of only one category and all the members of that category have the same, defined characteristics. For example, we may categorise a group as a sample of 'female students' of a particular 'study centre' of an open university. The categorisation of teachers at different educational levels—school, college and university—is another example of nominal data.

In ranked data, we apply the ordinal scale of measurement. The sets or classes of objects are ordered on a continuum in a series ranging from the lowest to the highest according to the characteristics we wish to measure. The ranking of students in a class for height, weight or academic achievement are examples of ordinal data.

Check Your Progress 1

Define quantitative data. Describe the various types of quantitative data along with examples.

Notes: (a) Space is given below for your answer.

(b) Compare your answer with the one given at the end of the Unit.

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1.3.2 Tabulation and Organisation of Quantitative Data

A. Frequency Distribution

Data collected from a test and by using other gathering/measuring tools are raw and may have little meaning to the researcher until they are tabulated and organised in a systematic order. One of the ways of doing so is to prepare a **frequency distribution**. The method for tabulating the quantified data in a frequency distribution can be illustrated by considering the following scores of 40 students of MA (DE) of the Indira Gandhi National Open University in course MDE-412.

Table 1.1: Tabulation of Scores on a Test in Course MDE-412

57	70	80	82	87
60	72	80	82	88
64	73	80	82	87
67	70	78	80	93
67	76	77	84	95
62	76	78	85	97
61	75	80	85	98
63	70	78	85	90

It is difficult to see from the above table how the scores are distributed. Inspection of scores, however, shows that many scores occur more than once.

You will observe that there are one 98, one 97, one 95, one 88, two 87s, three 85s, and so on. For our convenience, you can arrange the data in columns as shown in Table 1.2. In one column, you can arrange the marks in class-intervals and in the other, you can record the number of students who have scored these marks by tallies. Inspection of the scores in Table 1.1 shows that the highest score is 98 and the lowest is 57. The range is 41 (i.e. 98-57). Therefore, the distribution of scores can be conveniently arranged by dividing the range of 41 into eight or more class-intervals if the classes are taken to be of 5 points each. If you take the starting point at 56, the scores within the range 56 to 60, that is all scores with the values 57 and 60 will be grouped together to form the lowest class-interval. All scores from 61 to 65, that is, 61, 62, 63, 64 and 65 will form the next class-interval. Similarly you shall group all scores within the ranges 66 to 70, 71 to 75 and so on. The highest class interval will be 96-100.

**Table 1.2: Frequency Distribution of the Scores of 40 Students:
Course MDE-412**

Class Interval	Tallies	Frequency (f)
96 -100	II	2
91 - 95	II	2
86 - 90	IIII	4
81 - 85	~~IIII~~ II	7
76 - 80	~~IIII~~ ~~IIII~~ I	11
71 - 75	III	3
66 - 70	~~IIII~~	5
61 - 65	IIII	4
56 - 60	II	2
Total number of scores N = 40		

In Table 1.2, the class-intervals have been arranged serially from the smallest at the bottom to the largest at the top, each class-interval covering 5 scores. For each score, we have marked a 'tally' against the corresponding class-interval. The first score, 57, is represented by a tally placed against the class interval 56-60, the second score of 60 by a 'tally' marked against the class interval 56-60, and the third score 64 by a tally against the class interval 61-65. The remaining scores have been tabulated in the same way. When all the 40 scores are listed, the total number of tallies in each class-interval are counted and written in the next column f. The total of 'f' gives the total number of scores (in the present case 40) and is denoted by N.

It may be noted that the interval 56-60 takes care of all the scores from 56 upto 60. The score of 56 ordinarily means the interval 55.5 to 56.5 and that the score of 60 means 59.5 to 60.5. The mid-point of the bottom most class-interval is 58. Hence, the distribution represented in Table 1.2 may also be expressed as:

**Table 1.3: Frequency Distribution of the Scores of 40 Students:
Course MDE-412**

Score Intervals	Exact Units of Class-Intervals	Mid Point (x)	(f)
96-100	95.5-100.5	98	2
91-95	90.5-95.5	93	2
86-90	85.5-90.5	88	4
81-85	80.5-85.5	83	7
76-80	75.5-80.5	78	11
71-75	70.5-75.5	73	3
66-70	65.5-70.5	68	5
61-65	60.5-65.5	63	4
56-60	55.5-60.5	58	2
N = 40			

Check Your Progress 2

Tabulate the following data in a frequency distribution using an interval of 5 units.

185	176	166	177	171
147	176	170	171	180
173	168	181	165	173
175	158	156	162	173
197	151	153	162	188
166	145	191	164	174
178	142	158	167	178
148	187	172	169	184
156	187	172	193	183
181	161	172	179	179

Notes: (a) Space is given below for writing your answer.

(b) See whether you have followed the procedure as shown in Tables 1.2 and 1.3.

(c) The answer is incorporated in Check Your Progress 3.

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B. Cumulative Frequency Distribution

In some cases, you may not be concerned with the frequencies within the class-intervals, but rather with the number or the percentage of values greater than or less than a

specified value. These values, called ‘cumulative frequencies’ or ‘cumulative percentage frequencies’ are obtained by adding successively the individual frequencies of class-intervals.

**Table 1.4: Cumulative Frequency Distribution of the Test Scores of 40 Students:
Course MDE - 412**

Score Intervals	Exact Units of Class-intervals	Frequency (f)	Cumulative Frequency (F)	Cumulative Percentage Frequency
96-100	95.5-100.5	2	$38 + 2 = 40$	100.00
91-95	90.5-95.5	2	$36 + 2 = 38$	95.00
86-90	85.5-90.5	4	$32 + 4 = 36$	90.00
81-85	80.5-85.5	7	$25 + 7 = 32$	80.00
76-80	75.5-80.5	11	$14 + 11 = 25$	62.50
71-75	70.5-75.5	3	$11 + 3 = 14$	35.00
66-70	65.5-70.5	5	$6 + 5 = 11$	27.50
61-65	60.5-65.5	4	$2 + 4 = 6$	15.00
56-60	55.5-60.5	2	2	5.00
N = 40				

1.3.3 Graphical Presentation of Quantitative Data

Graphical presentation often facilitates understanding of a set of data. With the help of a well-drawn graph, the data can be read and interpreted very easily. Brief descriptions of the various types of graph which are useful in visualizing the important properties of a frequency distribution are given below.

The following three types of graph are commonly used for the above mentioned purposes:

- i) **Histogram or column diagram**
- ii) **Frequency polygon**
- iii) **Cumulative percentage curve or ogive.**

i) *Histogram or column diagram*

A **histogram** or **column diagram** is a graph in which class-intervals are represented along the horizontal axis and their corresponding frequencies are represented by areas in the form of rectangular vertical bars drawn on the intervals.

The following steps are followed in preparing a histogram:

- Step 1: A horizontal line is drawn at the bottom of a graph paper. Units representing class-intervals are marked along this line.
- Step 2: A vertical line is drawn at the left hand extreme of the horizontal axis. Along this vertical axis, units representing individual frequencies of the class-intervals are marked.
- Step 3: Taking class units as bases, rectangles are drawn, such that the areas of rectangles are proportional to the frequencies of the corresponding classes.

Let us consider the following data for drawing a histogram as an illustration of what you have read above.

Table 1.5: Frequency Distribution of the Scores of 40 Students: Course MDE-412

Class Intervals	Exact Units of Class Intervals	Mid Point	Frequency (f)	Cummulative Frequency (F)	Cummulative Percentage Frequency
35 - 39	34.5 - 39.5	37	4	40	100.00
30 - 34	29.5 - 34.5	32	8	36	90.00
25 - 29	24.5 - 29.5	27	11	28	70.00
20 - 24	19.5 - 24.5	22	8	17	42.50
15 - 19	14.5 - 19.5	17	6	9	2.50
10 - 14	9.5 -14.5	12	3	3	7.50
N = 40					

The histogram drawn for the above data is shown in figure 1.

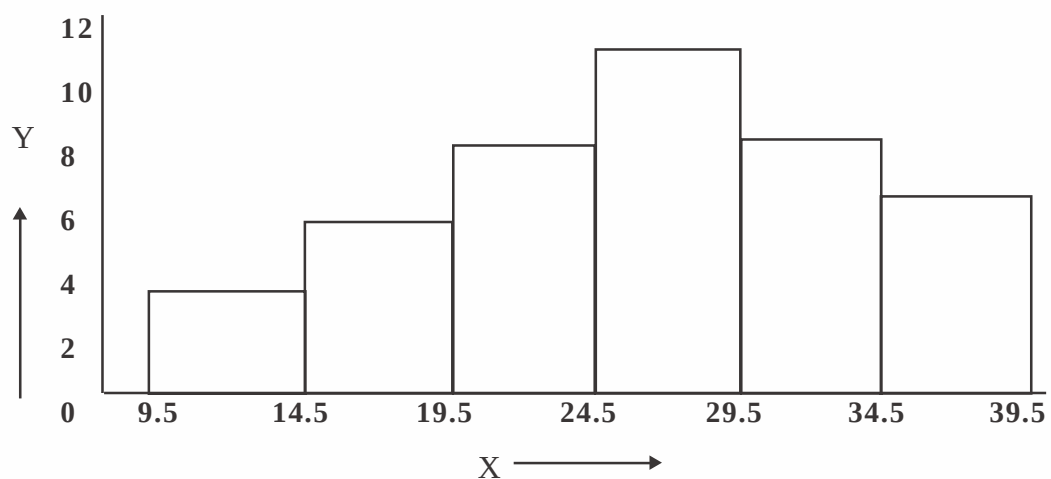


Fig. 1: Histogram plotted from the data of Table 1.5

ii) Frequency Polygon

Frequency polygon is drawn by plotting the mid-point of each class-interval at a height proportional to its respective frequency and then joining the points by straight lines. The first two steps are identical to those used in the construction of a histogram. The next step to be followed is given as under:

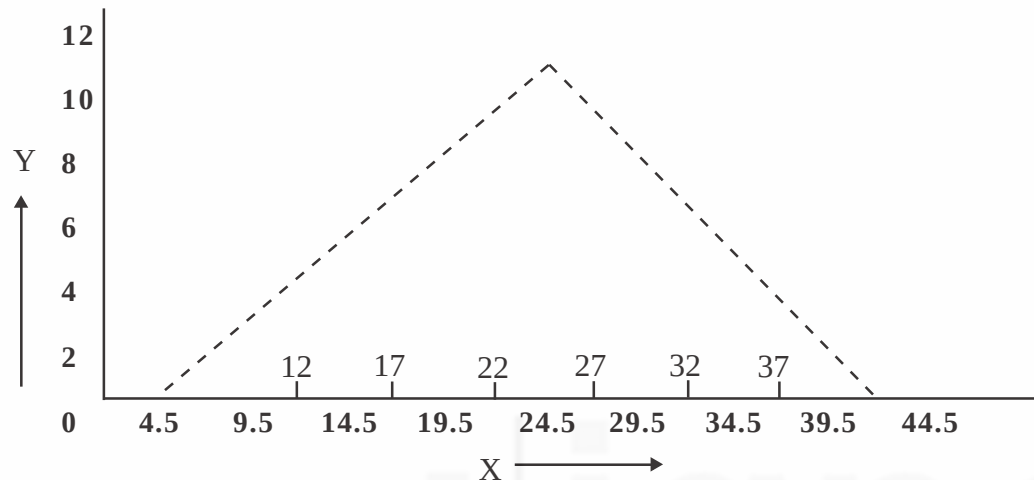


Fig. 2: Frequency Polygon plotted from the data of Table 1.5

Step 3: Directly above the mid-point of each class-interval along the horizontal axis plot the points at a height proportional to the respective frequencies. Join these points by straight lines. The frequency polygon for the distribution of table 1.5 is shown in the figure 2.

iii) Cumulative Percentage Curve or Ogive

When the frequencies are expressed as **cumulative percentages** of N on the vertical axis, the graphic representation is known as a cumulative percentage curve or ogive. After finding the cumulative percentage frequencies, the points are plotted on the exact upper limits of the class-intervals. A curve joining the points thus obtained is called the **cumulative percentage curve** or **ogive**.

The cumulative percentage curve or ogive of the distribution represented in table 1.5 is illustrated in figure 3.

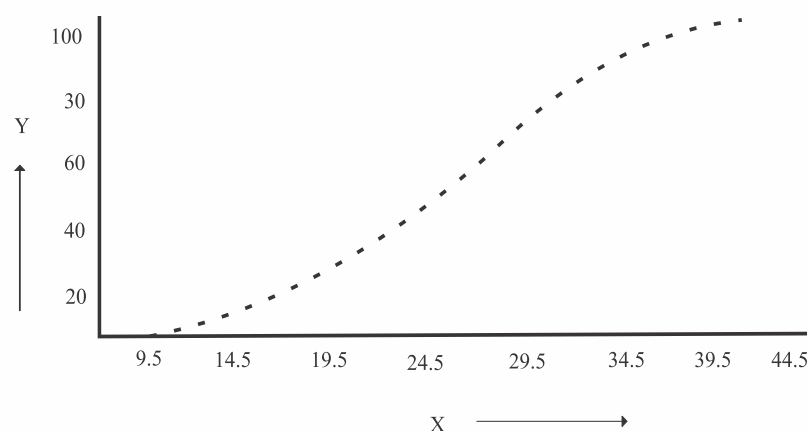


Fig. 3: Cumulative percentage curve or ogive plotted from the data of Table 1.5.

1.3.4 Analysis of Quantitative Data

Analysis of quantified data means studying the organised or tabulated data in order to discover the inherent facts. The data are studied from as many angles as possible to explore the new facts. Two types of statistical methods are used in the analysis of the tabulated data measured/expressed in quantified terms. The first category of methods pertain to '**descriptive analysis**' and the second, to '**inferential analysis**' of data.

In this Unit, you will be concerned with 'descriptive analysis'. Analysis of quantitative data can be also done by using computer software like SPSS, SAS, Stata and XL Stat. If you are interested to know more about these software you can check the websites. But it require thorough understanding of the program and computer.

Descriptive statistical analysis limits generalisation to the particular observed group of individuals. This analysis describes only one single group. The computed statistical values provide valuable information about the nature of that particular group only.

The following methods are generally used in descriptive statistical analysis of the tabulated data:

- i) **Measures of central tendency**
- ii) **Measures of variability**
- iii) **Measures of relative positions**
- iv) **Measures of relationships.**

We shall touch upon each one of them in some detail as follows:

A. Measures of Central Tendency

The three most commonly used measures of central tendency are the **Mean**, the **Median** and the **Mode**.

I) *The Mean (M)*

The arithmetic average of a distribution is known as its mean. The mean of a set of observations or measures is obtained by dividing the sum of all values by the total number of values.

a) Mean for an ungrouped data:

The formula for finding the mean for an ungrouped data is:

$$M = \frac{\sum X}{N} \dots\dots\dots(1)$$

in which

M = Mean

$\sum$ = Sum of

X = Observations in a distribution
 N = Total number of observations.

To illustrate the use of formula (1) let us consider the data:

16, 14, 12, 18, 21, 22, 13, 15, 16, 18

Using the formula (1):

$$M = \frac{16 + 14 + 12 + 18 + 21 + 22 + 13 + 15 + 16 + 18}{10}$$

$$= \frac{\sum X}{N} = 16.5.00$$

b) Mean for grouped data

When the number of observations or measures is large, the data is grouped in a frequency distribution.

The mean is computed by the formula:

$$M = AM + \frac{\sum fx'}{N} \times i \quad \dots\dots\dots(2)$$

Where

M = Mean
 AM = Assumed Mean
 x' = [Midpoint score(x) - AM]/(length of the class interval)
 $\sum fx'$ = Sum of the products of frequencies and deviation of observations from the assumed mean.
 i = Width of the class-interval
 N = Total number of observation

To illustrate the use of formula (2), consider the grouped data given in table 1.5.

Computations

- Step 1: Put the class-intervals in exact limits
- Step 2: Find the mid-point of each class interval and take the assumed mean at the interval which has the maximum frequency.
- Step 3: Find the difference between each mid-point score and the assumed mean and divide it by the length of the class-interval to get the deviation x.
- Step 4: Compute fx for each class-interval (fx is the product of the frequency and deviation of the observation from the assumed mean in a particular case.)

Step 5: Find the sum of all fx

Step 6: Apply formula (2) to compute the mean.

Table 1.6: The Calculation of the Mean from Data Grouped into a Frequency Distribution (Ref. Table)

Class Interval	Mid-point (x)	Frequency (f)	Deviation from the AM x	fx
34.5 - 39.5	37	4	2*	8
29.5 - 34.5	32	8	1	8
24.5 - 29.5	27 AM		11	0 0 (+16)
9.5 - 24.5	22	8	-1	-8
14.5 - 19.5	17	6	-2	-12
9.5 - 14.5	12	3	-3	-9 (-29)
		N = 40		

$$*2 = \frac{37 - 27}{5}$$

Using the formula (2):

$$\begin{aligned}
 M &= AM + \frac{\sum fx'}{N} \times i \\
 &= 27.0 + \frac{-13}{40} \times 5 \\
 &= 27.0 - 1.625
 \end{aligned}$$

II) The Median = 25.375

The median is a point in an array, above and below which one half of the observations fall. It is a measure of position rather than magnitude.

a) Median for Ungrouped data

If the observations are ungrouped and their number is small, the observations are arranged in the order of magnitude. The middle score is determined by counting up half the value of N if the number of observation (N) is even. When the number of observations (N) is odd, the mid-observation value is median. For example, 10 is the median of scores : 7, 8, 9, 10, 11, 12, 13. When the number of scores (N) is even, the

median is the mid-point between the two middle scores. For example:

$$\frac{(10+11)}{2} = 10.5 \text{ is the median of scores:}$$

7, 8, 9, 10, 11, 12, 13, 14.

b) Median for grouped data

In the case of grouped data, cumulative frequency distribution is prepared and the median is calculated by the formula:

$$Mdn = l + \frac{N/2 - F}{f} \times i \quad \dots\dots\dots(3)$$

Mdn = Median

l = Exact lower limit of the class-interval upon which the median lies.

$N/2$ = One half of the total number of observations

F = Sum of all frequencies below l .

f = Frequency within the class-interval upon which the median lies.

i = Width of the class interval in which the median lies.

To illustrate the use of formula (3) consider the data of table 1.5 once again.

Table 1.7: The Calculation of the Median from Data Grouped into a Frequency Distribution

	Class-Interval	Frequency (F)	Cumulative Frequency (F)
	34.5 – 39.5	4	40
	29.5 – 34.5	8	36
Median Class	24.5 – 29.5	11	28
	19.5 – 24.5	8	17
	14.5 – 19.5	6	9
	9.5 – 14.5	3	3
		N = 40	

Here $N/2 = 20$, $l = 24.5$, $F = 17$, $f = 11$ and $i = 5$

Using formula (3)

$$\begin{aligned}
 \text{Mdn} &= l + \frac{N/2 - F}{f} \times i \\
 &= 24.5 + \frac{(20 - 17)}{11} \times 5 \\
 &= 24.5 + \frac{15}{11} \\
 &= 25.86
 \end{aligned}$$

III) The Mode

The mode is defined as the most frequently occurring measure of an observation in a distribution. If only one value occurs a maximum number of times the distribution is said to have one mode; i.e. the distribution is unimodal. In some distributions there may be more than one mode. A two mode distribution is bimodal and it is multimodal in a distribution, which has more than two modes.

a) Mode for Ungrouped Data

In a simple ungrouped series of measures, the crude or empirical mode is that single measure which occurs most frequently. For example, in the series 7, 8, 9, 10, 11, and 12 the most often recurring measure, namely, 9 is the crude or empirical mode.

b) Mode for grouped data

When data are grouped into a frequency distribution, the crude or empirical mode is usually taken to be the mid-point of that interval which contains the largest frequency. In the example given in table 1.5, the interval 24-29 contains the largest frequency and hence 26.5, its mid-point, is the crude mode.

The true mode, that is, the point of greatest concentration in the distribution, or the point at which more measures fall than at any other point, is calculated by the formula:

$$\text{Mode} = l + \frac{fm - f_1}{2fm - f_1 - f_2} \times i \quad \dots\dots\dots(4)$$

Where

- l = Lower limit of the modal class i.e., the class interval having maximum frequency
- fm = Frequency of the modal class.
- f_1 = Frequency of the class-interval preceding the modal class.
- f_2 = Frequency of the class-interval following the modal class.
- i = Width of the modal class.

To illustrate, let us make use of formula (4) for the data in table 1.5. Here the maximum frequency is 11 which lies in class interval 24.5 - 29.5.

Therefore, the modal class is (24.5 - 29.5).

Here $fm = 11$, $f_1 = 8$, $f_2 = 8$, $i = 5$ and $l = 24.5$.

Using Formula (4) :

$$\begin{aligned}\text{Mode} &= l + \frac{fm - f_1}{2fm - f_1 - f_2} \times i \\ &= 24.5 + \frac{11 - 8}{2 \times 11 - 8 - 8} \times 5 \\ &= 24.5 + \frac{3}{6} \times 5 \\ &= 24.5 + 2.5 \\ &= 27.00\end{aligned}$$

B. Measures of Variability

The measures of central tendency are very useful in describing the nature of a distribution of measures, but they do not give the researcher a complete picture of the data. These measures will not tell the researcher how the scores tend to be distributed. For this, you use a different set of measures which are called measures of **'variability'** or measures of **'spread'** or **'dispersion'**. The most commonly used measures of variability include the **range**, the **variance** and **standard deviation**.

I. The Range

The range is defined as the difference between the two extreme measures or values in a distribution. Suppose the scores of 10 learners in the course MDE -412 are :

50, 40, 39, 35, 29, 28, 24, 27, 19, 18.

The range for this distribution will be $(50-18) = 32$. Although the range has the advantage of being easily calculated, it has the following serious limitations:

- 1) As the value of range is based on only two extreme values in the total distribution, it does not give any idea of the variation of many other values of the distribution.

- 2) It is not a stable statistic as its value can differ from sample to sample drawn from the same population.

II. The Variance and Standard Deviation

The average of the squared deviations of the measures or values from their mean is known as the variance. The standard deviation is the positive square root of variance.

a) The Variance and Standard Deviation for the Ungrouped Data

The variance for the ungrouped data is found by using the formula:

$$\sigma^2 = \frac{\sum x^2}{N} \dots\dots\dots(5)$$

= Variance of the sample

x = Deviation of the raw measures or values from the mean.

N = Number of values or measures

Let us consider the following data of scores for the application of formula (5):

10, 10, 9, 9, 8, 8, 7, 7, 6, 6.

As the deviation of each score from the mean is required, the first thing to do is to calculate the mean. Using formula (1)

$$M = \frac{\sum x}{N} = \frac{80}{10} = 8$$

Now, from each raw score, the mean is subtracted to get the value of x.

Table 1.8: Distribution of the Test Scores of Ten Learners of Course MDE - 412

Score (X)	Deviation (X-M) (x)	Deviation Squared (x ²)
10	2	4
10	2	4
9	1	1
9	1	1
8	0	0
8	0	0
7	-1	1
7	-1	1
6	-2	4
6	-2	4
		----x ² = 20

Using formula (5)

$$\begin{aligned}\sigma^2 &= \frac{\sum x^2}{N} \\ &= \frac{20}{10} = 2\end{aligned}$$

Now to get the standard deviation, you need the positive square root of the variance, σ^2 .

$$\begin{aligned}\text{Standard Deviation} = \sigma &= \sqrt{\frac{\sum x^2}{N}} \\ &= \sqrt{2} \\ &= 1.41\end{aligned}$$

The raw scores instead of deviation scores may also be used. The raw score formulae for variance and standard deviation are given as follows

$$\text{Variance} = \sigma^2 = \frac{N \sum X^2 - (\sum X)^2}{N^2} \dots\dots\dots(6)$$

$$\text{Standard Deviation} = \sigma = \frac{\sqrt{N \sum X^2 - (\sum X)^2}}{N^2} \dots\dots\dots(7)$$

In which

X = Raw score

N = The number of scores in the distribution.

Using the same set of data, you can calculate variance and standard deviation with the help of raw-score formulae:

Table 1.9: The calculation of variance and standard deviation from original (row) scores when the assumed mean is taken at zero and the data is ungrouped

Score (X)	X ²
10	100
10	100
9	81
9	81
8	64
8	64
7	49
7	49
6	36
6	36
....X = 80	X ² = 660

Using formula (6)

$$\begin{aligned}
 \text{Variance} &= \frac{N \sum X^2 - (\sum X)^2}{N^2} \\
 &= \frac{10 \times 660 - (80)^2}{100} \\
 &= \frac{6600 - 6400}{100} \\
 &= 2
 \end{aligned}$$

Using formula (7)

$$\begin{aligned}
 \text{Standard Deviation} = \sigma &= \frac{\sqrt{N \sum X^2 - (\sum X)^2}}{N} \\
 &= \sigma = \frac{\sqrt{10 \times 660 - (80)^2}}{10} \\
 &= \frac{\sqrt{6600 - 6400}}{10} \\
 &= \frac{14.14}{10} \\
 &= 1.414
 \end{aligned}$$

b) Variance and Standard Deviation for Grouped Data

In the case of grouped data in a frequency distribution, the variance and standard deviation are calculated by using the formulae:

$$\text{Variance} = \sigma^2 = \frac{i^2}{N^2} \left[N \sum f x'^2 - \left(\sum f x' \right)^2 \right] \quad \dots\dots\dots(8)$$

$$\text{Standard Deviation} = \frac{i}{N^2} \left[\sqrt{N \sum f x'^2 - \left(\sum f x' \right)^2} \right] \quad \dots\dots\dots(9)$$

Where

- i = Width of the class-interval
- N = Total number of measures
- f = Frequency of class-interval
- x' = Deviation of the raw measure from the assumed mean divided by the length of class-interval.

To illustrate the use of these formulae let us consider the distribution given in table 1.10.

Table 1.10: The Calculation of Variance and Standard Deviation from Data Grouped in a Frequency Distribution

Class Interval	x	f	x'	fx'	fx'^2
71-75	73	3	3	9	27
66-70	68	4	2	8	16
61-65	63	9	1	9	9
56-60	58	15	0	0	0
51-55	53	8	-1	-8	8
46-50	48	6	-2	-12	24
41-45	43	5	-3	-15	45
		$N = 50$	$\dots\dots fx' = -9$	$\dots\dots fx'^2 = 129$	

Using formula (8)

$$\begin{aligned}
 \text{Variance} &= \sigma^2 = \frac{i^2}{N^2} \left[N \sum f x'^2 - \left(\sum f x' \right)^2 \right] \\
 &= \frac{(5)^2}{(50)^2} \left[50 \times 129 - (-9)^2 \right] \\
 &= 63.69
 \end{aligned}$$

Using formula (9)

$$\begin{aligned}\text{Standard Deviation} &= \frac{i^2}{N^2} \left[\sqrt{N \sum f_x'^2 - \left(\sum f_x' \right)^2} \right] \\ &= \frac{5}{50} \sqrt{50 \times 129 - (-9)^2} \\ &= \frac{1}{10} \sqrt{6369} \\ &= \frac{1}{10} \times 79.81 \\ &= 7.98\end{aligned}$$

The standard deviation is a very useful device for comparing characteristics that may be different or expressed in different units of measurement. It is also used in describing the status or position of an individual in a group. But before this concept is developed further, it is essential to understand the nature of the 'normal probability distribution'.

Check Your Progress 3

Compute (i) Mean (ii) Variance and (iii) Standard Deviation for the following frequency distribution:

Class Interval	F
195-199	1
190-194	2
185-189	4
180-184	5
175-179	8
170-174	10
165-169	6
160-164	4
155-159	4
150-154	2
145-149	3
140-144	1

Notes: (a) Space is given below to write your answer.

(b) Compare your answer with the one given at the end of this unit.

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Normal Probability Distribution

The **normal probability distribution** is based upon the law of probability. It is not an actual distribution of measures or scores; instead, it is a mathematical model. It is represented by a curve which is called the Normal Probability Curve. Figure 4 represents an ideal normal probability curve.

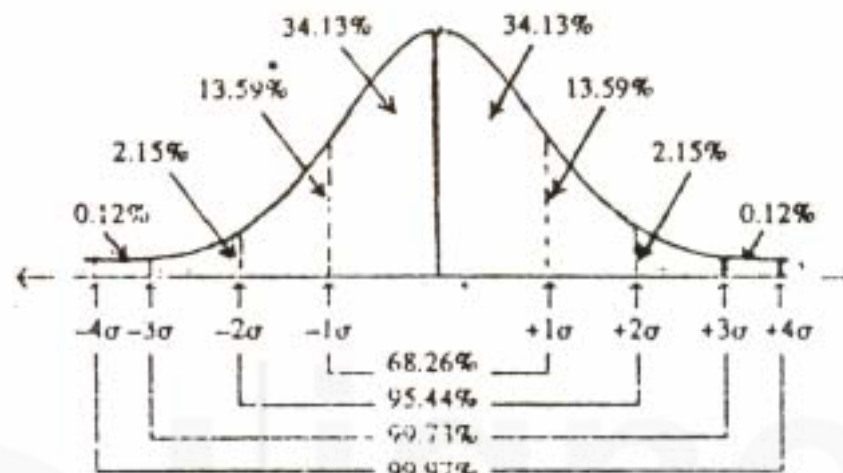


Fig. 4: Ideal Normal Probability Curve

The normal probability curve has the following characteristics:

1. The curve is symmetrical around its vertical axis called ordinate. It implies that the size, shape and slope of the curve on one side of the ordinate is identical to that on its other side.
2. The values of mean, mode and median computed for a distribution following this curve, are always the same.
3. The height of the vertical line called ordinate is maximum at mean and in the unit normal curve it is equal to 0.3989.
4. The curve is asymptotic. It approaches but does not meet horizontal axis and extends from $-\infty$ (minus infinity) to $+\infty$ (plus infinity).
5. The points of inflection of the curve occur at points ± 1 , standard deviation ($\pm 1\sigma$), above and below the mean. Thus the curve changes from convex to concave in relation to the horizontal axis at these points.
6. About 68.26 percent of the total area falls between the limits $M + 1\sigma$ and $M - 1\sigma$; 95.44 percent of the total area of the curve falls between the limits $M + 2\sigma$ and $M - 2\sigma$ and 99.73 percent of the total area of the curve falls between $M + 3\sigma$ and $M - 3\sigma$.

However, these calculations are rarely necessary, as Normal Table is available from which the information about the area is readily available. For this reason it is very essential that the use of Normal Table (Table I Appendix, Unit 2) be clearly understood. Table I gives the fractional parts of the total area under the normal curve found between

mean and ordinate (Y's) erected at various distances from the mean. The total area under the curve is taken arbitrarily to be 10,000, because of the greater convenience with which fractional parts of the total area may then be calculated. You know that $x = (X-M)$ measures the deviation of a raw score (X) from the mean (M). If x is divided by σ , then this deviation is expressed in σ units. These σ deviation scores are called sigma scores

or z-scores $\left(i.e. z = \frac{X - M}{\sigma} = \frac{x}{\sigma} \right)$. The first column of the table under $\frac{x}{\sigma}$ gives

distance from the mean in the tenth of σ and distance from the mean in the hundredth of σ are given by the headings of the other columns.

To find the number of cases in the normal distribution between the mean and the ordinate

erected at a distance of 1σ from the mean, you go down the $\frac{x}{\sigma}$ column until 1.0 is

reached, and in the next column under .00 you take the entry opposite to 1.0, namely 34.13. This figure means that 3413 cases in 10,000, or 34.13 percent of the entire area of the curve lies between the mean and 1σ . Similarly, if you have to find out the

percentage of the distribution between mean and 1.65σ , you go down the $\frac{x}{\sigma}$ column till 1.6, then across horizontally to the column headed .05, and take the entry 45.5.

This shows that in a normal distribution, 45.05 percent of the total area lies between the mean and 1.65σ .

Check Your Progress 4

Describe the characteristics of a Normal Probability Distribution

Notes: (a) Space is given below for writing your answer.

(b) Compare your answer with the one given at the end of this unit.

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C. Measures of Relative Positions

A raw score on a test, taken by itself, has no meaning. It gets meaning only by comparison with some reference group or groups. for eg. If a student score 50 in Maths and 30 in Science, it does not mean that the student did better in Maths. 50 may be the lowest score in Maths test and 30 may be the highest score in Science test. The comparison may be done with the help of the following measures:

1. **Sigma Scores**
2. **Standard Scores**
3. **Percentiles**
4. **Percentile Ranks.**

What does each one of these mean?

1. *Sigma Scores*

A **sigma score** makes a realistic comparison of scores possible and provides a basis for equal weighting of the scores as the scores on different tests are expressed on a scale with a mean of zero and standard deviation of 1.

Let us suppose that the mean of a test is 75 and the standard deviation is 5.0. Then if A earns a score of 85 on this test, his/her deviation from the mean is $85 - 75 = 10$. Dividing this deviation of 10 by the standard deviation (σ), i.e., 5.0, we give him a score of

$\frac{10}{5} = 2$. If B's score on this test is 64, his/her deviation from the mean is $64 - 75 = -11$ and the score in σ units is -2.20. Deviations from the mean expressed in σ terms are called sigma scores.

Half of the scores in a distribution lie below and half above the mean, about half of σ scores are positive and half are negative.

2. *Standard Scores*

The sigma scores, which are often small decimal fractions and half of them are negative, are somewhat inconvenient to deal with. Hence, scores are usually converted into a new distribution with mean and standard deviation so selected that it makes all scores positive and relatively easy to handle in computation. Such scores are called '**standard scores**'.

The formula for the conversion of a raw score to a standard score is as follows:

$$X' = \frac{\sigma'}{\sigma}(X - M) + M' \quad \dots\dots\dots(10)$$

in which

$$\begin{aligned} X' &= \text{A standard score in a new distribution} \\ \sigma' \text{ and } \sigma &= \text{SD's of standard and raw scores.} \\ X &= \text{A score in the original distribution.} \end{aligned}$$

M and M' = Means of raw and standard scores.

When the mean (M') and standard deviation (σ') are taken to be 50 and 10 respectively, the standard score is called a T-score.

$$\text{i.e. } T = \frac{10}{\sigma}(X - M) + 50 \quad \dots\dots\dots(11)$$

Example: To illustrate, let us consider a distribution with its mean 67 and $\sigma = 12.5$. Let us also suppose that A's score is 76 and B's score is 54.

Express these scores as (i) standard scores in a distribution with a mean of 250 and σ' of 50 and (ii) T-scores.

Using formula (10)

$$X' = \frac{50}{12.5}(X - 67) + 250$$

Substituting A's score of 76 in the above equation you have:

$$X' = \frac{50}{12.5}(76 - 67) + 250$$

$$= \frac{50 \times 9}{12.5} + 250$$

$$= 286$$

Substituting B's scores of 54 in the above equation

$$X' = \frac{50}{12.5}(54 - 67) + 250$$

$$= 198$$

Using formula (11)

$$T = \frac{10}{12.5}(X - 67) + 50$$

Substituting A's score in the above equation you have:

$$T = \frac{10}{12.5}(76 - 67) + 50$$

$$T = 0.8 \times 9 + 50$$

$$= 57.2$$

Substituting B's score in the above equation you have:

$$T = \frac{10}{12.5}(54 - 67) + 50$$

$$= 39.6$$

3. Percentiles

Percentiles are the points which divide the entire scale of measurement into 100 equal parts. They are denoted by $P_0, P_1, P_2, P_3, P_4, P_5, \dots, P_{99},$ and P_{100} .



The first percentile may be defined as that point in a frequency distribution below which lie 1 percent of the total measures or scores. Similarly, twentieth percentile may be defined as that point in a frequency distribution below which 20 percent of the total measures or scores fall. It is evident that the median, expressed as a percentile, is P_{50} . It should be noted that P_0 lies at the beginning of the distribution and P_{100} at the end of the distribution.

The formula for calculating percentiles is

$$P_p = l + \frac{(PN - F)}{f_p} \times i \quad \dots\dots\dots(12)$$

in which

- P_p = percentile of the distribution wanted
 l = exact lower limit of class-interval upon which P_p lies.
 PN = part of the N to be counted off in order to reach P_p .
 F = sum of all scores upon intervals below l .
 fp = number of scores within the interval upon which P_p falls
 i = length of the class-interval.

The use of formula (12) may be illustrated by the following example.

Calculate P_{25} , P_{45} and P_{95} from the following distribution:

Table 1.11: The Calculation of Percentiles from Data Grouped in a Frequency Distribution

Scores Class-intervals	Frequency (f)	Cumulative Frequency (F)
81.5 - 86.5	1	8
76.5 - 81.5	4	79
71.5 - 76.5	5	75
66.5 - 71.5	10	70
61.5 - 66.5	35	60
56.5 - 61.5	12	25
51.5 - 56.5	9	13
46.5 - 51.5	2	4
41.5 - 46.5	2	2
N=80		

For computing P_{25} you have to first find PN

Here, 25 percent of 80 is 20, $PN = 20$

Now $l = 56.5$, $F = 13$, $fp = 12$ and $i = 5$

Using formula (12)

$$P_{25} = 56.5 + \frac{20-13}{12} \times 5$$

$$= 56.5 + 2.92 = 59.42$$

Similarly

$$P_{45} = 61.5 + \frac{36 - 25}{35} \times 5$$

$$= 61.5 + 1.57 = 63.07$$

$$P_{95} = 76.5 + \frac{76 - 75}{4} \times 5$$

$$= 76.5 + 1.25 = 77.25$$

4. Percentile Ranks

The **percentile rank** is the point in the distribution below which a given percentage of scores falls. If the 80th percentile rank is a score of 65, then 80 percent of the scores falls below 65. The median is the 50th percentile rank, for, 50 percent of the scores fall below it.

The process of calculating percentile ranks is the reverse process of calculating percentile points. You have to calculate ranks corresponding to particular scores. If R is the rank and N is the total number of cases, then:

$$\text{Percentile Rank} = 100 - \frac{100R - 50}{N} \dots\dots\dots (13)$$

Suppose A ranks 13th in the class of 80 learners, 12 learners rank above it, 67 below it. Its percentile rank is :

$$= 100 - \frac{100 \times 13 - 50}{80}$$

$$= 100 - 15.625$$

$$= 84$$

D. Measures of Relationship

The data in which we secure measures of two variables for each individual is called **bivariate data**. The essential feature of bivariate data is that one measure can be

compared with another measure for each member of the group. When bivariate data are studied, you may like to know the degree of relationship between the variables of such data. This degree of relationship is known as correlation. It can be quantitatively represented by the **coefficient of correlation**. Its value ranges from -1.00 to +1.00. A value of -1.00 describes a perfect negative correlation and +1.00 describes perfect positive correlation. A zero value describes complete lack of correlation between the two variables. The sign of the co-efficient indicates the direction of relationship and numerical value is its strength/magnitude.

Methods of correlating variables

There are various methods of correlating variables. Their use is relative to the situation and type of data. **Product Moment Correlation** and **Rank Order Correlation** are mostly used for computing correlation between two variables.

1. Product-moment correlation

In some situations, the data for two variables X and Y are expressed in interval or ratio level of measurement and the distributions of these variables have a linear relationship. Moreover, the distributions of variables are uni-modal and their variances are approximately equal. In such situations, product moment method of correlation is used generally. It is also called **Pearson's r**.

i) Calculation of Pearson's r from ungrouped data:

When the size of the sample is small, there is no need of grouping the data and Pearson's r may be calculated with the help of the following formula:

$$r_{xy} = \frac{N \sum xy - (\sum x)(\sum y)}{\sqrt{[N \sum x^2 - (\sum x)^2][N \sum y^2 - (\sum y)^2]}} \dots\dots\dots(14)$$

in which

x = deviations of X measures from the assumed mean.

y = deviations of Y measures from the assumed mean.

To illustrate the use of formula (14), let us compute the product moment 'r' from the following data for the two variables X and Y for 10 learners who are enrolled in a Study Centre of an Open University.

X : 45 54 52 58 62 46 55 49 50 54

Y : 42 50 55 46 59 41 46 48 45 48

Using formula (14) for the data in Table 1.12

Table 1.12: The Calculation of Product Moment Correlation from Ungrouped Data when Deviations are taken from Assumed Mean

X	Y	x	y	x ²	y ²	xy
45	42	-7	-6	49	36	42
54	50	2	2	4	4	4
52(AM)	55	0	7	0	49	0
59	46	6	-2	36	4	-12
62	59	10	11	100	121	110
46	41	-6	-7	36	49	42
55	46	3	-2	9	4	-6
49	48(AM)	-3	0	9	0	0
50	45	-2	-3	4	9	6
54	48	2	0	4	0	0
		$\sum x = 5$	$\sum y = 0$	$\sum x^2 = 251$	$\sum y^2 = 276$	$\sum xy = 186$

Using formula (14)

$$\begin{aligned}
 r_{xy} &= \frac{N\sum xy - (\sum x)(\sum y)}{\sqrt{[N\sum x^2 - (\sum x)^2][N\sum y^2 - (\sum y)^2]}} \\
 &= \frac{10 \times 186 - 5 \times 0}{\sqrt{[10 \times 251 - (5)^2][10 \times 276 - (0)^2]}} \\
 &= \frac{1860}{2618.89} \\
 &= 0.71
 \end{aligned}$$

ii) Calculation of Pearson's r from grouped data:

When N is large or even moderate in size, and when no calculating machine is available, the best procedure is to group data in both variables X and Y and to form a scattergram.

The values from the scattergram may be used in the following formula:

$$r_{xy} = \frac{N\sum f_{xy} - (\sum f_x)(\sum f_y)}{\sqrt{[N\sum f_x^2 - (\sum f_x)^2][N\sum f_y^2 - (\sum f_y)^2]}} \dots\dots\dots(15)$$

To illustrate the use of the formula (15) consider the data of 50 learners enrolled with IGNOU in Course X and in Course Y in the following scattergram:

		COURSE X											
COURSE (Y)	X \ Y	20-21	22-23	24-25	26-27	28-29	30-31	32-33	f _(y)	y	fy	fy ²	fxy
	51-53			₂ 1 ⁻²	₀ 2 ⁰				3	2	6	12	-2
	48-50	₄ 2 ⁻³	₄ 2 ⁻²	₃ 3 ⁻¹	₀ 3 ⁰				10	1	10	10	-13
	45-47	₀ 1 ⁰	₀ 3 ⁰	₀ 4 ⁰	₀ 8 ⁰	₀ 3 ⁰	₀ 2 ⁰	₀ 1 ⁰	22	0	0	0	0
	42-44	₂ 2 ³	₄ 2 ²	₃ 3 ¹	₀ 5 ⁰				12	-1	-12	12	13
	39-41		₄ 1 ⁴	₂ 1 ²	₀ 1 ⁰				3	-2	-6	12	6
	f _(x)	5	8	12	19				50				
x		-3	-2	-1	0	1	2	3					
fx		-15	-16	-12	0	3	4	3	-33				
fx ²		45	32	12	0	3	8	9	109				
fxy		0	4	0	0	0	0	0	04				

Fig. 5: A Scattergram Showing Paired Scores of 50 Learners on the Tests of Course X and Course Y.

The computation for the values $\sum f_{xy}$, $\sum f_x^2$, $\sum f_{xy}$ etc., may be done in the following steps in the order given below.

Step 1

The distribution of Course X scores for the 50 learners is found in the f(y) column on the right of the scattergram. Assume a mean for the distribution of scores of course X (the mid-point of that interval which contains the largest frequency), and draw double lines to mark off the row in which the assumed mean falls. In the present example, the mean

score for course X has been taken at 46 (mid point of interval 45-47) and y's (deviations from the assumed mean) have been taken from this point.

Fill in fy and then fy^2 columns.

Step 2

The distribution of the Course Y of 50 learners is found in the $f(x)$ row at the bottom of the scattergram. Assume a mean for this distribution and draw double lines to designate the column under the assumed mean. The mean for the Course Y scores is taken at 26.5 (mid-point of interval 26-27), and the x's (deviations from assumed mean) are taken from this point. Fill in the fx and then fx^2 rows.

Step 3

The fx for a cell is computed by multiplying the frequency given in the particular cell with the corresponding x and y. For example, there is a frequency 1 corresponding with Course Y score 24-25 and Course X score 51-53. The corresponding x for this cell frequency is -1 and corresponding y is +2. Thus fx for this cell is $(1)(-1)(+2) = -2$. Similarly the value for fx is computed for all the cells and their sum is calculated row-wise as well as column-wise. The two sums should equal each other. In the present example, it has come to be 4.

Step 4

Substituting the values for $\sum fx$, $\sum fx^2$, $\sum fy$, $\sum fy^2$, and $\sum xy$ in the formula (15) we get :

$$r_{xy} = \frac{50 \times 4 - (-33)(-2)}{\sqrt{[50 \times 109 - (-33)^2][50 \times 46 - (-2)^2]}}$$

$$= 0.042$$

2. Rank Order Correlation

It is also known as the **Spearman rank order co-efficient of correlation** and is denoted by **r (rho)**. When the data are available in ordinal (rank) form of measurement rather than in interval or ratio form, this type of correlation is useful.

To find out Spearman rank order coefficient of correlation, the following formula is used:

$$p = 1 - \frac{6 \sum D^2}{N(N^2 - 1)} \dots\dots\dots(16)$$

in which

D = Difference between the paired ranks.

$\sum D^2$ = Sum of the squared differences between ranks

N = Number of paired ranks.

To make use of formula (16) let us consider the following data. Two judges X and Y ranked 10 distance learners in a declamation contest. The ranks given to them by the judges are given in table 1.13.

Table 1.13: The Calculation of Rank Difference Correlation

Students	Rank assigned by X	Rank assigned by Y	D	D ²
A	2	3	-1	1
B	4	5	-1	1
C	5	4	1	1
D	10	9	1	1
E	8	7	1	1
F	1	2	-1	1
G	3	1	2	4
H	9	8	1	1
I	6	10	-4	16
J	7	6	1	1
				$\sum D^2 = 28$

Using formula (16)

$$p = 1 - \frac{6 \sum D^2}{N(N^2 - 1)}$$

$$= 1 - \frac{6 \times 28}{10(100 - 1)}$$

$$= 0.83$$

Check Your Progress 5

Compute product moment correlation for the following data:

X : 45, 55, 56, 58, 60, 65, 68, 70, 75, 80, 85

Y : 56, 50, 48, 60, 62, 64, 65, 70, 74, 82, 90

Notes: (a) Space is given below for writing your answer.

(b) Compare your answer with the one given at the end of the Unit.

[illegible]

1.4 QUALITATIVE DATA

It has already been explained that quantitative measurement makes use of tools that provide a standardised framework in order to limit data collection to certain predetermined responses or categories. The variables that describe a phenomenon are fit in the standardised categories to which numerical values are attached . But in some situations it is difficult to analyse a phenomenon into various components or variables which can be measured in quantified terms. In such cases the researcher takes into consideration the phenomenon as a whole and assumes that there is some quality in the phenomenon in its entirety. When the researcher attempts to retain the totality of a phenomenon while verifying propositions regarding it, he/she adopts a qualitative approach. While using this approach the researcher seeks to capture what people have to say in their own words. **Qualitative approach** describes the experiences of people in depth and permits the researcher to record and understand people in their own perceptions.

Qualitative data consist of ‘detailed descriptions’ of situations, events, people, interactions, and observed behaviours. These data are also available in the form of ‘direct quotations’ from people about their experiences, attitudes, beliefs, and thoughts. The verbal data gathered through questionnaires, observations and interviews are mostly qualitative in nature. The ‘excerpts’ or ‘entire passages’ from documents, correspondence records and case histories are also examples of data of a qualitative nature. It may be noted that detailed descriptions, direct quotations, and case documentation of a qualitative nature are raw data from empirical situations.

1.4.1 Organisation of Qualitative Data

The responses to open-ended questions on a questionnaire are pretty extensive; they are neither systematic nor standardised. However, they permit the researcher to understand situations as seen and felt by the respondent. The data gathered through participant observation or an open ended/unstructured interview are also descriptive in nature. These descriptions may be in the form of field notes specifying some basic information pertaining to the place where the observation has taken place as well as descriptions about the people who participated in the activities and their extrinsic behaviour in the course of the activities. However, it is not possible to interpret minds while observing their extrinsic behaviour. Through an open-ended/unstructured interview, you can know more about those events which had occurred earlier or could not be observed during participant observation. It provides a framework within which the researcher should be able to gather information from people conveniently and accurately. The information may pertain to a programme, the reaction of participants about the programme and the type of change the participants perceive in themselves after their involvement in the programme. The data are mostly in the form of responses to structured and unstructured questions put to respondents by the researcher during conversation. The responses are generally direct quotations from respondents in their own words and provide details about the situations, events, people, experiences, behaviours, values, customs, etc.

The qualitative data gathered using open-ended questionnaires, participant observations and in-depth interviews are voluminous. They need to be organised and classified into specific patterns, categories and descriptive units to avoid any chaos. However, before any such classification is done, it is advisable to make some copies of the data. One copy may be stored in a safety deposit box so that in case of a loss, this copy can be used by the researcher. The second copy may be used for further treatment of the data throughout. The third copy may be used to fill the missing gaps, identified during scrutiny by the researcher. Additional notes can also be recorded in this copy. Since the organisation of qualitative data involves a lot of cutting and pasting, a fourth copy may be used for that purpose.

Actual classification or organisation of the data can begin only after the copies are made. There are no formal or universal rules for organising the data in various units, patterns, or categories. It requires a creative approach and a lot of perseverance to give a meaningful look to the data. The contents of field notes about interviews or observations may be read carefully by the researcher and he/she may note down his/her comments on the margins

or attach small pieces of paper with his/her written comments/notes using staples or tags. The arrangement of data in topics, using abbreviations, is the next step. The abbreviated topics are written down either on the margins of the relevant data or on slips of paper which may be attached to the relevant pages. The process of classifying or labelling various kinds of data help in the preparation of a data index. Sometimes there are large data. In such situations, computers are helpful in developing systematic and comprehensive classification schemes using code numbers for different categories and sub-categories. The computerized classification system permits the use of organised data by several groups of people over a long period of time. It permits easy cross-classification and cross- comparison of descriptive narrations for complex analysis.

1.4.2 Analysis of Qualitative Data

Analysis of qualitative data means studying the organised material available in the form of detailed descriptions, direct quotations or case-documentation in order to discover inherent facts. These data are studied from as many angles as possible either to explore the new facts or to reinterpret already known or existing facts.

The following methods are generally used in the analysis of qualitative data:

- i. **Content Analysis**
- ii. **Inductive Analysis**
- iii. **Logical Analysis**

A. Content Analysis

Content analysis is concerned with the classification, organisation and comparison of the content of the document or communication. The terms, content analysis and coding are sometimes used interchangeably as both the processes involve objective, systematic, and qualitative description of any symbolic behaviour. Since content analysis involves the classification, evaluation and comparison of the content of communication or document, it is sometimes referred to as 'documentary activity' or 'information analysis'. The communication may be in the form of responses to an open-ended questionnaire, conversation as a result of an interview, or description of an observed activity. It may also be in the form of official records (census, birth, accident, crime, school, institutional and personal records), judicial decisions, laws, budget and financial records, cumulative records, courses of study, content of text books, reference works, news papers, periodicals or journals, prospectus of various educational institutions or universities, direct quotations, and notes of an interview.

There are three approaches that a researcher may adopt in content analysis. These include: (i) characteristics of content, (ii) procedures or causes of content, and (iii) audience or effects of content. In the first approach, the researcher is interested primarily in the characteristics of the content itself. He/she may focus either on the 'substantive nature' of the content or upon the 'form' of the content. In the second approach, the

researcher attempts to draw valid inferences about the nature of the procedures of the content or the causes of the symbolic material from the characteristics of the material itself. In the third approach to content analysis, the researcher interprets the content so as to reveal something about the nature of its 'audience' or its 'effects'. He/she takes the content material as a basis for drawing inference about the characteristics of the 'audience' for whom the material (content) is designed or about the effects of communication, which it brings about.

The steps involved in the process of content analysis includes (i) defining the unit of analysis, (ii) specifying variables and categories, (iii) frequency, direction and intensity of units, (iv) contingency analysis, (v) sampling of units, and (vi) constructing the content analysis outline. Defining the unit of analysis indicates whether the unit (material) is confined to single words, phrases, complete sentences, paragraphs, or to even larger amounts of materials. Once the unit is defined, the researcher conducts its analysis so as to create reproducible or objective data for scientific treatment and generalisation beyond the specific set of symbolic material analysed. For converting symbolic material into objective data, it is necessary to specify the "variables" explicitly in terms of which descriptions are to be made. Once the unit is defined and the variables along with their categories specified, the researcher will classify units in the material to be analysed according to : (i) the number of units (frequency), (ii) favourableness/ unfavourableness of the content (direction), and (iii) the emotional impact of the units (intensity). The contingency analysis aims at considering the content within which the unit is found. The researcher considers the favourableness or unfavourableness of a single unit in the light of the reminder of the communication so that its real meaning is not lost.

Steps in the Analysis of Qualitative Data.

1. The first step is to understand your data. Must read the data carefully again and again for the quality.
2. Second step is to identify the purpose of evaluation. See that how the respondents have answered to the question.
3. Categorize the data into themes/patterns. Then organize into categories. This is the most important step in Qualitative Analysis. You can assign the codes which can be few letters or words or symbols.
4. In the next step you have to find out the patterns and connections within the categories or between the categories identified.
5. The last step is the interpreting the data. You have to think and design an outline to present the findings.
6. You can feed the data to the computer by entering the text to word processing program. These days software programmes like Ethnograph, MODIST etc. can be used to analyze the qualitative data. If the data is not big, you can also analyze manually. There are other software also available. You can choose according to your convenience.

B. Inductive Analysis

Inductive analysis means that patterns, themes, and categories of analysis emerge out of the data. In this analysis, researcher looks for natural variation in the data. The study of natural variation involves particular attention to variations in programme processes and how participants respond to and are affected by programmes. Two ways of representing the patterns emerge from the analysis of data. First, the researcher can use the categories developed and articulated in the programme studied to organize presentation of particular themes. Second, the researcher may also become aware of categories or patterns for which the people in the programme did not have labels or terms, and the analyst develops terms to describe these inductively generated categories.

C. Logical Analysis

Logical analysis is used for representing patterns as dimensions or categories using either participant-generated constructions or evaluator generated constructions. It is sometimes useful to cross-classify different dimensions to generate new insights about how the data can be organized and to look for patterns that may not have been recognised in the initial induction analysis. Logical analysis aims at creating potential categories by crossing one typology with another, and then moving back and forth between the logical construction and the actual data for creating a “new typology” using cross-classification matrices.

There are other ways of analysing qualitative data. We have not discussed all of them. The idea is to give you a feel of qualitative data analysis and show how it differs from quantitative data analysis.

Check Your Progress 6

Define qualitative data. Give some examples of these data.

Notes: (a) Space is given below for writing your answer.

(b) Compare your answer with the one given at the end of the Unit.

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1.5 LET US SUM UP

In this Unit, we discussed the nature of quantitative and qualitative data, the various methods of representing the quantified data graphically, and the methods used in the analysis of quantitative and qualitative data. The main points are as follows:

1. The data collected through the administration of various tools on the selected samples are of (i) quantitative and (ii) qualitative nature.
2. Quantitative data are expressed in nominal, ordinal, interval or ratio scales of measurement. These data are classified into two categories: (i) parametric and (ii) non-parametric. The parametric data are obtained by applying interval or ratio scales of measurement, whereas non-parametric data are either enumerated or ranked. In the enumerated data we make use of nominal scale and in the ranked one we apply ordinal scale.
3. The quantified data is tabulated in 'frequency distribution' and can be represented graphically with the help of a histogram, a frequency polygon, and/or an ogive.
4. Measures of (i) central tendency, (ii) variability, (iii) relative positions, and (iv) relationship are the four types of descriptive statistical measures.
5. Mean, median and mode are the three measures of central tendency.
6. Mean is the arithmetic average of a distribution. It is obtained by dividing the sum of all values of observation by the total number of values. The formula for finding the mean for ungrouped data is:

$$M = \frac{\sum X}{N}$$

When the number of observations is large, the data is grouped in a frequency distribution. The formula for computing the mean here is:

$$M = AM + \frac{\sum fx}{N} \times i$$

7. Median is a point in an array, above and below which one half of the values or measures fall. If the values are ungrouped and their number is small, the values are arranged in order of magnitude and the middle value is determined by counting up half the value of N.

When the number of values is odd, the mid-value is the median. When the number of values is even, the median is the mid-point between the two middle values.

In the case of grouped data, the median is calculated by the formula:

$$Mdn = l + \frac{\frac{N}{2} - F}{x} \times i$$

8. Mode is the most frequently occurring value in a distribution. If only one value occurs a maximum number of times, the distribution is said to have one mode (uni-modal). A two mode distribution is bi-modal, and more than a two mode distribution is called multimodal.

In a simple ungrouped series of measures or values, the crude mode is that single measure or value which occurs most frequently.

For a group distribution, the mode is calculated by the formula:

$$\text{Mode} = l + \frac{fm - fi}{2fm - f_1 - f_2} xi$$

9. The range, variance and standard deviation are the most commonly used measures of variability.
10. The range is the difference between the two extreme values or measures in a distribution.
11. The average of the squared deviations of the measures or values from their mean is known as variance. Standard deviation is the positive square root of variance. Variance and standard deviation for the ungrouped data are found by the formulae:

$$\text{Variance} = \sigma^2 = + \frac{N \sum X^2 - (\sum X)^2}{N^2}$$

$$\text{Standard Deviation } \sigma = \sqrt{\frac{N \sum X^2 - (\sum X)^2}{N^2}}$$

When the data are grouped in a frequency distribution, the variance and standard deviation are computed by the formulae:

$$\text{Variance} = \sigma^2 = \frac{i^2}{N^2} + \left[N \sum fx'^2 - (\sum fx')^2 \right]$$

$$\text{Standard Deviation} = \sigma = \frac{i}{N} \sqrt{\left[N \sum fx'^2 - (\sum fx')^2 \right]}$$

12. The normal probability distribution is represented by a curve which has the following characteristics:
 - i) The curve is symmetrical around its vertical axis called ordinate.
 - ii) The mean, mode and median of the distribution have the same values.
 - iii) The height of the vertical line called ordinate is maximum at the mean and in the unit normal curve, it is equal to 0.3989.
 - iv) The curve is asymptotic.
 - v) The points of inflection of the curve occur at points $1 \pm$, standard deviation ($\pm 1\sigma$) above and below the mean.
 - vi) About 68.26 percent of the total area of the curve falls between limits Mean $\pm 1\sigma$, 95.44 percent of the total area falls between $M \pm 2\sigma$ and 99.73 percent of the total area falls between $M \pm 3\sigma$.

13. Sigma scores, standard scores, percentiles and percentile ranks are the measures of relative positions.
14. A sigma score makes it possible to obtain a realistic comparison of scores and provides a basis for equal weighting of the scores as the scores on different tests are expressed on a scale with a mean of zero and standard deviation 1.
15. When the sigma scores are converted into a new distribution with mean and standard deviation so selected as to make all scores positive, the scores are called standard scores.

The formula for the conversion of a raw score to a standard score is:

$$X = \frac{\sigma'}{\sigma} (X - M) + M'$$

When the mean (M) and standard deviation (σ') are taken to be 50 and 10 respectively, the standard score is called a T-score. It is expressed by the formula:

$$T = \frac{10}{\sigma} (X - M) + 50$$

16. Percentiles are the points which divide the entire scale of measurement into 100 equal parts.

The formula for computing percentiles is:

$$P_p = l + \frac{(P - F)}{f} \times i$$

17. Percentile rank is the point in the distribution below which a given percentage of scores fall. If R is the rank and N is the total number of cases.

$$\text{Percentile Rank} = 100 - \frac{100R - 50}{N}$$

18. Product Moment correlation and rank-difference correlation are the commonly used measures of relationship between any two variables.
19. When the size of sample is small and the variables are measured in interval scales of measurement, the product-moment correlation is computed by the formulae:

$$r_{xy} = \frac{N\sum xy - (\sum x)(\sum y)}{\sqrt{[N\sum x^2 - (\sum x)^2][N\sum y^2 - (\sum y)^2]}}$$

When the size of the sample is large, the product-moment correlation is found by the formulae:

$$r_{xy} = \frac{N\sum f_{xy} - (\sum f_x)(\sum f_y)}{\sqrt{[N\sum f_x^2 - (\sum f_x)^2][N\sum f_y^2 - (\sum f_y)^2]}}$$

20. When the data are available in ordinal (rank) form of measurement and the size of the sample is small, the formula for computing the rank-difference correlation is:

$$\rho = 1 - \frac{6\sum D^2}{N(N^2 - 1)}$$

21. In some situations if it is difficult to measure or analyse a phenomenon into various components or variables in quantified terms, the researcher takes into consideration the phenomenon as a whole, in detail and depth. In other words, the researcher uses qualitative techniques of analysis. Qualitative data consist of detailed descriptions of situations, events, people, interactions, and observed behaviours. These data are also available in the form of direct quotations from people about their experiences, attitudes, beliefs, and thoughts. The excerpts or entire passages from documents, correspondence, records and case studies are also examples of qualitative data.
22. Content analysis, inductive analysis and logical analysis are some methods of qualitative analysis.
23. Content analysis pertains to the classification, quantification and consideration. It is also called documentary or information analysis.
24. Inductive analysis leads to patterns, themes and categories emerging out of the data. In this type of analysis, the researcher looks for natural variation in the data.
25. Logical analysis is used for representing patterns as dimensions or categories, either using participant-generated constructions or evaluator-generated constructions.

To assess your learning yourself, see whether you are now able to:

- name various types of data
- define quantitative data
- describe quantitative data
- describe various types of quantitative data with examples
- tabulate a given quantitative data into frequency distribution
- illustrate the methods of expressing the class intervals with the help of examples
- compute the cumulative frequencies and cumulative percents for a given frequency distribution
- name the four methods of representing a data graphically
- construct a histogram, a frequency polygon and an ogive for a given distribution
- name the four descriptive statistical measures
- name and define the three measures of central tendency or averages (mean, median and mode)
- compute mean, median and mode from a given (i) ungrouped data (ii) grouped data

- name and define the three measures of variability (range, variance and standard deviation)
- compute range for ungrouped data
- compute variance and standard deviation for a given (i) ungrouped and (ii) grouped data
- describe the nature and characteristics of Normal Distribution
- use the Normal Table
- name and define the various measures of comparing individuals on the basis of different types of scores (Sigma Scores, Standard Scores, Percentiles and Percentile ranks)
- convert a raw score into a sigma score corresponding to the mean and standard deviation of a distribution
- convert a given raw score into a standard score (Z-score or T-score) corresponding to the mean and standard deviation of a distribution
- define a percentile
- compute certain percentiles for a given distribution of scores
- define percentile rank
- compute the percentile rank of an individual corresponding to his/her rank in the group to which he/she belongs
- name the various measures of relationships
- compute the product moment correlation for a given (i) ungrouped and (ii) grouped data
- compute rank order correlation for a given ungrouped data
- define qualitative data with examples
- name and describe some methods used in the analysis of qualitative data

1.6 GLOSSARY

- | | |
|------------------------|---|
| 1. Quantitative Data: | Data which are expressed in nominal, ordinal, interval or ratio scales of measurement. |
| 2. Qualitative Data: | Data which are available in the form of detailed descriptions of situations, events, people, interactions, and observed behaviour, direct quotations from people about their experiences, attitudes, beliefs, and thoughts, and excerpts from documents, correspondence, records, and case histories. |
| 3. Parametric Data: | These are data which are got by applying interval or ratio scales of measurement. |
| 4. Nonparametric Data: | These are data which are got by applying nominal or ordinal scales of measurement. These types of data are either counted or ranked. |
| 5. Central Tendency: | A measure of central tendency provides a single most typical value as representative of a group of |

	values; the 'trend' of a group of measures as indicated by some type of averages, usually the mean, median or mode.
6. Mean:	A kind of average obtained by dividing the sum of a set of measures by their number.
7. Median :	The middle value in a distribution or set of ranked values; the point that divides the group into two equal parts.
8. Mode:	The value that occurs most frequently in a distribution.
9. Variability:	The spread or dispersion of measures or values.
10. Range:	For some specified groups, the difference between the highest and the lowest obtained measure or value on a tool. It is a rough measure of variability.
11. Variance:	A measure of variability of a distribution. It is the average of the squared deviations of the measures or values from the mean.
12. Standard Deviation:	The positive square root of variance.
13. Standard Score:	A general term referring to any of the variety of 'transformed' scores, in terms of which raw scores may be expressed for reasons of convenience, comparability, ease of interpretation, etc. Sigma Scores, T-Scores etc. are the examples of standard score.
14. Normal Distribution:	A distribution of measures that in graphic form has a distinctive bell-shaped appearance. It is symmetrical and asymptotic. The mean, mode and median for this type of distribution have equal values.
15. Percentile Rank:	The expression of an obtained test score in terms of its position within a group of 100 scores.
16. Co-efficient of correlation:	A measure of the degree of relationship between two sets of measures for the same group of individuals. Its value ranges from 00, denoting a complete absence of relationship, to +1.00 and -1.00, indicating perfect positive and negative correspondence respectively.

1.7 CHECK YOUR PROGRESS: THE KEY

1. Quantitative data is the description of an empirical event or phenomenon in a numerical system presented with the help of different scales of measurement such as nominal, ordinal, interval and ratio. The two major types of quantitative data are: parametric (obtained through interval or ratio scales) and non-parametric (counted by a nominal scale

or ranked by a ordinal scale).

2&3 Class Interval	Mid Point	f		fx'	fx'^2
195-199	197	1	5	5	25
190-194	192	2	4	8	32
185-189	187	4	3	12	36
180-184	182	5	2	10	20
175-179	177	8	1	8	8
170-174	172	10	0	0	0
165-169	167	6	1	-6	6
160-164	162	4	-2	-8	16
155-159	157	4	-3	-12	36
150-154	152	2	-4	-8	32
145-149	147	3	-5	-15	75
140-144	142	1	-6	-6	36
		N=50		$\Sigma fx' = -12$	$\Sigma fx'^2 = 322$

$$\begin{aligned}
 \text{(i) Mean} &= A.M. + \frac{\Sigma fx'}{N} \times i \\
 &= 172 + \frac{(-12)}{50} \times 5 \\
 &= 170.80
 \end{aligned}$$

$$\begin{aligned}
 \text{(ii) Variance} &= \sigma^2 = \frac{i^2}{N} [N \Sigma fx'^2 - (\Sigma fx')^2] \\
 &= \frac{(5)^2}{(50)^2} [(50 \times 322 - (-12)^2)] \\
 &= 159.52
 \end{aligned}$$

$$\begin{aligned}
 \text{(iii) Standard Deviation} &= \frac{i}{N} \sqrt{[N \Sigma fx'^2 - (\Sigma fx')^2]} \\
 &= \frac{5}{50} \sqrt{[(50 \times 322 - (-12)^2)]} \\
 &= 12.63
 \end{aligned}$$

4 Normal probability curve is symmetrical around its vertical axis, i.e. ordinate.

The values of mean median and mode coincide and have the same value.

The height ordinate is maximum at the mean,

The curve is asymptotic.

The points of inflection of the curve occur at points $1 \pm$, standard deviation above and below the mean.

About 68.26 percent of the total area falls between the limits $M + 1\sigma$ and $M - 1\sigma$; 95.44 per cent of the total area of the curve falls between limits $M + 2\sigma$ and $M - 2\sigma$; and 99.73 percent of the total area of the curve falls between $M + 3\sigma$ and $M - 3\sigma$.

5.

X	Y	x	y	x ²	y ²	xy
45	56	-20	-9	400	81	180
55	50	-10	-15	100	225	150
56	48	-9	-17	81	289	153
58	60	-7	-5	49	25	35
60	62	-5	-3	25	9	15
65(AM)	64	0	-1	0	1	0
68	65(AM)	3	0	9	0	0
70	70	5	5	25	25	25
75	74	10	9	100	81	90
80	82	15	17	225	289	225
85	90	20	25	400	625	500

$$\sum x = 2, \quad \sum y = 6, \quad \sum x^2 = 14/4, \quad \sum y^2 = 1650, \quad \sum xy = 1403,$$

$$\begin{aligned}
 r_{xy} &= \frac{N\sum xy - (\sum x)(\sum y)}{\sqrt{[N\sum x^2 - (\sum x)^2][N\sum y^2 - (\sum y)^2]}} \\
 &= \frac{11 \times 1403 - 2 \times 6}{\sqrt{[11 \times 1414 - (2)^2][11 \times 1650 - (6)^2]}} \\
 &= 0.92
 \end{aligned}$$

- 6 Qualitative data describes a phenomenon which cannot be measured or quantified. The phenomenon is looked at in its totality. Detailed descriptions of situations, events, people, interactions, and observed behaviours constitute qualitative data.

UNIT 2 STATISTICAL TESTING OF HYPOTHESIS

Structure

2.0 Introduction

2.1 Objectives

2.2 Classification of Statistical Tests

2.3 Parametric Tests

2.3.1 Sampling Distribution of Means

A. Large Samples

B. Confidence Intervals and Levels of Significance

C. Small Samples

D. Degree of Freedom

2.3.2 Application of Parametric Tests

A. Application of Z-test

B. Two-tailed and one-tailed tests

C. Application of t-test

D. Application of F-test

E. Factor Analysis

2.4 Non-parametric Tests and Application of Chi-square Test

A. Application of Chi-square test

B. Application of Median test

2.5 Let Us Sum Up

2.6 Glossary

2.7 Check Your Progress: The Key

2.8 References

2.9 Appendix

2.0 INTRODUCTION

In Unit 1, we focussed on descriptive statistics including the various measures of central tendency, variability, relative positions and relationships. These measures are used to describe the properties of particular samples. In this Unit, we shall introduce inferential or sampling statistics. The knowledge of these statistics is useful for testing the hypothesis(es) related to your research problems, and to make generalisations about populations on the basis of data analysis. This requires you to be familiar with certain statistical tests - parametric and nonparametric.

2.1 OBJECTIVES

This Unit aims to provide you with detailed information about the nature and use of parametric and non-parametric tests in general and the application of some of these tests for drawing inferences and generalizations. After the completion of this Unit, you should be able to:

- Classify various statistical tests,
- Describe the nature of parametric tests alongwith the assumptions on which they are based,
- Work out sampling distribution of means in the context of (i) large samples, and (ii) small samples,
- Define and illustrate the concept of confidence intervals and levels of significance,
- Define and illustrate the concept of degrees of freedom,
- Use Z-test and t-test in testing the significance of the difference between means,
- Define and illustrate the concept of one-tailed and two-tailed tests of significance,
- Describe the nature and uses of analysis of variance,
- Describe the nature of the non-parametric tests alongwith their assumptions,
- Use of chi-square test, and
- Describe the use of median test and its application.

2.2 CLASSIFICATION OF STATISTICAL TESTS

The descriptive statistics already discussed in Unit 1 are used to explain the properties of samples drawn from a population. The researcher computes certain 'statistics' (sample values) as the basis for inferring the corresponding 'parameters' (population values). Ordinarily, a single sample is drawn from a given population so as to determine how well a researcher can infer or estimate the 'parameter' from a computed sample 'statistics'. For making the inferences about the various parameters, the researcher makes use of **parametric** and **non-parametric tests**.

2.3 PARAMETRIC TESTS

Under this section you will read the two sub-themes: sampling distribution of means and application of parametric tests. Sampling distribution of means covers a) large samples, b) confidence intervals and levels of significance, c) small samples, and d) degree of freedom. Application of parametric tests covers three tests, namely Z-test, t-test and F-test.

Parametric tests are the most powerful statistical tests for testing the significance of the computed sampling statistics. These tests are based on the following assumptions:

1. the variables described are expressed in interval or ratio scales and not in nominal or ordinal scales of measurement,

- 2. the population values are normally distributed,
- 3. the samples have equal or nearly equal variances ¾ this condition is known as ‘equality or homogeneity of variances’ and is particularly important to determine for small samples,
- 4. the selection of one case in the sample is not dependent upon the selection of any other.

Z-test, t-test and F-test are the most commonly used parametric tests. Before discussing the application of these tests, it is necessary to describe certain concepts relating to ‘sampling distribution of means’, ‘confidence intervals’, ‘levels of confidence of significance’, and ‘degrees of freedom’.

Check Your Progress 1

Describe the assumptions on which the use of parametric tests are based.

- Notes:** (a) Space is given below for writing your answer.
(b) Compare your answer with the one given at the end of the unit.

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2.3.1 Sampling Distribution of Means

A. Large Samples

An important principle, known as the ‘central limit theorem’, describes the characteristics of sample means. If a large number of equal-sized samples (greater than 30) are selected at random from an infinite population,

- the distribution of ‘sample means’ is normal and it possesses all the characteristics of a normal distribution,
- the average value of ‘sample means’ will be the same as the mean of the population,
- the distribution of the sample means around the population mean will have its own standard deviation, known as ‘standard error of mean, which is denoted as SE_M or σ_M . It is computed by the formula:

$$SE_M = \sigma_M = \frac{\sigma}{\sqrt{N}} \quad \dots\dots\dots(1)$$

in which σ = Standard deviation of the population and
 N = The number of cases in the sample.

Since the value of σ (i.e. standard deviation of population) is usually not known, you make an estimate of this standard error of mean by the formula:

$$\sigma_M = \frac{\sigma}{\sqrt{N}} \quad \dots\dots\dots(2)$$

in which σ = Standard deviation of the sample
 N = The number of cases in the sample.

To illustrate the use of formula (2), you assume that the mean of the attitude scores of a sample of 100 distance learners enrolled with IGNOU towards student support services is 25 and the standard deviation is 5. The standard error of mean can be calculated accordingly:

$$SE_M = \sigma_M = \frac{5.0}{\sqrt{100}} = 0.50$$

This standard 'error of mean' may be assumed as the standard deviation of a distribution of sample means, around the fixed population mean of all distance learners. In the case of large randomly selected samples, the sampling distribution of sample means is assumed to be normal.

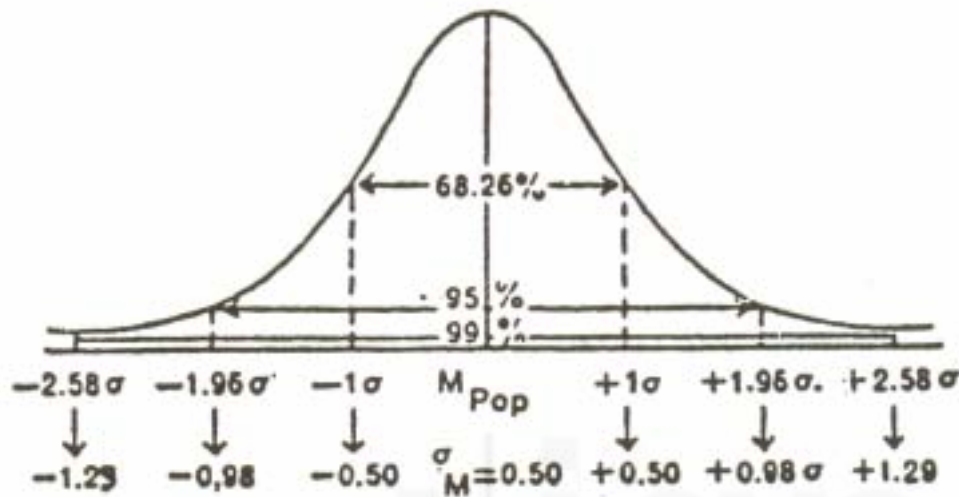


Fig. 1: Sampling Distribution of Means showing Variability of obtained Means around the Population Mean in terms of σ_M

The normal curve in Figure 1 shows that this sampling distribution is centered around the unknown population mean with standard deviation 0.50. The sample means often fall between the positive and the negative side of the population mean. About 2/3 of our sample means (exactly 68.26 per cent) will lie within $\pm 1.00 \sigma_M$ of the population mean, i.e., within a range of $\pm 1 \times 0.50 = \pm 0.50$. Furthermore, 95 of our 100 sample means will lie within $\pm 2.00 \sigma_M$ (more exactly $\pm 1.96 \sigma_M$) of the population mean, i.e. 95 of 100 sample means will lie within $\pm 1.96 \times 0.50$ or ± 0.98 of the population mean. In other words, the probability that our sample mean of 25 does not miss the population mean ($M_{pop.}$) by more than ± 0.98 is 0.95. Also, 99 of our sample means will be within $\pm 3.00 \sigma_M$ (more exactly $\pm 2.58 \sigma_M$) of the population mean. This indicates that 99 out of 100 sample means will fall within $\pm 2.58 \times 0.50$ or ± 1.29 of the population mean. The probability (P) that our sample mean of 25 does not miss the $M_{pop.}$ by more than ± 1.29 is .99.

Thus, the value of a population mean, to be inferred from a randomly selected sample mean, can be estimated on a probability basis.

Check Your Progress 2

Given a sample of 100 distance learners with mean = 175.50 and S.D. = 5.82 of the scores of an intelligence test. Compute the standard error of mean.

Notes: (a) Space is given below for writing your answer.

(b) Compare your answer with the one given at the end of the Unit.



B. Confidence Intervals and Levels of Significance

When you draw a large random sample from the population to obtain measures of a variable and compute the mean for the sample, you can use the ‘central limit theorem’ and ‘normal probability curve’ to have an estimate of the population mean. You can say that $\bar{M}$ has a 95 percent chance of being within 1.96 standard error units of M_{pop} . In other words, a mean for a random sample has a chance of 95 percent of being within $1.96s_{\bar{M}}$ units from M_{pop} . It may also be said that there is a 99 percent chance that the sample mean lies within $2.58s_{\bar{M}}$ units of M_{pop} . To be more specific, it may be stated that there is a 95 percent probability that the limits $\bar{M} \pm 1.96s_{\bar{M}}$ enclose the population mean, and the

limits $M \pm 2.58\sigma_M$ enclose the population mean with 99 percent probability. Such limits enclosing the population mean are known as the 'confidence intervals'.

These limits help us to adopt particularly two levels of confidence. One is known as 5 percent level or 0.05 level, and the other is known as 1 per cent level or .01 level. The .05 level of confidence indicates that the probability M pop that lies within the interval $M \pm 1.96\sigma_M$ is 0.95 and that it falls outside of these limits is .05. By saying that probability is 0.99, it is meant that M pop. lies within the interval $M \pm 2.58\sigma_M$ and that the probability of its falling outside of these limits is .01.

To illustrate, let us apply the concept to the previous problem. Taking as our limits $M \pm 1.96\sigma_M$, you have $25 \pm 1.96 \times 0.50$ or a confidence interval marked off by the limits 24.02 and 25.98. Our confidence that this interval contains M pop. is expressed by a probability of .95. If you want a higher degree of confidence, you can take the .99 level of confidence for which the limits are $M \pm 2.58\sigma_M$ or a confidence interval given by the limits 23.71 and 26.29. You may be quite confident that M pop. is not lower than 23.71 nor higher than 26.29, i.e., the chances are 99 in 100 that the M pop. lies between 23.71 and 26.19.

C. Small Samples

When the number of cases in the sample is less than 30, you may estimate the value of σ_M by the formula:

$$SE_M = \frac{S}{\sqrt{N}} \quad \dots\dots\dots(3)$$

In which

S = Standard deviation of the small sample.

N = The number of cases in the sample.

The formula for computing S is

$$SE_M = \sqrt{\frac{\sum x^2}{N-1}} \quad \dots\dots\dots(4)$$

In which

$\sum x^2$ = Sum of the squares of deviations of individual scores from the sample mean.

N = The number of cases in the sample.

The concept of small size was developed by William Seely Gosset, a consulting statistician for Guinness Breweries of Dublin (Ireland) around 1915. The principle is that we should not assume that the sampling distribution of means of small samples is normally distributed. He found that the distribution curves of small sample means were somewhat different from the normal curve. When the size of the sample is small, the t-distribution lies under the normal curve, but the tails or ends of the curve are higher than the corresponding parts of the normal curve. Figure 2 shows that the t-distribution does not differ significantly from the normal distribution unless the sample size is quite small. Further, as the sample size increases in size, the t-distribution approaches more and more closely to the normal curve.

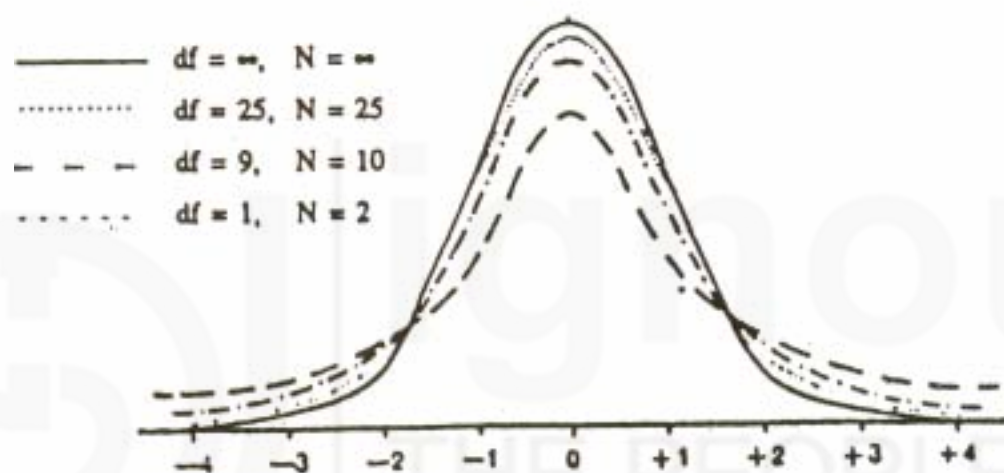


Fig. 2: Distribution of t-values for Degrees of Freedom from 2 to ∞ (when df is very large, the distribution of t approaches the normal).

For small samples, it is necessary to make use of selected points in the table of Gosset's t-critical values or student's t-values, given in Appendix (Table II). As the sample size increases, the student's t-values approach the Z-values of Normal probability table. When small samples are used, the use of t-values involves an important concept known as 'degrees of freedom', which we shall now discuss separately.

D. Degrees of Freedom

While finding the standard deviation of small samples we use $N-1$ in the denominator instead of N in the basic formula for standard deviation. The difference in the two formulae may seem very little, if N is sufficiently large. But there is a very important difference in the 'meaning' in the case of small samples. $N-1$ is known as the 'number of degrees of freedom', denoted by df. The 'number of degrees of freedom' in a distribution is the number of observations or values that are independent of each other and cannot be deduced from each other. In other words, we may say that the 'degrees of freedom' connote freedom to vary.

To illustrate as to why the df used here is N-1, we take 5 scores, i.e., 5,6,7,8 and 9, the mean of which is 7. This mean score is to be used as an estimate of the population mean. The deviations of the scores from the mean 7 are -2, -1, 0, +1 and +2. A mathematical requirement of the mean is that the sum of these deviations should be zero. Of the five deviations, only 4, i.e., N-1 can be chosen freely (independently) as the condition that the sum is equal to zero restricts the value of the 5th deviate. With this condition, you can arbitrarily change any four of the five deviates and thereby fix the fifth. You could take the first four deviates as -2, -1, 0 and +1, which would mean that for the sum of deviates to be zero, the fifth deviate has to be +2. Similarly, you can try other changes and if the sum is to remain zero, one of the five deviates is automatically determined. Hence, only 4, i.e., (5-1)'s are free to vary within the restrictions imposed.

When a statistic is to be used to estimate a parameter, the number of degrees of freedom depends upon the restrictions imposed. One df is lost for each of the restrictions imposed. Therefore, the number of df varies from one statistics to another. For example, in estimating and computing the population mean (M pop) from the sample Mean (M), you lose 1 df. So, the number of degrees of freedom is (N-1).

Let us determine the .95 and .99 confidence intervals for the population mean (M pop) of the scores 10, 15, 10, 25, 30, 20, 25, 30, 20 and 15, obtained by 10 distance learners on an attitude scale. The mean of the scores is

$$= \frac{10 + 15 + 10 + 25 + 30 + 20 + 25 + 30 + 20 + 15}{10}$$

$$= \frac{200}{10} = 20.00$$

Using formula (4) we compute the standard deviation as:

X	x = X-M	x ²
10	-10	100
15	-5	25
10	-10	100
25	5	25
30	10	100
20	0	0
25	5	25
30	10	100
20	0	0
15	-5	25
	$\sum x = 0$	$\sum x^2 = 500$

$$\begin{aligned}
 S &= \sqrt{\frac{\sum x^2}{N - 1}} \\
 &= \sqrt{\frac{500}{10 - 1}} \\
 &= 7.45
 \end{aligned}$$

From formula (3) we compute

$$\begin{aligned}
 SE_M &= \frac{7.45}{\sqrt{10}} \\
 &= 2.36
 \end{aligned}$$

For estimating the M pop from the sample mean of 20.00, we determine the value of t at the selected points using appropriate number of degrees of freedom. The available df for determining t is N-1 or 9. Entering Table II (See Appendix) with 9 df, we read that t = 2.26 at .05 level and 3.25 at .01 level. From the first t-value we know that 95 of our 100 sample means will lie within $\pm 2.26 SE_M$ or $\pm 2.26 \times 2.36$ of the population mean and 5 out of 100 fall outside of these limits. The probability (P) that our sample mean 20.00 does not miss the M pop by more than $\pm 2.26 \times 2.36$ or ± 5.33 is .95. From the second t-value, we know that 99 percent of our sample mean will lie between M pop and $3.25 SE_M$ or $\pm 3.25 \times 2.36$, and that 1 percent fall will beyond these limits. So, the probability (P) that our sample mean of 20.00 does not miss the M pop by more than $\pm 3.25 \times 2.36$ or ± 7.67 is .99.

Taking our limits as $M \pm 2.26 SE_M$, we have $20.00 \pm 2.26 \times 2.36$ or 14.67 and 25.33 as the limits of the .95 confidence interval. The probability (P) that M pop is not less than 14.67 nor greater than 25.33 is .95. Taking the limits $M \pm 3.25 SE_M$, we have $20.00 \pm 3.25 \times 2.36$, or 12.33 and 27.67 as the limits of the .99 confidence interval, and the probability (P) so that M pop is not less than 12.33 and not greater than 27.67 is .99.

The use of small samples to build generalizations in educational research should be made cautiously as it is difficult to ensure that a small sample adequately represents the population from which the sample is drawn. Further more, conclusions drawn from small samples are usually unsatisfactory because of the great variability from sample to sample. In other words, large samples drawn randomly from the population will provide a more accurate basis than will small samples for inferring population parameters.

2.3.2 Application of Parametric Tests

In this subsection, we shall discuss the application of three parametric tests, namely **Z-test**, **t-test** and **F-test**.

A. Application of Z-test for Testing the Significance of Difference between Means of two independent Large Samples

It has already been explained in earlier sections that the frequency distribution of large sample means drawn from the same population fall into a normal distribution around M

pop as their measure of central tendency. It is also reasonable to expect that the frequency distribution of the difference between the means computed from the two samples will also tend to be normal with a mean of zero and standard deviation of 1. It is termed the ‘standard error of the difference between two means’ and is denoted by σ_{d_m} . It is computed by the formula:

$$\sigma_{d_M} = \sqrt{\sigma_{M_1}^2 + \sigma_{M_2}^2} \dots\dots\dots (5)$$

In which

σ_{M_1} = the SE of the mean of the first sample

σ_{M_2} = the SE of the mean of the second sample

To illustrate, you apply formula (5) to a problem. Suppose a test of creativity was administered on two groups, one of 120 males and the other of 75 females enrolled in MA (DE) Distance Education course of IGNOU.

The results are summarized in table 2.1 below.

Table 2.1: Means and Standard Deviations of Two Independent Large Samples

Statistics	Boys	Girls
N	120	75
Mean (M)	57.50	55.75
Standard Deviation		
σ	8.42	8.13

Assuming that our samples are random, it is to be ascertained whether the difference between the means 57.50 and 55.75 is significant.

Using formula (5) you compute the ‘standard error of the difference between means’.

$$\begin{aligned} \sigma_{d_M} &= \sqrt{\frac{(8.42)^2}{120} + \frac{(8.13)^2}{75}} \\ &= 1.21 \end{aligned}$$

The obtained difference between the means of males and females is 1.75 (i.e., 57.50 – 55.75); and the SE of this difference (σ_{d_M}) = 1.21.

To determine whether two groups of males and females actually differ in creative thinking ability, we set-up a null hypothesis, i.e., the difference between the population means of males and females is zero and that, except for sampling errors, mean differences from sample to sample will also be zero. In accordance with a null hypothesis, you assume a sampling distribution of differences to be normal with the mean at zero, (or at $M_{\text{pop (males)}} - M_{\text{pop (females)}} = 0$). The deviation of each sample difference, $[M_{\text{males}} - M_{\text{females}}] - [M_{\text{pop (males)}} - M_{\text{pop (females)}}]$ or $[M_{\text{males}} - M_{\text{females}}] = 0$. The deviation of each sampled difference between two means, given in terms of standard measure, would be the deviation divided by the standard error, which gives us a z - value in terms of a general formula:

$$\bar{z} = \frac{|M_1 - M_2|}{d_M} \dots\dots\dots(6)$$

Using formula (6)

$$\bar{z} = \frac{1.75}{1.21} = 1.45$$

For the sake of convenience, you use .05 and .01 levels of significance as two arbitrary standards for accepting or rejecting a hypothesis. From the normal distribution Table 1 (See Appendix) we read that $\pm 1.96\sigma$ mark off points along the base line of the normal curve to the left and right of which lie 5 percent of the cases (i.e., 2.5 percent at each end of the curve). When a z - value is 1.96 or more, we reject a null hypothesis at .05 level of significance. The computed z -value of 1.45 in our problem falls short of 1.96, i.e., it does not reach the .05 level. Accordingly, we retain the null hypothesis and conclude that two groups of males and females actually do not differ in their mean performance on creative-thinking-test.

Furthermore, from Table I (See Appendix) we know that $\pm 2.58\sigma$ mark off points to the left and right of which lie 1 percent (0.5 percent at each end of the curve) of the cases in the normal distribution. If the z -value is 2.58 or more, we reject the null hypothesis at .01 level and the probability (P) is that not more than once in 100 trials would a difference of this size arise if the true difference ($M_{\text{pop}_1} - M_{\text{pop}_2}$) was zero.

B. Two-tailed and one-tailed tests of significance

Suppose a null-hypothesis were set up that there was no difference, other than a sampling error difference, between the mean height of two groups, A and B. You should be concerned only with the difference and not with the superiority or inferiority in height of either group. To test this hypothesis, you apply two- tailed test as the difference between the obtained means of height of two groups may be as often in one direction (plus) as in the other (minus) from the true difference of zero. Moreover, for determining probability, we take both tails of sampling distribution.

For a large sample two-tailed test, we make use of a normal distribution curve. The 5 percent area of rejection is divided equally between the upper and the lower tails of this curve and we have to go out to ± 1.96 on the base line of the curve to reach the area of rejection as shown in the Figure 3.

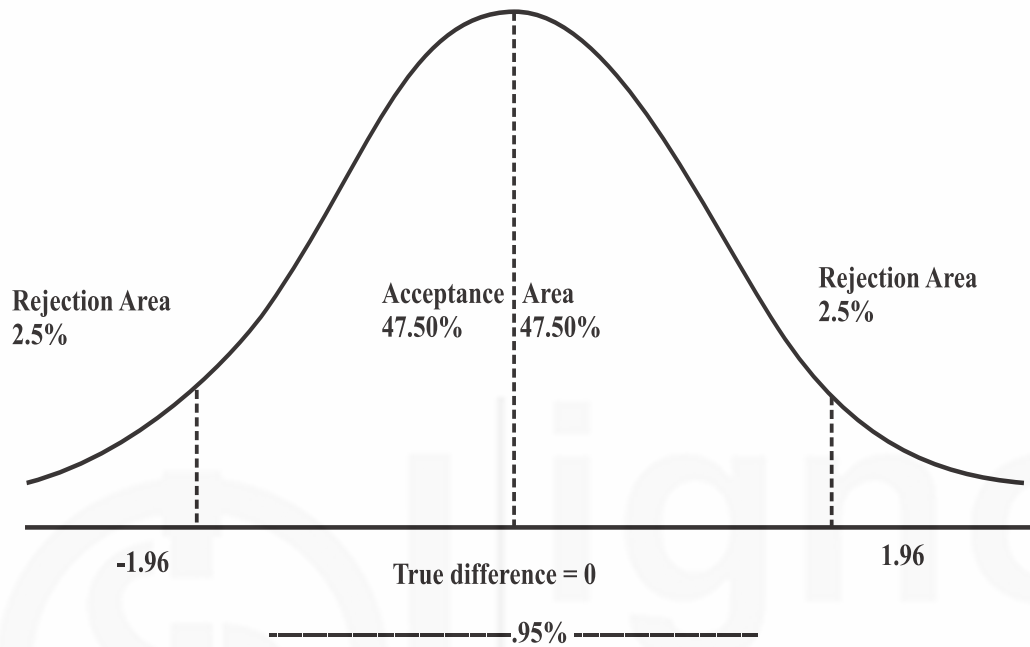


Fig. 3: A Two-tailed Test at .05 level (2.5 per cent at each level)

Similarly, if we have 0.5 percent area at each end of the normal curve where 1 percent area of rejection is to be divided equally between its upper and lower tails, it is necessary to go out to ± 2.58 on the base line to reach the area of rejection as shown in the Fig.4.

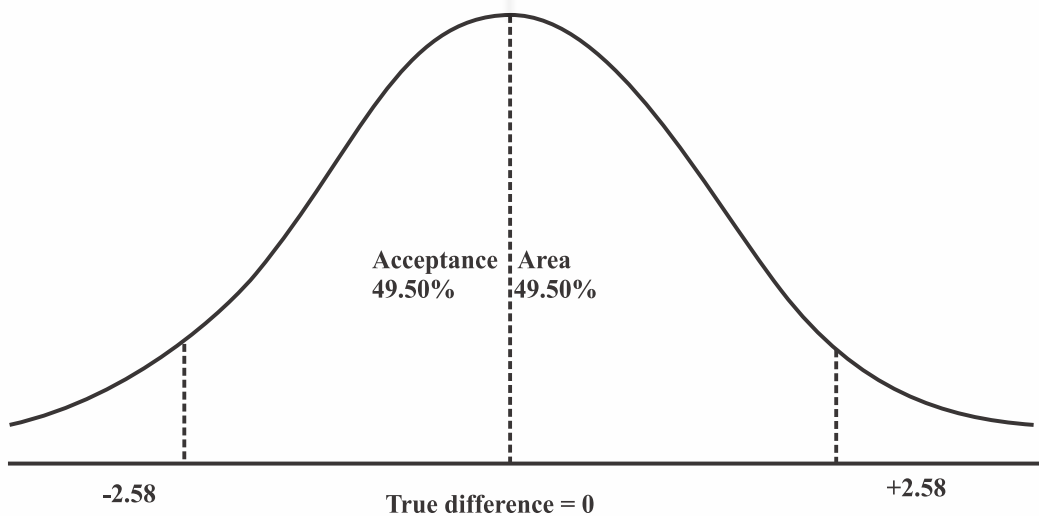


Fig. 4.: A Two-tailed Test at .01 level (0.5 per cent at each level)

In the case of the above example a null hypothesis was set up that there was no difference other than a sampling error difference between the mean creative thinking score of males and females of MA (DE). Thus, you were concerned with a difference, and not in superiority or inferiority of either group in the creative thinking ability. To test this hypothesis, we applied 'two-tailed test' as the difference between the two means might have been in one direction (plus) or in the other (minus) from the true difference of zero; and we took both tails of sampling distribution in determining probabilities.

As is evident from the above example, we make use of a normal distribution curve in the case of a large sample 'two-tailed test'. The 5 percent area of rejection is equally divided between the upper and lower tails of the curve and we have to go out to ± 1.96 on the base line of the curve to reach the area of rejection.

Similarly, we have 0.5 percent area at each end of the normal curve when 1 percent of rejection is to be divided equally between its upper and lower tails and it is necessary to go out to ± 2.58 on the base line to reach the area of rejection.

In the above problem, if we change the null hypothesis as: male group of MA (DE) have significantly higher creative thinking than that of the female group; or male group have significantly lower creative thinking than the female group of MA (DE) course, then each of these hypotheses indicates a direction of difference. In such situations, the use of 'one-tailed test' is made. For such a test, the 5 percent area or 1 per cent area of rejection is either at the upper tail or at the lower tail of the curve, to be read from 0.10 column (instead of .05) and .02 column (instead of .01).

C. Application of t-test for testing the Significance of Difference between two Independent Small Samples

We have already discussed that the frequency distribution of small sample means drawn from the same population forms a t-distribution and it is reasonable to expect that the sampling distribution of the difference between the means computed from two different populations will also fall under the category of t-distribution. Fisher provided the formula for testing the difference between the means computed from independent small samples.

$$= \frac{|M_1 - M_2|}{\sqrt{\left[\frac{\sum x_1^2 + \sum x_2^2}{N_1 + N_2 - 2} \right] \left[\frac{N_1 + N_2}{N_1 \times N_2} \right]}} \quad \dots\dots\dots(7)$$

in which

- M_1 and M_2 = means of two samples
= sums of squares of the deviations from the means in the two samples
 N_1 and N_2 = number of cases in the two samples.
df = degrees of freedom = $N_1 + N_2 - 2$

To illustrate the use of the formula, let us test the significance of the difference between mean scores of 7 boys and 10 girls on an intelligence test.

Table 2.2: Scores of 7 boys and 10 girls on an intelligence test

(N ₁ =7)			(N ₂ =10)		
Boys X ₁	x ₁	X ₁ ²	Girls X ₂	x ₂	X ₂ ²
13	0	0	10	-4	16
14	1	1	16	2	4
11	-2	4	12	-2	4
12	-1	1	13	-1	1
15	2	4	18	4	16
13	0	0	13	-1	1
13	0	0	19	5	25
			14	0	0
			13	-1	1
			12	-2	4
$\sum X_1 = 91$		$\sum X_1^2 = 10$	$\sum X_2 = 140$		$\sum X_2^2 = 72$
$M_1 = \frac{91}{7} = 13$			$M_2 = \frac{140}{10} = 14$		
$df = N_1 + N_2 - 2 = 7 + 10 - 2 = 15$					

Using formula (7)

$$\begin{aligned}
 t &= \frac{|14 - 13|}{\sqrt{\left(\frac{10 + 72}{7 + 10 - 2}\right)\left(\frac{7 + 10}{7 \times 10}\right)}} \\
 &= \frac{1}{\sqrt{\left(\frac{82}{15}\right)\left(\frac{17}{70}\right)}} \\
 &= \frac{1}{\sqrt{9.29}} \\
 &= 0.33
 \end{aligned}$$

To test the significance of difference between the two means by making use of two-tailed test (null hypothesis, i.e., no differences between the two groups), we look for the t-critical values for rejection of null hypothesis in Table II (Appendix) for $(7 + 10 - 2)$ or 15 df. These t-values are 2.13 at .05 and 2.95 at .01 levels of significance. Since the obtained t-value 0.33 is less than the table value necessary for the rejection of the null hypothesis at .05 level for df 15, the null hypothesis is accepted and it may be concluded that there is no significant difference in the mean intelligence scores of males and females.

If we change the null hypothesis as: boys will have higher intelligence scores than girls, or males will have lower intelligence scores than females, then each of these hypotheses indicates a direction of difference rather than simply the existence of the difference. So, we make use of one-tailed test. For given degrees of freedom, i.e., 15, the .05 level is read from the 0.10 column ($p_2 = .05$) and the .01 level from 0.02 column ($p_2 = .01$) of the t-

table. In the one-tailed test, for 15 df t-critical values at .05 and .01 levels, as read from the 0.10 and the 0.02 columns of Table II are 1.75 and 2.60 respectively. Since the computed t-value of 0.33 does not reach the table value at .05 level (i.e., 1.75 for .10), we may conclude that the difference in two groups is there merely because of chance factors.

D. Application of F-test for Testing the Significance of Difference between Independent Means

The use of Z and t-test is made by a researcher to determine whether there is any significant difference between the means of two random samples. Suppose you have seven randomly drawn samples from a population and you want to determine whether there are any significant differences among their means. This will require computation of

$$\frac{7(7-1)}{2} = 21 \text{ t-tests to determine the significance of difference between the seven means}$$

by taking two means at a time. This procedure is time consuming as well as cumbersome. The technique of analysing of variance is applied to determine if any two of the seven means differ significantly from each other by a single test, known as F-test, rather than 21 t-tests. The F-test makes it possible to determine whether the sample means differ from one another (between group variance) to a greater extent than the test scores differ from their own sample means (within group variance). Using the ratio:

$$F = \frac{\text{Variance the groups}}{\text{Variance within groups}} \quad \dots\dots\dots (8)$$

The values of F-ratio are given in the Appendix (Table III). This table indicates the F-critical values necessary for rejecting the null hypothesis at selected levels of significance, usually .05 and .01 levels.

E. Factor Analysis

Factor Analysis is a technique mainly used in research in psychology and education. We will not examine factor analysis in detail here, but very briefly describe about this technique.

Factor Analysis is a procedure for determining the number and nature of constructs that underlie a set of measures (Wiersman 1986). Construct as you are already aware, is a trait or an attribute that explains some phenomena, e.g., anxiety, intelligence, motivation, attitude etc. In factor analysis artificial variables are generated and called factors. These factors represent the constructs. Factor analysis is initiated from the correlation matrix of the variables. The variables which are highly correlated are grouped together.

Suppose you have scores of 100 students on 10 different tests. Question here is – How many different traits or constructs these 10 tests measure. The possibility can be that three or four tests measure the same trait or one test may measure two or more traits. The researcher can determine the correlation co-efficient among the 10 different tests. High correlation's between test scores indicate that common constructs are measured. Low or zero correlation's indicate the absence of common constructs.

There are few terms used in factor analysis. If a test measures only one construct, it is labeled as factorially pure. A factorially complex test is one that measures two or more factors.

Factor loading is the extent to which a test measures a factor. Factor loading is very important in factor analysis because factors which are artificial variables generated from the data must be described and integrated. It is a correlation coefficient between a test and a factor.

Uses of Factor Analysis in Research

In conducting research, the aim of using factor analysis is to identify the nature and number of constructs that underlie a set of variables. Factor analysis is associated with construct related evidence when establishing validity (construct validity is explained in Block 3, Unit 2). Factor analysis is used in confirmatory analysis and exploratory analysis.

Confirmatory factor analysis is used in studies where hypothesized constructs measured by a set of variables are either confirmed or refuted. It is also used to analyze a single test by factor analyzing the item scores.

Suppose 50 item test measures three traits, a confirmatory analysis of the item scores would support or refute this proposition.

On the other side, in the exploratory analysis the number of variables are reduced to a manageable number of explanatory purposes. A set of measures can be factor analyzed to enhance the explanation of what is measured in a more persimmons manner.

Eg. A group of teachers in an open university were observed and measured on two different competencies. A factor analysis of the competency scores undoubtedly would generate a smaller number of factors, say three or four, that represents the constructs underlying the performance of teacher.

Thus factor analysis in any research analysis provide valuable insights into the nature of phenomena.

Check Your Progress 3

The following scores were obtained on an interest test for 5 males and 8 females of MA (DE) enrolled with IGNOU.

Male : 20, 22, 30, 32, 26.

Female: 34, 25, 16, 30, 22, 27, 20, 26.

Is the difference between the Mean Interest Scores of the Males and the Females significant?

Notes: (a) Space is given below for writing your answer.

(b) Compare your answer with the given at the end of the unit.

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Basic Assumptions for the Analysis of Variance

Certain basic assumptions underlying the technique of analysing of variance are:

1. The population distribution should be normal. This assumption is, however, not so important. The study of Norton (Guilford, 1954; pp.300-301) also points out that F is rather insensitive to variations in the shape of population distribution.
2. All groups of a certain criterion or of the combination of more than one criterion should be randomly chosen from the sub-population having the same criterion or having the same combination of more than one criterion. For example, if we wish to select two groups from a study centre, one belonging to a rural area and the other to the urban area, we must choose the groups randomly from the respective sub-populations.
3. The sub-groups under investigation must have the same variability. In other words, there should be homogeneity of variance. It is tested either by applying Bartlett's test of homogeneity or by applying Hartley's test.

To illustrate the use of F-test, let us consider an example of twenty distance learners who have been randomly assigned to 4 groups of 5 each, to be taught by different methods, i.e., A, B, C and D. Their performance scores on an achievement test, administered after the completion of experiment are given in Table 2.3.

Table 2.3: Achievement Test Scores of the Four Groups Taught through Four Different Methods

	Methods or Groups				
	A (X ₁)	B (X ₂)	C (X ₃)	D (X ₄)	
	14	19	12	17	
	15	20	16	17	
	11	19	16	14	
	10	16	15	12	
	12	16	12	17	
ΣX	62	90	71	77	300
ΣX ²	786	1634	1025	1207	4652

You may compute the analysis of variance using the following steps:

$$1.. \quad \text{Correction} = \frac{(\sum X)^2}{N} = \frac{(300)^2}{20} = 4500$$

2. Total sum of squares (Total SS)

$$\begin{aligned} &= \quad \quad \quad - \text{Correction} \\ &= \quad 14^2 + 15^2 + \dots\dots\dots 12^2 + 17^2 - 4500 \\ &= \quad 4652 - 4500 \\ &= \quad 152 \end{aligned}$$

3. Sum of squares between means of treatments (Methods) A, B, C, and D (between means):

$$\begin{aligned} &= \frac{(\sum X_1)^2}{N_1} + \frac{(\sum X_2)^2}{N_2} + \frac{(\sum X_3)^2}{N_3} + \frac{(\sum X_4)^2}{N_4} - \text{Correction} \\ &= \frac{(62)^2}{N_1} + \frac{(90)^2}{N_2} + \frac{(71)^2}{N_3} + \frac{(77)^2}{N_4} - 4500 \\ &= 4582.8 - 4500 \\ &= 82.8 \end{aligned}$$

4. Sum of squares within treatments (Methods) A, B, C, and D (SS within means):

$$\begin{aligned} &= \text{Total SS} - \text{SS between means} \\ &= 152 - 82.8 \\ &= 69.2 \end{aligned}$$

5. Calculation of variances from each SS and analysis of the total variance into its components.

Each SS becomes a variance when divided by the degrees of freedom (df) allotted to it. There are 20 scores in all in Table 3, and hence there are (N-1) or (20-1) = 19 df in all. These 19 df are allocated in the following ways:

If N = number of scores in all and K = number of treatments or groups, we have df for total SS = N-1 = 20-1 = 19, df for within treatments = N-K = 20-4 = 16; and df for between the means of treatments = K-1 = 4-1 = 3.

The variance among means of treatments is $82.8/3$ or 27.60; and the variance within means is $69.2/16$ or 4.33.

The summary of the analysis of variance may be presented in tabular form as follows:

Table 2.4 : Summary of Analysis of Variance

Source of Variance	df	Sum of Squares (SS)	Mean Square (Variance)
Between the means of treatment	3	82.8	27.60
Within treatment	16	69.2	4.33
Total	19	152.0	

Using formula (8)

$$F = \frac{27.60}{4.33} = 6.374$$

In the present problem, the null hypothesis asserts that four sets of scores are in reality the scores of four random samples drawn from the same normally distributed population, and that the means of the four groups A, B, C, and D will differ only through fluctuations of sampling. For testing this hypothesis, we divided the 'between means' variance by the 'within treatments' variance and compared the resulting variance ratio, called F, with the F-values in Table III. The F value of 6.374 in the present case is to be checked for table value for df 3 and 16 (the degrees of freedom for numerator and denominator). The table values for .05 and .01 levels of significance are 3.24 and 5.29. Since the computed F-value of 6.374 is greater than the table values, we reject the null hypothesis and conclude that the means of the four groups differ significantly.

2.4 NON-PARAMETRIC TESTS AND APPLICATION OF CHI-SQUARE TEST

In the preceding section, we described some important parametric tests involving the assumptions based upon the nature of the population distribution. There are some tests which do not make numerous or stringent assumptions about the nature of the population distribution. These tests are known as distribution-free or non-parametric tests. The non-parametric tests are based upon the following assumptions:

1. The nature of the population, from which samples are drawn, is not known to be normal.

2. The variables are expressed in nominal form, that is, classified in categories and represented by frequency counts.
3. The variables are expressed in ordinal form, that is, ranked in order or expressed in numerical scores which have the strength of ranks.
4. The sample sizes are small.

The most frequently used non-parametric tests are: Chi-square test, the median test, the sign test, the Mann-Whitney U test, the Kolmogorov-Smirnov Two Sample Test, the Wilcoxon-Matched-Pairs Signed-Ranks Test, the McNemar Test for Significance of changes, contingency co-efficient, etc. For the present unit, we will discuss the applications of Chi-square test and median test only.

Check Your Progress 4

Describe the assumptions on which non parametric tests are based.

Notes: (a) Space is given below for writing your answer.

(b) Compare your answer with the one given at the end of the unit.

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A. Application of Chi-Square Test

The Chi-square (pronounced as Ki-square) test is used with discrete data in the form of frequencies. It is a test of independence and is used to estimate the likelihood that some factor other than chance accounts for the observed relationship. Since the null hypothesis states that there is no relationship between the variables under study, the Chi-square test merely evaluates the probability that the observed relationship results from chance. The formula for Chi-square (X^2) is:

$$X^2 = \sum \left[\frac{(fo - fe)^2}{fe} \right] \dots\dots\dots(9)$$

in which

fo = frequency of the occurrence of observed or experimentally determined facts

fe = expected frequency of occurrence

To test the significance of Chi-square, we enter Table IV of the Appendix with the computed value of Chi-square for the appropriate number of degrees of freedom. The number of degrees of freedom $df = (r-1)(c-1)$, in which r is the number of rows and c is the number of columns in which the data are tabulated.

For example consider the following data (in Table 2.5) of 500 distance learners who have been categorised into three groups, elder, middle-aged and younger on the basis of age and their preference for four colours, red, blue, yellow and green.

Table 2.5: The Chi-square Test of Independence in Contingency Table

Colour ► Age Group ▼	Red	Blue	Yellow	Green	Total
Elder	40 (38.42)	50 (45.22)	35 (39.10)	45 (47.26)	170
Middle	35 (36.16)	42 (42.56)	44 (36.80)	39 (44.48)	160
Younger	38 (38.42)	41 (45.22)	36 (39.10)	55 (47.26)	170
Total	113	133	115	139	500

Across the first row of the table, you find that out of 170 distance learners in the older age-group, 40 have given their preference for red colour, 50 for blue, 35 for yellow, and 45 for green. Reading down the first column, you find that out of 113 distance learners giving preference for red colour, 40 belong to the older age-group, 35 to middle and 38 to younger age-group. The other columns and rows are interpreted in the same way.

The hypothesis to be tested is the null hypothesis, that is, age and colour preferences are essentially unrelated or independent. To compute Chi-square you must calculate an independent value, i.e., expected frequency for each cell in the contingency table. Independent values are represented by the figures in parentheses within the different cells. They give the number of students whom you should expect to fall in a particular age-group, showing their preference for a particular colour in the absence of any real association.

The calculation of expected frequencies (f_e) and Chi-square (X^2) are shown as under:

1. Calculation of expected frequencies (f_e)

$$\text{Row I:} \quad \frac{133 \times 170}{500} = 38.42; \quad \frac{133 \times 170}{500} = 45.22$$

$$\frac{115 \times 170}{500} = 39.10; \quad \frac{139 \times 170}{500} = 47.26$$

$$\text{Row II:} \quad \frac{113 \times 160}{500} = 36.16; \quad \frac{133 \times 160}{500} = 44.56$$

$$\frac{115 \times 160}{500} = 36.80; \quad \frac{139 \times 160}{500} = 44.48.$$

$$\text{Row III:} \quad \frac{113 \times 170}{500} = 38.42; \quad \frac{133 \times 170}{500} = 45.22$$

$$\frac{115 \times 170}{500} = 39.10; \quad \frac{139 \times 170}{500} = 47.26$$

2. Computation of the Chi-square value

Using formula (9)

$$X^2 = \sum \left[\frac{(fo - fe)^2}{fe} \right]$$

$$\frac{(40 - 38.42)^2}{38.42} + \frac{(50 - 45.22)^2}{45.22} + \frac{(35 - 39.10)^2}{39.10} + \frac{(45 - 47.26)^2}{38.42} +$$

$$\frac{(35 - 36.16)^2}{36.16} + \frac{(42 - 42.56)^2}{42.56} + \frac{(44 - 36.80)^2}{36.80} + \frac{(39 - 44.48)^2}{44.48} +$$

$$\frac{(38 - 38.42)^2}{38.42} + \frac{(41 - 45.22)^2}{45.22} + \frac{(36 - 39.10)^2}{39.10} + \frac{(55 - 47.26)^2}{47.26}$$

$$X^2 = 5.182$$

$$\begin{aligned} 3. \quad df &= (r-1)(c-1) \\ &= (3-1)(4-1) \\ &= 8 \end{aligned}$$

The X^2 critical values for 8 df as given in Table IV (See Appendix) are 15.507 and 20.090 respectively for .05 and .01 levels of significance and the obtained value, 5.182, is less than the table value even at .05 level. This indicates that there is no relationship between the age and the colour preference and thus the hypothesis that age and colour preference are essentially independent may be accepted at .05 level of significance.

In the case of 2 x 2 contingency table, with $(r-1)(c-1) = 1$ df, there is no need of computing the expected frequencies (independence values) for each cell. The formula is:

$$X^2 = \frac{N(|AD - BC|)^2}{(A+B)(C+D)(A+C)(B+D)} \dots\dots\dots(10)$$

In the above formula A, B, C and D are the frequencies in the first, second, third and fourth cells respectively and the vertical lines in $|AD - BC|$ mean that the difference is to be taken as positive.

To illustrate the use of formula (10), let us determine whether item 5 of an achievement test differentiates between high and low achievers. The responses to items are given in the following 2 x 2 contingency Table.

Table 2.6: The Chi-square Test in 2 x 2 Fold Contingency Table

	Passed item 5	Failed item 5	Total
	(A)	(B)	(A + B)
High Achiever	115	35	150
	(C)	(D)	(C + D)
Low Achiever	40	90	130
	(A+C)	(B+D)	
Total	155	125	280

Using formula (10)

$$\begin{aligned}
 X^2 &= \frac{280 (|115 \times 90 - 35 \times 40|)^2}{(115 + 35)(40 + 90)(115 + 40)(35 + 90)} \\
 &= \frac{280 (|10350 - 1400|)^2}{(150)(130)(155)(125)} = 59.36
 \end{aligned}$$

Since the computed X^2 value of 59.36 exceeds the critical X^2 value of 6.635 to be significant at .01 level, we reject the hypothesis that item 5 of the test, does not discriminate significantly between high and low achievers. In other words, it may be concluded that item 5 of the achievement test discriminates significantly between the two groups, namely high and low achieving students.

Further, when entries in 2x2 table are less than 10, Yate's correction for continuity is applied to formula (10). The corrected formula reads:

$$X^2 = \frac{N (|AD - BC| - N/2)^2}{(A+B)(C+D)(A+C)(B+D)} \dots\dots\dots(11)$$

The following example illustrates the use of formula (11).

Fifteen male and twelve female counsellors of a study centre were asked to express their attitude towards population education. Both the groups of counsellors were administered

the attitude scale and were classified as having either positive or negative attitude towards population education. The distribution of the sample is shown in table 2.7.

Table 2.7: Distribution of Male and Female Counsellors in Terms of their Positive or Negative Attitude towards Population Education.

	Positive Attitude	Negative Attitude	Total
	(A)	(B)	(A+B)
Female Counsellors	7	5	12
	(C)	(D)	(C+D)
Male Counsellors	9	6	15
	(A+C)	(B+D)	
Total	16	11	27

$$\begin{aligned}
 X_c^2 &= \frac{27 (|7 \times 6 - 5 \times 9| - 27/2)}{(7+5)(9+6)(7+9)(5+6)} \\
 &= \frac{27(|42 - 45| - 13.5)}{12 \times 15 \times 16 \times 11} \\
 &= 0.23
 \end{aligned}$$

Since the obtained value of X^2 , 0.23, is less than the table value of 3.842 to be significant at .05 level of significance, it may be inferred that there is no true difference in the attitude of male and female counsellors towards population education.

B. Application of Median Test

The median test is used for testing whether two independent samples differ in central tendencies. It gives information as to whether it is likely that two independent samples have been drawn from populations with the same median. It is particularly useful whenever the measurements for two samples are expressed in an ordinal scale.

In the median test, you first compute the combined median for all rank measures in both samples. Then both sets of rank measures at the combined median are dichotomised and the data are set in a 2x2 Table as shown in Table 2.8.

Table 2.8: 2x2 Table for use of the Median Test

	Group I	Group II	Total
No. of measures above the combined median	(A)	(B)	(A + B)
No. of measures below the combined median	(C)	(D)	(C + D)
Total	(A+C)	(B+D)	

Under the null-hypothesis, you would expect about half of each group's measures to be above the combined median and about half to be below it, that is, you would expect frequencies A and C to be equal, and frequencies B and D to be nearly equal. In order to test this null-hypothesis, you calculate, f^2 using the formula (12):

$$f^2 = \frac{N(|AD - BC| - N/2)^2}{(A+B)(C+D)(A+C)(B+D)} \dots\dots\dots(12)$$

Let us illustrate the use of the formula (12) in the following example.

Eighteen male and female distance learners of a study centre of an open university were asked to express their attitude towards the functioning of a study centre. Both the groups were administered an attitude scale and a common median attitude measure was worked out. The number of cases from both the groups falling above and below the median point is shown in Table 2.9

Table 2.9: Distribution of Distance Learners (Male and Female) Below and Above the Common Median

	Below Median	Above Median	Total
Female Distance Learners	10	4	14
Male Distance Learners	6	12	18
Total	16	16	32

Using formula (12),

$$= 3.17$$

Since the obtained value 3.17 of f^2 for 1 df does not exceed the f^2 critical value of 3.84 for a two-tailed test at .05 level, the null hypothesis is retained and we may conclude that there is no difference in the attitude of male and female distance learners towards the functioning of the centre.

Check Your Progress 5

The following table shows the number of the male and the female distance learners who have passed or failed an item of an achievement test. Test whether the item of the test differentiates between the two groups of males and females.

	Number Passed the Test Item	Number Failed the Test Item
Males	30	20
Females	25	15

Notes: (a) Space is given below for writing your answer.
(b) Compare your answer with the one given at the end of the Unit.

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2.5 LET US SUM UP

In this Unit you studied the nature of parametric and non-parametric tests alongwith the assumptions they are based on. The applications of some parametric tests (Z, t and F) and non-parametric tests (Chi-square) in the analysis of data have also been discussed.

- 1. Parametric tests are used in the analysis of data available in interval or ratio scales of measurement.

2. Parametric tests assume that the data are normally or nearly normally distributed.
3. Z-test, t-test and F-test are the most commonly used parametric tests.
4. If large-sized samples, i.e., those greater than 30 in size, are selected at random from an infinite population, the distribution of sample means is called the 'sampling distribution of means'. This distribution is normal and it possesses all the following characteristics of a normal distribution:
 - i) The average value of sample means will be the same as the mean of population.
 - ii) The distribution of the sample means around the population mean has its own standard deviation which is known as the 'standard error of the mean' (SE_M or σ_M).
 - iii) The sampling distribution is centred at the unknown population mean with its standard deviation 0.50.
 - iv) The sample means often fall equally on the positive and negative sides of the population mean.
 - v) About 2/3 of the sample means (exactly 68.26 per cent) will lie within $\pm 1.00 \sigma_M$ of the population mean, i.e., within a range of $\pm 1 \times 0.50$ or ± 0.50 of the population mean.
 - vi) 95 of the 100 sample means will lie within $\pm 1.96 \sigma_M$ of the population mean, i.e., 95 of 100 sample means will lie within $\pm 1.96 \times 0.50$ or ± 0.98 of the population mean.
 - vii) 99 of the 100 sample means will be within $\pm 2.58 \sigma_M$ of the population mean, i.e., 99 of our sample means will lie within $\pm 2.58 \times 0.50$ or ± 1.29 of the population mean.
5. If we draw a large sample randomly from a population and compute its mean, the mean has 95 percent chance of being within $1.96 \sigma_M$ units from the population mean. Also, there is a 99 percent chance that the sample mean lies within $2.58 \sigma_M$ units from the population mean. To be more specific, there is 95 percent probability that the limits $M \pm 1.96 \sigma_M$ enclose the population mean and 99 percent probability that the limits $M \pm 2.58 \sigma_M$ enclose the population mean.
6. The limits $M \pm 1.96 \sigma_M$ and $M \pm 2.58 \sigma_M$ are called 'confidence intervals' for .05 and .01 levels of confidence respectively.
7. When a 'statistic' is used to estimate a 'parameter', the number of 'degrees of freedom' depends upon the restrictions placed. Therefore, the number of degrees of freedom (df) will vary from one statistic to another. In estimating the population mean from the sample mean, for example, 1 df is lost and so the number of degrees of freedom is N-1.

8. The Z-test is used for testing the significance of the difference between the means of two large samples.
9. The t-test is used for testing the significance of the difference between the means of two small samples.
10. Under the null hypothesis, the difference between the sample means may be either plus or minus and as often in one direction as in the other from the true (population) difference of zero, so that in determining probabilities we take both tails of the normal sampling distribution and make use of two-tailed test. But in many situations our primary concern is with the direction of the difference rather than with its existence in absolute terms. In such situations, we make use of one-tailed test.
11. We use Z-test and t-test to determine whether there is any significant difference between means of two random samples. But when the number of samples is more than two, F-test, based on the technique of analysis of variance, is used for testing the significance of the sample means.
12. Non-parametric tests are used in the analysis of non-parametric data, i.e., when the data are available in nominal or ordinal scales of measurement.
13. Non-parametric tests are distribution-free tests and do not rest upon the more stringent assumptions of normally distributed population.
14. Chi-square test, median test, Sign-test, Mann-Whitney U test, Wilcoxon Matched Pairs Signed Ranks test and Kolmogorov Smirnov two Sample test are examples of some non-parametric tests.
15. Chi-square is used with discrete data in the form of frequencies. It is a test of independence, and is used to estimate the likelihood that some factor other than 'chance' accounts for the observed relationship between the variables.
16. Median test is used for testing whether two independent samples differ in central tendencies. It is particularly useful whenever the measurements for the two samples are expressed in an ordinal scale.

Now, use the following check list and see whether you have learnt to:

- classify various statistical tests,
- describe the nature of parametric tests along with the assumptions on which they are based,
- define sampling distribution of means,
- define the standard error of mean,
- define the confidence intervals and levels of confidence,
- compute 0.95 and 0.99 confidence intervals for the true mean from a large sample mean,
- define and illustrate the concept of degrees of freedom,

- compute 0.95 and 0.99 confidence intervals for the true mean from the sample mean,
- apply Z-test for testing the significance of the difference between means of two independent large samples involving: (i) one-tailed and (ii) two tailed tests,
- apply t-test for testing the significance of the difference between means of two independent small samples involving: (i) one-tailed and (ii) two tailed tests,
- describe the nature and uses of the analysis of variance,
- state the basic assumptions of the technique of analysis of variance,
- apply F-test for testing the significance of the difference between means,
- describe the nature of the non-parametric tests alongwith their assumptions,
- name various non-parametric tests,
- describe the use of Chi-square test,
- illustrate the application of Chi-square test, and
- describe the use of median test.

2.6 GLOSSARY

Parametric Tests:

These are statistical tests which are used for analysing parametric data and making inferences about the parameters from the statistics. These tests are based upon certain assumptions about the nature of data distributions and the types of measure used.

Non-parametric Tests:

These are statistical tests which are used for analysing non-parametric data and making possible useful inferences without any assumptions about the nature of data distributions.

Standard Error of Mean:

It is the standard deviation of a distribution of sample means.

Degrees of Freedom:

The number of degrees of freedom in a distribution is the number of observations or values that are independent of each other, and cannot be deduced from each other.

2.7 CHECK YOUR PROGRESS: THE KEY

1. Parametric data should be used if the following basic assumptions are met. These assumptions are based on the nature of the population distribution and on the way the scale is used to quantify the data observations.
 - i) The observations are independent. The selection of one case is not dependent upon the selection of any other case.
 - ii) The population values are normally distributed.
 - iii) The samples have equal or near equal variances. This condition is known as equality or homogeneity of variances and is particularly important to determine when the samples are small.
 - iv) The variables described are expressed in interval or ratio scale and not in nominal or ordinal scales of measurement.

2. The Standard Error of Mean is

$$\begin{aligned}
 SE_M &= \sigma_M = \frac{\sigma}{\sqrt{N}} \\
 &= \frac{5.82}{\sqrt{100}} \\
 &= \frac{5.82}{10} \\
 &= 0.582
 \end{aligned}$$

3 i)

Boys (N ₁ =5)			Girls (N ₂ =8)		
X ₁	x ₁	X ₁ ²	X ₂	x ₂	X ₂ ²
20	-6	36	34	9	81
22	-4	16	25	0	0
30	4	16	16	-9	81
32	6	36	30	5	25
26	0	0	22	-3	9
$\sum X_1 = 130$		$\sum X_1^2 = 104$	27	2	4
			26	1	1
			$\sum X_1 = 200$	$\sum X_2^2 = 226$	

$$\begin{aligned}
 \text{Mean} = M_1 &= \frac{\sum X_1}{N_1} = \frac{130}{5} \\
 &= 26.00
 \end{aligned}$$

$$\begin{aligned}
 \text{Mean} = M_2 &= \frac{\sum X_2}{N_2} = \frac{200}{5} \\
 &= 25.00
 \end{aligned}$$

- ii) $df = N_1 + N_2 - 2 = 5 + 8 - 2 = 11$
- iii) Using formula (7)

$$\begin{aligned}
 t &= \frac{|M_1 - M_2|}{\sqrt{\left(\frac{\sum x_1^2 + \sum x_2^2}{N_1 + N_2 - 2}\right) \left(\frac{N_1 + N_2}{N_1 \times N_2}\right)}} \\
 &= \frac{|26 - 25|}{\sqrt{\left(\frac{104 + 226}{5_1 + 8 - 2}\right) \left(\frac{5 + 8}{5 \times 8}\right)}} \\
 &= \frac{1}{\sqrt{9.75}} \\
 &= 0.32
 \end{aligned}$$

- iv) We used a two-tailed test as we are not hypothesising a direction of the difference between the means. The t-values as given in Table II in the Appendix for 11 df for .05 and .01 columns are 2.20 and 3.1 respectively. Since the obtained value of 0.32 is less than these table values, the difference between the mean interest scores of boys and girls is not significant.

4. Non-parametric tests are distribution-free tests and are based on the following assumptions:
 - i) The nature of the population distribution, from which samples are drawn is not known to be normal.
 - ii) The variables are expressed in nominal form (classified in categories and represented by frequency counts).
 - iii) The variables are expressed in ordinal form (ranked in order).

5. i) The number of the males and the females who have passed or failed the test item is given in the following 2 x 2 table.

	Number Passed	Number Failed	Total
Males	30 (A)	20 (B)	50 (A+B)
Females	25 (C)	15 (D)	40 (C+D)
Total	55 (A+C)	35 (B+D)	90

- ii) Using formula (10)

$$\begin{aligned}
 X^2 &= \frac{N(|AD - BC|)^2}{(A+B)(C+D)(A+C)(B+D)} \\
 &= \frac{90(|(30)(15) - (20)(25)|)^2}{(30+20)(25+15)(30+25)(20+15)} \\
 &= \frac{90(450 - 500)^2}{(50)(40)(55)(35)} \\
 &= 0.58
 \end{aligned}$$

- iii) Since the obtained value 0.058 of X^2 does not exceed the Table value 3.841 of X^2 at .05 level of significance, we may conclude that the test item does not differentiate between the two groups of males and females

2.8 REFERENCES

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- Guilford, J.P., (1954) *Psychometric Methods*, New York: McGraw Hill.
- Wiersmar, William, (1986) *Research Methods in Education: An Introduction*, Allyn and Bacon, Inc. Massachusetts.

2.9 APPENDIX

Table I: Fractional parts of the total area (taken as 10,000) under the normal probability curve, corresponding to distance on the base line between mean and successive points laid off from the mean in units of standard deviation

$\frac{x}{\sigma}$	00	.01	0.02	.03	.04	.05	.06	.07	.08	.09
0.0	0000	00040	080	0120	0160	0199	0239	0279	0319	0359
0.1	0398	0438	0478	0517	0557	0596	0636	0675	0714	0753
0.2	0793	0832	0871	0910	0948	0987	1026	1054	1103	0141
0.3	1179	1217	1255	1293	1331	1368	1406	1443	1480	1517
0.4	1554	1591	1628	1664	1700	1736	1772	1808	1844	1879
0.5	1915	1950	1985	2019	2054	2088	2123	2157	2190	2224
0.6	2257	2291	2324	2357	2389	2422	2454	2486	2517	2549
0.7	2580	1611	2642	2673	2704	2734	2764	2794	2823	2852
0.8	2881	2910	2939	2967	2995	3023	3051	3078	3106	3133
0.9	3159	3186	3212	3238	3264	3290	3315	3340	3365	3389
1.0	3413	3438	3461	3485	3508	3531	3554	3577	3599	3621
1.1	3643	3665	3686	3708	3729	3749	3770	3790	3810	3830
1.2	3849	3869	3888	3907	3925	3944	3962	3980	3997	4015
1.3	4032	4049	4066	4082	4099	4115	4131	4147	4162	4177
1.4	4192	4207	4222	4236	4251	4265	4279	4292	4306	4319
1.5	4332	4345	4357	4370	4383	4394	4406	4418	4429	4441
1.6	4452	4463	4474	4484	4495	4505	4515	4525	4535	4545
1.7	4554	4564	4573	4582	4591	4599	4608	4616	4625	4633
1.8	4641	4649	4656	4664	4671	4678	4686	4693	4699	4706
1.9	4713	4719	4726	4732	4738	4744	4750	4756	4761	4767
2.0	4772	4778	4783	4788	4793	4798	4803	4808	4812	4817
2.1	4821	4826	4830	4834	4838	4842	4846	4850	4854	4857
2.2	4861	4864	4868	4871	4875	4878	4881	4884	4887	4890
2.3	4893	4896	4898	4901	4904	4906	4909	4911	4913	4916
2.4	4918	4920	4922	4925	4927	4920	4931	4932	4934	4936
2.5	4938	4940	4941	4943	4945	4946	4948	4949	4951	4952
2.6	4953	4955	4956	4957	4959	4960	4961	4962	4963	4964
2.7	4965	4966	4967	4968	4969	4970	4971	4972	4973	4974
2.8	4974	4975	4976	4977	4977	4978	4979	4979	4980	4981
2.9	4981	4982	4982	4983	4984	4984	985	4985	4986	4987
3.0	4986.5	4986.9	4987.2	4987.8	4988.2	4992.4	4988.9	4989.3	4989.7	74990
3.1	4990.3	4990.6	4991	4991.3	4991.6	4991.8	4992.1	4992.4	4992.6	64992.9
3.2	4993.129									
3.3	4995.166									
3.4	4996.631									
3.5	4997.674									
3.6	4998.409									
3.7	4998.992									
3.8	4999.277									
3.9	4999.519									
4.0	4999.683									
4.5	4999.966									
5.0	4999.997133									

Table II: Table of Critical Values of t

Degree of Freedom	Level of Significance			
	0.10	0.05	0.02	0.01
1	6.34	12.71	31.82	63.66
2	2.92	4.30	6.96	9.62
3	2.35	3.18	4.54	5.84
4	2.13	2.78	3.75	4.60
5	2.02	2.57	3.36	4.03
6	1.94	2.47	3.14	3.71
7	1.90	2.36	3.00	3.50
8	1.86	2.31	2.90	3.36
9	1.83	2.26	2.82	3.25
10	1.81	2.23	2.76	3.17
11	1.80	2.20	2.72	3.11
12	1.78	2.18	2.68	3.06
13	1.77	2.16	2.65	3.01
14	1.76	2.14	2.62	2.98
15	1.75	2.13	2.60	2.95
16	1.75	2.12	2.58	2.92
17	1.74	2.11	2.57	2.90
18	1.73	2.10	2.55	2.88
19	1.73	2.09	2.54	2.86
20	1.72	2.09	2.53	2.84
21	1.72	2.08	2.52	2.83
22	1.72	2.07	2.51	2.82
23	1.71	2.07	2.5	2.81
24	1.71	2.06	2.49	2.8
25	1.71	2.06	2.48	2.79
26	1.71	2.06	2.48	2.78
27	1.7	2.05	2.47	2.77
28	1.7	2.05	2.47	2.76
29	1.7	2.04	2.46	2.76
30	1.7	2.04	2.46	2.75
35	1.69	2.03	2.44	2.72
40	1.68	2.02	2.42	2.71
45	1.68	2.02	2.41	2.69
50	1.68	2.01	2.4	2.68
60	1.67	2.00	2.39	2.66
70	1.67	2.00	2.38	2.64
80	1.66	1.99	2.38	2.64
90	1.66	1.99	2.37	2.63
100	1.66	1.98	2.36	2.63
125	1.66	1.98	2.36	2.62
150	1.66	1.98	2.35	2.61
200	1.65	1.97	2.35	2.6
300	1.65	1.97	2.34	2.59
400	1.65	1.97	2.34	2.59
500	1.65	1.96	2.33	2.59
1000	1.65	1.96	2.33	2.58
∞	1.65	1.96	2.33	2.58

Table III: F-ratios for .05 (roman) and .01 (bold face) levels of Significance

		Degrees of freedom for greater mean square									
1		2	3	4	5	6	8	12	24	8	
Degrees of freedom for smaller mean square	1	161.45	199.5	215.72	224.57	230.17	233.97	238.89	243.91	249.04	254.32
		4052.1	4999.93	5403.49	5625.14	5764.08	5859.39	5981.34	6105.83	6234.16	6366.48
	2	18.51	19	19.16	19.25	19.3	19.33	19.37	19.41	19.45	19.5
		98.49	99.01	99.17	99.25	99.33	99.33	99.36	99.42	99.46	99.5
	3	10.13	9.55	9.28	9.12	9.01	8.94	8.84	8.74	8.64	8.53
		34.12	30.81	29.46	28.71	28.24	27.91	27.49	27.05	26.6	26.12
	4	7.71	6.94	6.59	6.39	6.26	6.16	6.04	5.91	5.77	5.62
		21.2	18	16.69	15.98	15.52	15.21	14.8	14.37	13.93	13.46
	5	6.61	5.79	5.41	5.19	5.05	4.95	4.82	4.68	4.53	4.36
		16.26	13.27	12.06	11.39	10.97	10.67	10.27	9.89	9.47	9.02
	6	5.99	5.14	4.76	4.53	4.39	4.28	4.15	4	3.84	3.67
		13.74	10.92	9.78	9.15	8.75	8.47	8.1	7.72	7.31	6.88
	7	5.59	4.74	4.35	4.12	3.97	3.87	3.73	3.57	3.41	3.23
		12.25	9.55	8.45	7.85	7.64	7.19	6.84	6.47	6.07	5.65
	8	5.32	4.46	4.07	3.84	3.69	3.58	3.41	3.28	3.12	2.93
		11.26	8.65	7.59	7.01	6.63	6.37	6.03	5.67	5.28	4.86
	9	5.12	4.26	3.86	3.64	3.48	2.37	3.23	3.07	2.9	2.71
		10.56	8.02	6.99	6.42	6.06	8.8	5.47	5.11	4.73	4.31
	10	4.96	4.1	3.71	3.48	3.33	3.22	3.07	2.91	2.74	2.54
		10.04	7.56	6.55	5.99	5.64	5.39	5.06	4.71	4.33	3.91
	11	4.84	3.98	3.59	3.36	3.2	3.09	2.95	2.79	2.61	2.4
		9.65	7.2	6.22	5.67	5.32	5.07	4.74	4.4	4.02	3.6

Table III: Continued

	Degrees of freedom for greater mean square									
	1	2	3	4	5	6	8	12	24	8
12	4.75	3.88	3.49	3.26	3.11	3	2.85	2.69	2.5	2.3
	9.33	6.93	5.95	5.41	5.06	4.82	4.5	4.16	3.78	3.36
13	4.67	3.8	3.41	3.18	3.02	2.92	2.77	2.6	2.42	2.21
	9.07	6.7	5.74	5.2	4.86	4.62	4.3	3.96	3.59	3.16
14	4.6	3.74	3.34	3.11	2.96	2.85	2.7	2.53	2.35	2.13
	8.86	6.51	5.56	5.03	4.69	4.46	4.14	3.8	3.43	3
15	4.54	3.68	3.29	3.06	2.9	2.79	2.64	2.48	2.29	2.07
	8.68	6.36	5.42	4.89	4.56	4.32	4	3.67	3.29	2.87
16	4.49	3.63	3.24	3.01	2.85	2.74	2.59	2.42	2.24	2.01
	8.53	6.23	5.29	4.77	4.44	4.2	3.89	3.55	3.18	2.75
17	4.45	3.59	3.20	2.96	2.81	2.7	2.55	2.38	2.19	1.96
	8.4	6.11	5.18	4.67	4.34	4.1	3.79	3.45	3.08	2.65
18	4.41	3.55	3.16	2.93	2.77	2.66	2.51	2.34	2.15	1.92
	8.28	6.01	5.09	4.58	4.25	4.01	3.71	3.37	3.01	2.57
19	4.38	3.52	3.13	2.9	2.74	2.63	2.48	2.31	2.11	1.88
	8.18	5.93	5.01	4.5	4.17	3.94	3.63	3.3	2.92	2.49
20	4.35	3.49	3.1	2.87	2.71	2.6	2.45	2.28	2.08	1.84
	8.1	5.85	4.94	4.43	4.1	3.87	3.56	3.23	2.86	2.42
21	4.32	3.47	3.07	2.84	2.68	2.57	2.42	2.25	2.05	1.81
	8.02	5.78	4.87	4.37	4.04	3.81	3.51	3.17	2.8	2.36
22	4.3	3.44	3.05	2.82	2.66	2.55	2.4	2.23	2.03	1.78
	7.94	5.72	4.82	4.31	3.99	3.75	3.45	3.12	2.75	2.3
23	4.28	3.42	3.03	2.8	2.64	2.53	2.38	2.2	2	1.76
	7.88	5.66	4.76	4.46	3.94	3.71	3.41	3.07	2.7	2.26

Table III: Continued

	Degrees of freedom for greater mean square									
	1	2	3	4	5	6	8	12	24	8
24	4026	3.4	3.01	2.78	2.62	2.51	2.36	2.18	1.98	1.73
	7.82	5.61	4.72	4.22	3.9	3.67	3.36	3.03	2.66	4.21
25	4.24	3.38	2.99	2.76	2.6	2.49	2.34	2.16	1.96	1.71
	7.77	5.57	4.68	4.18	3.86	3.63	3.32	2.99	2.62	2.17
26	4.22	3.37	2.98	2.74	2.59	2.47	2.32	2.15	1.95	1.69
	7.72	5.53	4.64	4.14	3.82	3.59	3.29	2.96	2.58	2.13
27	4.21	3.35	2.96	2.73	2.57	2.46	2.3	2.13	1.93	1.67
	7.68	5.49	4.6	4.11	3.78	3.56	3.26	2.93	2.55	2.1
28	4.2	3.34	2.95	2.71	2.56	2.44	2.29	2.12	1.91	1.65
	7.64	5.45	4.57	4.07	3.75	3.53	3.23	2.9	2.52	2.06
29	4.18	3.33	2.93	2.7	2.54	2.43	2.28	2.1	1.9	1.64
	7.6	5.42	4.54	4.04	3.73	3.5	3.2	2.87	2.49	2.08
30	4.17	3.32	2.92	2.69	2.53	2.42	2.27	2.09	1.89	1.62
	7.56	5.39	4.51	4.02	3.7	3.47	3.17	2.84	2.47	2.01
35	4.12	3.26	2.87	2.64	2.48	2.37	2.22	2.04	1.83	1.57
	7.42	5.27	4.4	3.91	3.59	3.37	3.07	2.74	2.37	1.9
40	4.08	3.23	2.84	2.61	2.45	2.34	2.18	2	1.79	1.52
	7.31	5.18	4.31	3.83	3.51	3.29	2.99	2.66	2.29	1.82
45	4.06	3.21	2.81	2.58	2.42	2.31	2.15	1.97	1.76	1.48
	7.23	5.11	4.25	3.77	3.45	3.23	2.94	2.61	2.23	1.75
50	4.03	3.18	2.79	2.56	2.4	2.29	2.13	1.95	1.74	1.44
	7.17	5.06	4.2	3.72	3.41	3.19	2.89	2.56	2.18	1.68
60	4	3.15	2.76	2.52	2.37	2.25	2.1	1.92	1.7	1.39
	7.08	4.98	4.13	3.65	3.34	3.12	2.82	2.5	2.12	1.6

Table III: Continued

	Degrees of freedom for greater mean square									
	1	2	3	4	5	6	8	12	24	8
70	3.98	3.13	2.74	2.5	2.35	2.23	2.07	1.89	1.67	1.35
	7.01	4.92	4.07	3.6	3.29	3.07	2.78	2.45	2.07	1.53
80	3.96	3.11	2.72	2.49	2.33	2.21	2.06	1.88	1.65	1.31
	6.96	4.88	4.04	3.56	3.26	3.04	2.74	2.42	2.03	1.47
90	3.95	3.1	2.71	2.47	2.32	2.2	2.04	1.86	1.64	1.28
	6.92	4.85	4.01	3.53	3.23	3.01	2.72	2.39	2	1.43
100	3.94	3.09	2.7	2.46	2.3	2.19	2.03	1.85	1.63	1.26
	6.9	4.82	3.98	3.51	3.21	2.99	2.69	2.37	1.98	1.39
125	3.92	3.07	2.68	2.44	2.29	2.17	2.01	1.83	1.6	1.21
	6.84	4.78	3.94	3.47	3.17	2.95	2.66	2.33	1.94	1.32
150	3.9	3.06	2.66	2.43	2.27	2.16	2	1.82	1.5	1.18
	6.81	4.75	3.91	3.45	3.14	2.92	2.63	2.31	1.92	1.27
200	3.89	3.04	2.65	2.42	2.26	2.14	1.98	1.8	1.57	1.14
	6.76	4.71	3.88	3.41	3.11	2.89	2.6	2.28	1.88	1.21
300	3.87	3.03	2.64	2.41	2.25	2.13	1.97	1.79	1.55	1.1
	6.72	4.68	3.85	3.38	3.08	2.86	2.57	2.24	1.85	1.14
400	3.86	3.02	2.63	2.4	2.24	2.12	1.96	1.78	1.54	1.07
	6.7	4.66	3.83	3.37	3.06	2.85	2.56	2.23	1.84	1.11
500	3.86	3.01	2.62	2.39	2.23	2.11	1.96	1.77	1.54	1.06
	6.69	4.065	3.82	3.36	3.05	2.84	2.55	2.2	1.83	1.08
1000	3.85	3	2.61	2.38	2.22	2.1	1.95	2.76	1.53	1.03
	6.66	4.63	3.8	3.34	3.04	2.82	2.53	2.2	1.81	1.04
8	3.84	2.99	2.6	2.37	2.21	2.09	1.94	1.75	1.52	
	6.64	4.6	3.78	3.32	3.02	2.8	2.51	2.18	1.79	

Table IV: X2 Table. P give the probability of exceeding the tabulated value of X2 for the specified number of degrees of freedom (df). The values of X2 are printed in the body of the table

df	0.95	0.90	0.80	0.70	0.50	0.30	0.20	0.10	0.05	0.02	0.01
1	0.00393	0.0158	0.0642	0.148	0.455	1.074	1.642	2.706	3.841	5.024	6.635
2	0.103	0.211	0.446	0.713	1.383	2.408	3.219	4.605	5.991	7.824	9.21
3	0.352	0.584	1.005	1.424	2.366	3.665	4.642	6.251	7.815	9.837	11.345
4	0.711	1.064	1.649	2.195	3.357	4.878	5.989	7.779	9.488	11.668	13.277
5	1.145	1.61	2.343	3	4.351	6.064	7.289	9.236	11.07	13.388	15.086
6	1.635	2.204	3.07	3.828	5.348	7.231	8.558	10.645	12.592	15.083	16.812
7	2.167	2.833	3.822	4.671	6.346	8.383	9.803	12.017	14.067	16.622	18.475
8	2.733	3.49	4.594	5.527	7.344	9.524	11.03	13.362	15.507	18.168	20.09
9	3.325	4.168	5.38	6.393	8.313	10.656	12.242	14.684	16.919	19.679	21.666
10	3.94	4.865	6.179	7.267	9.312	11.781	13.442	15.987	18.307	21.161	23.209
11	4.575	5.578	6.989	8.148	10.341	12.899	14.631	17.275	19.675	22.618	24.725
12	5.226	6.304	7.807	9.034	11.31	14.011	15.812	18.549	21.026	24.054	26.217
13	5.892	7.042	8.634	9.926	12.34	15.119	16.985	19.812	22.362	25.472	27.688
14	6.571	7.79	9.467	10.821	13.339	16.222	18.151	21.064	23.685	26.873	29.241
15	7.261	8.547	10.307	11.721	14.339	17.322	19.311	22.307	24.996	28.259	30.578
16	7.962	9.312	11.152	12.624	15.338	18.418	20.465	23.542	26.296	29.633	32
17	8.672	10.085	12.002	13.531	16.338	19.511	21.615	24.76	27.587	30.995	33.409
18	9.39	10.865	12.857	14.44	17.338	20.601	22.76	25.989	28.869	32.346	34.805
19	10.117	11.651	13.716	15.352	18.338	21.689	23.9	27.204	30.144	33.687	36.191
20	10.851	12.443	14.578	16.266	19.337	22.775	25.038	28.412	31.41	35.02	37.566
21	11.591	13.24	15.445	17.182	20.337	23.858	26.171	29.615	32.671	36.343	38.932
22	12.338	14.041	16.314	18.101	21.337	24.939	27.301	30.813	33.924	37.659	40.289
23	13.091	14.848	17.187	19.021	22.337	26.015	28.429	32.007	35.172	38.968	41.638
24	13.848	15.659	18.062	19.943	23.337	27.096	29.553	33.196	36.415	40.27	42.98
25	14.611	16.473	18.94	20.867	24.337	28.172	30.675	34.382	37.652	41.566	44.314
26	15.379	17.292	19.82	21.792	25.336	29.246	31.795	35.563	38.885	42.856	45.642
27	16.151	18.114	20.703	22.719	26.336	30.319	32.912	36.741	40.113	44.14	46.963
28	16.928	18.939	21.588	23.647	27.336	31.391	34.027	37.913	41.337	45.419	48.278
29	17.708	19.768	22.475	24.577	28.336	32.461	35.139	39.087	42.557	46.693	49.588
30	18.493	20.599	23.364	25.508	29.336	33.53	36.25	40.256	43.773	47.962	50.892

UNIT 3 REPORTING RESEARCH

Structure

- 3.0 Introduction
- 3.1 Objectives
- 3.2 Why and How to Write a Research Report
- 3.3 The Beginning
 - 3.3.1 Chapters and their Functions
 - 3.3.2 Writing Style
 - 3.3.3 Footnotes/In-text References
 - 3.3.4 Typing and Production
 - 3.3.5 Tables and Figures
- 3.4 The End
 - 3.4.1 Bibliography and References
 - 3.4.2 Appendices
- 3.5 Let Us Sum Up
- 3.6 Check Your Progress: The Key
- 3.7 References and Further Readings



3.0 INTRODUCTION

If research findings are not reported and disseminated, the efforts put into the conduct of research are wasted. Therefore, every research activity is concluded by presenting the

results including major and minor recommendations. The reporting of a research study depends on the purpose with which it was undertaken — as a personal research, as an institutional project, as a project funded by an outside agency, or towards fulfilling the requirement for the award of a degree. While a personal research may be published in reputed journals of the discipline, projects and researches meant for the award of degrees are usually reported as a monograph (published or unpublished).

Research studies when reported follow certain standard patterns, styles and formats for maintaining parity in reporting and for easy grasp by others who are concerned with those studies. The present Unit is devoted to this aspect of educational research: **How to write a research report?** As a researcher at the Master degree level and beyond, the skills of good report writing would be an asset for you. So, we suggest you to carefully go through this unit that covers some important aspects of quality research reporting.

3.1 OBJECTIVES

After the completion of this Unit, you should be able to:

- State the reasons for writing a research report;
- List the three main components of a research report;
- Describe each component of a research report; and
- Write the final report of any research study conducted by you.

3.2 WHY AND HOW TO WRITE A RESEARCH REPORT

The least one expects out of a research work is a report. A research report is a precise presentation of the work done by a researcher while investigating a particular problem. Whether the study is conducted by an individual researcher or by an institution, the findings of the study should be reported for several reasons. The reasons are:

- People learn more about the area of study.
- The discipline gets enriched with new findings.
- Researchers and practitioners in the field can apply, test and retest the findings already arrived at.
- Other researchers can refer to the findings and utilize the findings for further work.
- Findings can be utilized and implemented by the policy makers or those who had sponsored the project.
- It adds to the growth and development of knowledge in the discipline.

It is important to understand as how to write a report. Your final report should be in accordance with the writing style required for the purpose. Whatever style you adopt, the content of the research report never varies.

The final report of a research exercise takes a variety of forms:

- A research report funded by an educational institution may be in the form of a written document.
- A research report may also take the form of an article in a professional journal.
- The research reports of students of M.Sc., M.Ed., MA(DE), M.Phil. or Doctoral programmes take the form of a thesis or dissertation.

In the following sections we shall discuss the main components of a research report. The entire research report is mainly divided into three major divisions — **the beginning, the main body** and **the end** (please see Box-1).

Beginning	Main Body	End
• Cover Page • Second Cover • Preface • Contents • List of Table • List of Figures	• Introduction • Review of related literature • Design of the study • Analysis and interpretation of data • Main findings and conclusions • Summary	• Bibliography and reference • Appendices

Box 1: Components of Research Report

3.3 THE BEGINNING

The beginning of a report is crucial to the entire work. The beginning or the preliminary section of the research report contains the following items, more or less in the order given below:

- **Cover or Title Page**
- **Preface including Acknowledgements**
- **Table of Contents**
- **List of Tables**
- **List of Figures and Illustrations**
- **Glossary**

Let us describe in brief each of the above six items of the preliminary section of a report.

i) Cover or Title Page

The cover page and the second cover page, which is called title page is the beginning of the report. Though different colleges, universities and sponsoring institutions prescribe their own format for the title page of their project report or thesis, generally, it indicates the following in the downward vertical order:

- title of the topic,
- relationship of the report to a degree, course, or organizational requirement,
- name of the researcher/author,
- name of the supervisor/guide (if required),

- name of the institution where the report is to be submitted, and
- the date of submission.

The title page should carry a concise and adequately descriptive title of the research study. Preferably, it should not contain more than 12 to 15 words. The title should briefly convey what the study is about. Researchers tend to make errors in giving the title by using too many redundant and unimportant words.

Here, we have drawn a list of a few titles of research reports and doctoral thesis:

- a) A Critical Analysis of Textual Material for Principles of Accounting and its Translation for Distance Education
- b) Developing Self-Instructional Material
- c) Planning, Design and Development of one Self-Instructional Unit in Print
- d) A Study of the Role of Distance Education in Zimbabwe in meeting the Manpower Training Needs of the Education System with particular reference to the Bachelor of Education, Educational Administration, Planning and Policy Studies Programme intake II, in Manica Land Province
- e) The Zimbabwe Government Correspondence Primary School: A Case Study

Let us analyse few of the above titles.

In title (b), it is not clear at which level the researcher is developing self instructional material. Title (d) has 40 words, whereas we have stated earlier that the title should be brief and concise. On the other hand, the title of the project (e) is clear and precise.

The title should be written either in bold letters or upper-lower case and be placed in the central portion of the top of the cover page. Here, we have reproduced the cover page of a research report in Box-2.

**THE ZIMBABWE GOVERNMENT CORRESPONDENCE
PRIMARY SCHOOL: A CASE STUDY**

A project submitted in part fulfillment for the
Master of Arts in Distance Education Degree

By
S MANYUCHI

Supervisor
L E DAHWA

STRIDE
IGNOU
NEW DELHI, INDIA
December, 2011

Box-2: Example of the title page of a research report

Note the other points mentioned on the cover page. Also observe the placement of these points.

ii) Preface including Acknowledgement

Preface is not a synonym for either Acknowledgement or Foreword. A preface should include the reasons why the topic was selected by the researcher. Preface is your chance to explain to the reader, why the topic of the research was of interest to you. It may contain your experience of conducting the study, including interesting episodes in the process that have insights into the data gathered, the methodology adopted, and the results and findings. Acknowledgement as a separate page is normally given to sincerely record the help and support received during the period of the research study. The preface and acknowledgements can also be in continuation. This page follows the title page. The acknowledgement should be non-emotional and simple.

iii) Table of Contents

A table of contents indicate the logical division of the report into various sections and subsections. In other words, the table of content presents in itemized form, the beginning, the main body and the end of the report. It should also indicate the page reference for each chapter or section and subsection on the right hand side of the table. Two sample tables of contents are given in Box 3 and 4.

TABLE OF CONTENTS		PAGE
ACKNOWLEDGEMENTS		i
TABLE OF CONTENTS		ii
LIST OF TABLES		iii
Chapter 1	Introduction	1
Chapter 2	Design of Study	14
Chapter 3	Origin of School	19
Chapter 4	Management and Operations	26
Chapter 5	Reasons for Continued Existence of Government Policy Regarding School	34
Chapter 6	Potential for Future Expansion	41
	Recommendations	45
	Suggestions for Further Studies	46
	Conclusion	48
	Reference	51
	Appendices	53

Box 3: Sample table of the contents

You must have noticed that no chapter is titled as Result or Findings. The alternative chapterization could have been as follows:

Chapter 1	Introduction
Chapter 2	Review of Related Literature
Chapter 3	Design and Methodology of the Study
Chapter 4	Results
Chapter 5	Interpretation of Results
Chapter 6	Summary & Conclusion

TABLE OF CONTENTS		Page
Preface		(i)
Acknowledgements		(ii)
List of Tables		(iii)
List of Illustrations		(iii)
Abstract		(iv)
CHAPTER 1: INTRODUCTION		
2.0	Introduction	1
2.1	Background to the Study and Rationale for Distance Education in Zimbabwe	1
2.2	Statement of the Problem	3
2.3	Objectives of the Study	4
2.4	Hypotheses	4
2.5	Significance of the Study	5
2.6	Limitations of the Study	5
2.7	Delimitation of the Study	6
2.8	Operational Definitions	6
2.9	Conclusion	7
CHAPTER 2: LITERATURE REVIEW		
2.0	Introduction	8
2.1	Origins of Distance Education in Zimbabwe	8
2.2	Objectives of the BEd (EAPPS) Programme	9
2.3	The target Group of the BEd (EAPPS) & Justification for Distance Education Mode of Learning	10
2.4	Cost-Effectiveness of Distance Education in Manpower Training	12
2.5	Distance Education and Growth with Equity	12
2.6	Importance of the BEd (EAPPS) Programme to Educational Administration	13
2.7	Distance Education and Quality Training in Manpower Development	13
2.8	Distance Education and Learner Characteristics	15
2.9	Other Research Findings on the Effectiveness of Distance Education	15
2.10	Conclusion	17
CHAPTER 3: METHODOLOGY		
3.0	Introduction	18
3.1	Research Design	18
3.2	Sampling	19
3.3	Instruments Used in Data Collection	20
3.4	Research Procedures	20
3.5	Processing and Analysing Data	22
3.6	Conclusion	22
CHAPTER 4: RESULTS AND DISCUSSION		
4.0	Introduction	23
4.1	Gender Distribution of Respondents among BEd (EAPPS) Students	23
4.2	Qualifications of Respondents among BEd (EAPPS) Students	24
4.3	Designation/Grade of Respondents among BEd (EAPPS) Students	25
4.4	Responses of BEd (EAPPS) Students on Likert Items	25
4.4.1	Response Profiles of BEd (EAPPS) Students on Positively Stated Likert items on the role of Distance Education	
4.4.2	Response Profiles of BEd (EAPPS) Students on Negatively Stated Likert items on the role of Distance Education	28
4.5	Responses on Open Ended Question by BEd (EAPPS) Students and	

	On Interview questions by Tutors	29
	4.5.1 Students' Responses from Categorised Statements	30
	4.5.2 Tutor's Responses from Categorised Statements	32
4.6	Conclusion	34
CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS		
5.0	Introduction	35
5.1	Conclusions on findings	35
5.2	Recommendations	36
5.3	Conclusion	37
REFERENCES		38
APPENDIX I – Students' Questionnaire		41
APPENDIX II – Interview Schedule for Tutors		46

Box 4: Sample table of the contents

iv) List of Tables

The table of contents page is followed by the page containing a list of tables.

The list contains the exact title of each table, table number and the page number on which the table as appear in the report. We provide you in Box 5 an example of a list of tables.

List of Tables

1.	SWOT Analysis of IEPT in India	5
2.	Projected Growth of Primary Teachers with Alternative Growth Rates	14
3.	Training Target of Teacher Educators and Guest Faculty	16
4.	Training Target of Supervisory Staff	17
5.	Total Training Target of All Categories	18
6.	Training Material for Different Categories of Trainees	24
7.	Exemplar Program Format for Primary Teachers	26
8.	Exemplar Program Format for Teacher Educators	28
9.	Exemplar Program Format for Supervisors	28
10.	Institutional Mechanism for Certification	29
11.	Nodes of the Proposed Network	33
12.	Institutional Workload	34
13.	Communication Requirements	44
14.	Role of National Educational Institutions	54
15.	Role of other Departments	55
16.	NAP Activity Schedule	58
17.	Cost of Staff/Personnel	60
18.	Cost of Preparation of Instructional Material	61
29.	Cost of Training	62
20.	Cost of Technology	63
21.	Miscellaneous Costs	63
22.	Proportion of Costs and Cost Sharing	64
23.	Year-wise Breakup of Costs during IX Plan	65

Box 5: Example of a list of tables

Source: National Action Plan: UNESCO, 1996.

In Box 5, you will notice that all the content words start with a capital letter.

v) *List of Figures and Illustrations*

The page 'List of Figures' comes immediately after the 'List of Tables' page. You will observe in the following example that the list of figures is written in the same way as the list of tables.

List of Figures		
1.	Existing IEPT Programs in a Jigsaw Puzzle	7
2.	Conceptual Framework of Capacity Building in NAP	9
3.	Network of Training Institutions	31
4.	Digital Earth Stations in India	38
5.	Interactive Distance Education Network	40
6.	Distant Classrooms	41
7.	Communication Network	43
8.	Implementation of NAP: Role of Institutions	48

Box 6: Example of a list of figures

Source: National Action Plan: UNESCO, 1996.

vi) *Glossary*

A glossary is a short dictionary, explaining the technical terms and phrases which are used with special connotation by the author. Entries of the technical terms are made in alphabetical order. A glossary may appear in the introductory pages although it usually comes after the bibliography. An example glossary is given in Box-7.

ATM (asynchronous transfer mode): A network technology for high-speed transfer of data. Packets of information are relayed in fixed sizes, enabling smooth transmission. ATM supports real-time voice and video as well as data and can reach speeds of up to 10 Gbps.

Audience: Those persons who are the receivers of a message, particularly of a mass media message. Also called receivers, readers, viewers or destination.

Audiographics: Computer-based technology that permits simultaneous transmission of voice and data communication and graphic images across local telephone lines in a way that is interactive between the instructor and all participants.

Audio Tele-Conferencing: Audio tele-conferencing, using either dedicated channels or normal telephone network, is generally used for tutorial/counselling purposes. Student groups located in different places are able to converse among themselves as well as with a distance academic counsellor simultaneously in real time in an audio teleconference. Such conferences can be a distance education equivalent of real class room situations and have the potential to obviate the need for academic counselling sessions at individual study centers. However, audio teleconferencing presupposes the existence of a highly reliable and widespread telephone system. It also needs special equipment like the audio conference bridge, etc.

Authoring Software: Software application used to produce interactive learning materials that bring together all components of a course, such as text presentation, graphics, tracking, and links.

Authoring Tool: A software application or programme that allows people to create their own e-learning courseware. Types of authoring tools include instructionally focused authoring tools, web authoring and programming tools, template-focused authoring tools, knowledge capture systems, and text and file creation.

Automatic Gain Control (AGC): Automatic gain control is a device or a control which regulates the volume of audio and video levels automatically, eliminating the need for manual adjustment for getting the desired quality of the outputs.

Box 7: Example of Glossary

(vii) List of Abbreviations

To avoid repeating long names again and again, a researcher uses abbreviations. Since abbreviations are not universal, it is necessary to provide the full form of the abbreviations in the beginning. A list of abbreviation is given in Box 8 as example.

Abbreviations

AIMA	All India Management Association
AIR	All India Radio
APPEP	Andhra Pradesh Primary Education Project
AVRC	Audio Visual Resource Centre
ATI	Administrative Training Institutes
BEL	Bharat Electronics Limited
BEO	Block Education Officer
BRC	Block Resource Centre
BSE	Board of Secondary/Senior Secondary Education
CABE	Central Advisory Board of Education
CBT	Computer Based Training
CEO	Circle Education Officer
CIET	Central Institute of Educational Technology
CRC	Cluster Resource Centre
CSS	Centrally Sponsored Scheme
DIET	District Institute of Education and Training
DIT	District Institute of Training
DD	Doordarshan
DOE	Department of Electronics
DoSpace	Department of Space
DOT	Department of Telecommunications
DPEP	District Primary Education Program
DPEPII	District Primary Education Program : Phase II
EFA	Education for All
EMRC	Educational Media Resource Centre

Box 8: Example of Abbreviation List

Activity

Take any report which has been prepared by your institution and check whether the title page contains all the essential information. If not, try to fill in the gaps.

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Check Your Progress 1

List the major parts of the 'beginning' of a research report. Describe briefly the importance of each part.

Notes: (a) Space is given below for writing your answer.

(b) Compare your answer with the one given at the end of the unit.

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3.4 THE MAIN BODY

The main body of the report presents the actual work done by an investigator or a researcher. It tells us precisely and clearly about the investigation/study from the beginning to the end. The methodology section of the final report should be written in the past tense because the study has been completed. The report should categorically avoid unnecessary details and loose language — we shall examine this point in detail in this section. At this stage, you may again look at the Box 1. You will find that the table of contents for the report outlined six sections/chapters in the main body. These are:

- **Introduction**
- **Review of Related Literature**
- **Design of the Study**
- **Analysis and Interpretation of Data**
- **Main Findings and Recommendations**
- **Summary**

Besides the logicity of sections/chapters in the main body there are certain other important aspects which need our attention. They are the style of writing, the design and

placement of references and footnotes, the typing of the report, and the tables and figures.

Let us elaborate these points in the following sub-sections.

3.4.1 Chapters and their Functions

We will discuss the chapterisation of a thesis or a research report under six heads as noted above. Let us begin with introduction which is usually the first chapter.

Introduction

This is the first chapter of a thesis or a research report. It introduces the topic or problem under investigation and its importance. The introductory chapter:

- gives the theoretical background to the specific area of investigation,
- states the problem under investigation with specific reference to its placement in the broader area under study,
- describes the significance of the present problem,
- defines the important terms used in the investigation and its reporting,
- states precisely the objective(s) of the study,
- states the hypothesis/hypotheses of the study that would be tested through statistical analysis of data, (however, in philosophical and historical research there is no need to formulate and test a hypothesis), and
- defines the scope and limitations of the investigations.

Although these sub-sections are common, it is not necessary to follow the given order strictly; there may be variations in the order of the sub-sections. Sometimes the review of literature related to the area under investigation is also presented in the first chapter and is placed immediately after providing the theoretical background to the problem. Many researchers use review to argue the case for their own investigation. In experimental research it becomes essential to review related studies to formulate the hypotheses. The introductory chapter should establish the *rationale* of the study and highlight the *significance*, including the possibility of further knowledge and understanding of the area of study.

Review of Related Literature

The second chapter of a research report usually consists of the review of the literature related to the problem under study. This includes the abstraction of earlier research studies and the theoretical articles and papers of important authorities in the field. This chapter has two functions. While selecting a problem area or simply a topic for investigation, the researcher goes through many books, journals, research abstracts, encyclopaedia, etc. to finally formulate a problem for investigation. The review of related literature is the first task for a researcher in order to decide on a specific problem for investigation. It also helps in formulating the theoretical framework for the entire study. Such a review helps the researcher to formulate the broader assumptions about the

factors/variables involved in the problem and later develop the hypothesis/hypotheses for the study.

Besides these, the review also indicates the understanding of the researcher in relation to the area under investigation, and thus his/her efficiency to carry out the study. While reviewing literature in the area concerned, you have to keep in mind that the (reviewed) literature has to be critically analyzed and summarized in terms of agreements and disagreements among the authors and researchers in order to justify the necessity for conducting your investigation. Researchers may make two types of errors in their review exercises — many simply report the findings of one study after another in sequential order without showing how the findings are connected with one another; and others report on studies that are at best only marginally related to their own hypothesis.

A comprehensive literature survey is a pre-condition for sophisticated research. Good research advances our understanding about the topic, and for that, it must tell us reasonably well all that has been already done in the past, and how the present work adds new knowledge to the already existing body of knowledge. Not doing so puts the researcher in a disadvantage position. A good review of literature accomplishes several important objectives (Boote, & Beile, 2005):

- It sets the broad contexts of the study;
- It clearly demarcates what is and what is not within the scope of the investigation;
- It justifies the decision taken to cover different constructs in the study;
- It reports on the claims made in the existing literature and provides a critique;
- It helps the researcher to distinguish between what has already been known and area left to be explored; and
- It synthesizes the body of knowledge to encourage theory development (perspective formulation).

While good research reviews are comprehensive and up-to-date, most often, it has been found that they are poorly conceptualized and written. We will see how literature reviews can be best presented in this section. However, it may be noted that literature reviews can be categorized according to a set of characteristics. According to Cooper (1988) they can be grouped into six groups: focus, goal, perspective, coverage, organization and audience. While the literature review can focus on the research findings, research methods, theories and application aspects of the research work, normally good research reviews tend to have more than one focus. Usually the goal of the research review is to integrate existing literature for articulating generalizations and resolution of conflict. It is also used to develop a critique on the topic of the study. A third goal of literature review is to identify central issues in a field of study. A third characteristic of review of literature is perspective that relates to the position taken by the researcher – neutral or espousal. The next characteristic is coverage that is normally expected to be exhaustive. However, some literature reviews are selective and representative in nature. The fifth characteristic of literature review is organization. One can take a historical (chronological) approach to

organization of review or present it in a more professional conceptual/thematic basis to align with the objectives, hypotheses and the variables in the study. The sixth characteristic is the nature of the intended audience – specialized researcher, general researchers, practitioners, policy-makers, and general public. The way reviews are presented would differ based on the target audience.

A significant aspect of good literature review is the way literature was searched. What ‘search strategies’ and ‘databases’ were used by the researcher and what ‘subject descriptors’ were used to find out the list of candidate articles for review. How the scope and duration of the review was decided is also important. Therefore, the literature review chapter must include in brief the inclusion and exclusion criteria for literature search in the beginning.

We also recommend you to follow a conceptual review approach that helps in better synthesis of knowledge and discuss related concepts at one place. It is important to build the review constructively, though it is expected that you also critically analyze the findings of the articles reviewed. In the process, you may also critique previous research, but the tone of the criticism has to be academic so as to point at the error and argue to build your perspective. It may also be noted that criticizing is easy, and it does not add value to the overall discussion, then it is better avoided.

Another important point often asked by novice researcher is to use present or past tense while writing the review. Webster and Watson (2002) recommend the use of present tense, though both can communicate effectively. The use of present tense in review writing gives a greater sense of immediacy to the reader. They also say, when attributing a statement or idea to a person, it is better to use past tense.

Good reviews identify the variables and help in formulation of hypothesis. While writing literature review, you may consider the following to improve the quality of your writing:

- Justify the criteria for inclusion and exclusion in the review
- Distinguish between what has been done in the field and what needs to be done
- Position the topic in the context of broader scholarly debate in the domain
- Review the historical contexts of the field by going to the earliest work
- Articulate important variable and phenomenon
- Use the subject vocabulary correctly and contextually
- Demonstrate the emergence of a new perspective through synthesis of ideas
- Review methodological issues to justify the research techniques
- Write in a clear, systematic and coherent manner
- Use categories and mind-map for presentation of ideas

Design of the Study

The design of a study is usually described in the third chapter of the report.

Broadly speaking, this chapter provides a detailed overview of “how” the study was

conducted. The various sub-sections include:

- i) description of the research methodology, i.e., “ descriptive, experimental, etc.;
- ii) variables: the dependent, independent and intervening variables with their operational definitions;
- iii) sample: defining the population, and the sampling procedure followed to select the sample for the present study;
- iv) listing and describing various tools and techniques used in the study, like questionnaires, attitude scales, etc., whether these have been adopted or developed by the investigator, their reliability, validity, item description, administration and scoring, etc. Tool development process needs to be explained clearly;
- v) describing the statistical technique used in the analysis of data including the rationale of the use and method of data analysis. In philosophical and historical researches, for example, this type of sub-section may not be there.

Analysis and Interpretation of Data

This is the fourth chapter of the research report. It is the heart of the whole report, for it includes the outcome of the research. The collected data are presented in tabular form and analysed with the help of statistical techniques — parametric and non-parametric. The tables are interpreted and if necessary, the findings are also presented graphically. The figures do not necessarily repeat the tables, but present data visually for easy understanding and easy comparison. Data may be presented in parts under relevant sections. The analysis of the data not only includes the actual calculations but also the final results. It is essential that at each stage of analysis the objective(s) of the study and their coverage is taken care of. This chapter also presents the details about the testing of each hypothesis and the conclusions arrived at. This gives the reader a clear idea regarding the status of the analysis and coverage of objectives from point to point.

Main Findings and Conclusion

This is usually the fifth chapter in a research report. The major findings of the study analysed and interpreted in the preceding chapter are precisely and objectively stated in this chapter. The fourth chapter contains such presentations as only a specialist or a trained researcher can understand because of the complexities involved; but in the fifth chapter the major findings are presented in a non-technical language so that even a non-specialist such as a planner or an administrator in the field can make sense out of them.

The main findings are followed by a discussion of the results/findings. The major findings are matched against the findings of other related research works which have already been reviewed in the second chapter of the report. Accordingly, the hypotheses formulated in the first chapter are either confirmed or discarded. In case the null-hypotheses are rejected, alternative hypotheses are accepted. If the findings do have any discrepancy in comparison with those of other researches, or if the findings do not explain sufficiently the situation or problem under study, or if they are inadequate for generalization, explanations with proper justification and explanation have to be provided.

The next task in this chapter is to provide implications of the findings and their generalizations. The implications should suggest activities for and provide some directions to the practitioners in the field. Unless these implications are clearly and categorically noted, it becomes difficult for the practitioners to implement them on the one hand, and on the other research findings do not get utilized at all even if they have been recorded in a report.

The implications follow a presentation/listing of the limitations of the study on the basis of which suggestions are made to carry out further investigation or extend the study from where it has reached. Normally this chapter is divided into three parts: findings, recommendations and areas of further research.

Summary

Some researchers include a summary along with the research report (as the last chapter) or as a pull-out to the report itself. It sums up precisely the whole of the research report right from the theoretical background to the suggestions for further study. Sometimes researchers get tempted to report more than what the data say. It is advisable to check this tendency and be always careful to report within the framework provided by the analysis and interpretation of data, i.e., within the limits of the findings of the study. This is also used in the beginning, when the report is expected to be used for decision-making, and the audience is high profile with less time for reading the full report.

Check Your Progress 2

Comment briefly on the uses of (a) review of literature, and (b) conclusion in a research report.

Notes: (a) Space is given below for writing your answer.

(b) Compare your answer with the one given at the end of the Unit.

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3.4.2 Writing Style

The style of writing a research report is different from other writings. The report should be very concise, unambiguous, and creatively presented. The presentation should be

simple, direct and in short sentences. Special care should be taken to see that it is not dull and de-motivating.

Statements made should be as precise as possible — they should be objective and there should be no room for subjectivity, personal bias and persuasion. Similarly, over generalisation must be avoided. There is no place for hackneyed, slang and flippant phrases and folk expressions. The writing style should be such that the sentences describe and explain the data, but do not try to convince or persuade the reader. Since the report describes what has already been completed, the writing should be in the past tense.

In the case of citations, only the last name of the author is used, and in all cases academic and allied titles like, Dr., Prof., Mr., Mrs., Ms. etc. should be avoided. Some authors recommend that the use of personal pronouns like “I”, “We” etc., should be avoided. There is, however, no hard and fast rule in this case. Similarly, a large number of research reports use passive voice which is strongly discouraged by the linguists. Similarly, abbreviations of words and phrases — like IGNOU, DDE, NIRD, etc. — should be used to avoid long names repeatedly inside the text, as well as in figures, tables, and footnotes. The first appearance of an abbreviation in the report should be used in expanded form.

Special care should be taken while using quantitative terms in a report, such as few for number, less for quantity etc. No sentence should begin with numerals like “40 students” instead it should start as “Forty students”. Commas should be used when numbers exceed three digits — 1,556 or 523,489, etc.

Language, grammar and usage are very important in a research report. *The Roget's Thesaurus* and a good dictionary would be of much help. Word processing software provides good support to

- Spelling and Grammar
- Thesaurus
- Auto Correct
- Auto Summarise

You are advised to use these features of the word processing software to make the report error free. It is always advisable to show the report to learned friends or language experts for correction before it is finally typed. Revision is an important feature of good report writing — even experienced researchers with many publications revise their reports many times before giving them for final typing.

3.4.3 Footnotes / In-text References

Articles, papers, books, monographs, etc. quoted inside the text should always accompany relevant references, i.e., the author and the year of publication e.g., (Mukherjee, 1988). If a few lines or sentences are actually quoted from a source, the page number too should

be noted e.g., (Mukherjee, 1988: 120-124). Besides, full reference should be placed in the Reference section of the report (see sub-section 3.5.1). The usual, though traditional style of giving references is to place them as the footnotes on the relevant page(s). The footnotes are serialized inside the text and in the footnotes of each chapter. These days, footnotes are usually avoided. However, they perform many functions. They provide ready reference on the page of the text itself to avoid botheration of consulting the references at the end of the report off and on. In certain cases, footnotes include explanatory statements, full form of the abbreviations, extra justifications with reference to a portion of the text that may be read by a reader if needed, i.e., if the text is not clearly understood. However, precision and necessity should be the main guidelines to bring in these types of footnote.

Footnotes, as noted earlier, may be serialised as 1, 2, 3, 4, etc., within a chapter or be inserted at the end of the sentence concerned in parentheses as (5:23) which implies reference number 5 and page number 23, the full reference of which is given at the end of the chapter or in the reference section at the end of the report. Footnotes are always double-spaced between each other, though each footnote is typed single-spaced.

Ibid. in the footnote refers to the same work and the reference that precedes it. For example, consider the following references:

⁵Best, John, W., *Research in Education*, New Delhi: Prentice Hall of India, 1993, p.146.

⁶*Ibid.* p.146 (This indicates the same work and the same page as above)

⁷*Ibid.* p.148 (This indicates the same work as above but a different page).

op. cit. (in Latin means the work cited) is used in a footnote when another reference to the same work is made on the same page but not consecutively. Consider the following example:

³Frend N. Kerlinger, *Foundations of Behavioural Research*, New York: Holt, Rinehart & Winston, 1973, p.256.

⁴William G. Campbell and Stephen V. Ballon, *Form and Style: Theses, Reports, Term Papers*, Boston: Houghton Mifflin Co., 1974, p.15.

⁵Kerlinger, *op.cit.*, p.258.

Reference '5' is the same as reference '3', except that the page references differ in the two cases.

In case there are more references to the text on the same page of the original text which has been listed once, they may be listed/entered by the abbreviation *loc. cit.*

Example: ⁶Campbell and Ballon, *loc. cit.*

Footnote is also a feature of word processing software. It allows serialization as well as customized footnote symbols.

In preparing the footnote references, another factor to be considered is the abbreviations of words and expressions and their right placement. While writing a research report, abbreviations may be used to conserve space in references or footnote references. If a researcher is not familiar with the abbreviations, he/she should consult the relevant literature as and when required. In the following table (Table 1) a comprehensive list of abbreviations has been given for ready reference (the Latin abbreviations have been italicised).

Table 1: List of some important abbreviations used in footnotes and bibliographies

Words	Abbreviations
About (approximate date)	<i>c. (circa)</i>
Above	<i>supra.</i>
And others	<i>et. al.</i>
Article, articles	art., arts.
Article, articles	<i>infra.</i>
Book, books	bk., bks.
Chapter, chapters	chap., chaps.
Column, columns	Col., Cols.
Compare	<i>cf.</i>
Division, divisions	div., divs.
Editor, editors	ed., eds.
Edition, editions	ed., eds.
For example	<i>e.g.</i>
Figure, figures	fig., figs.
Here and there (scattered)	<i>passim</i>
Illustrated	Ill
Line, lines	l. ll.
Manuscript	mss.
Mimeographed	mimeo.
No date given	n.d.
No name given	n.n.
No place given	n.p.
Number, numbers	no., nos.
Page, pages	p., pp.
Part, parts	pt., pts.
Paragraph in length	(....)
Paragraph, paragraphs	par., pars.
Previously cited	<i>op. cit.</i>
Revised	rev.
Same person	<i>idem.</i>
Same reference	<i>ibid.</i>
Section, sections	sec., secs.
See	<i>vide.</i>
The place cited	<i>loc. cit.</i>
Thus	<i>sic.</i>
Translated	trans.

3.4.4 Typing and Production

Typing of dissertations, research reports, project reports etc. needs greater care than other typed documents. In a research report, one does not expect overwriting, strikeouts, erasures and insertions.

Before typing the report, it is necessary to check whether the handwritten report, i.e., the manuscript is in a proper shape. Whether the manuscript of the report is typed by a typist or by the researcher himself/herself, a clear and comprehensible manuscript makes typing easy. Too many additions and corrections make the manuscript cramped, and a cramped manuscript makes typing difficult and time consuming. Only one side of the paper should be typed and typing should be double spaced. Space should be left on each side of the paper as follows:

- left side margin
- right side margin
- top margin
- bottom margin

If there is a lengthy quotation, it should be indented and typed in single space. At the end of each line, words should be divided as per convention. A dictionary which shows syllabification should be consulted if words are to be broken at all. Unlike the lengthy quotations, short quotations of three/four lines may be included in the text within quotation marks.

Subject to access to a computer and word processing software, it is better to prepare the report on a computer. It has several advantages, for example, you can

- edit time and again without incorporating new errors which is what happens when you use a manual typewriter,
- define your margin – top, bottom, left and right easily,
- define pages in landscape or portrait size, particularly for tables and diagrams,
- choose out of about 70+ fonts – shapes of letters and type sizes from the smallest 8 point to the large 72 point,
- check spelling, grammar, synonyms and antonyms,
- choose illustrations from the clip-art file, and
- can index (alphabetical order) the references automatically.

Graphs can be prepared using appropriate software and these can be inserted in the word processing file.

Finally, the computer output can be taken out in a Dot Matrix, Ink Jet or Laser printer. The Laser Printers are the current standard in the market. They produce quality printouts that make reading easy.

3.4.5 Tables and Figures

Tables: Preparation and appropriate placement of tables in the text are equally important. They need careful attention from the researcher. Tables help the readers to get a quick view of the data and comprehend vast data at one go. However, tables should be presented only when they are necessary. Too many tables may confuse the reader, instead of facilitating his/her reading. As such you need to be selective in placing tables in the report. If data are too complicated to be presented in one table, several tables may be used to give a clear picture of the data in proper sequential order. Tables, if small, may accompany the textual material, and if large, should be put on one full page without mixing them with the text. All the tables should be numbered serially in the text, so that they may be quoted or referred to with the help of those numbers conveniently.

If a table is large, it should continue on the next page with the table title repeated on the top of the next page; otherwise, tables can be typed in smaller fonts like 8pt. or 9pt. The table itself is centred between the two margins of the page, and its title typed in capital letters and is placed in pyramid size and preferably numbered. The title of the table should be brief but self-explanatory.

Figures: Figures are necessary when the data is to be presented in the graphic form. They include charts, maps, photographs, drawings, graphs, diagrams, etc. The important function of a figure is to represent the data in a visual form for clear and easy understanding. Textual materials should not be repeated through figures unless very necessary.

Figures should be as simple as possible and the title of each figure should precisely explain the data that has been presented. Usually, a figure is accompanied by a table of numerical data. Again, figures are presented only after textual discussion and not the other way round. The title design of figures should be followed consistently throughout the report. Every first letter of a word of the title should be in capitals, and figures should be numbered in Indian numerals like 1, 2, 3 etc. And the title, unlike for tables, is presented below the figure.

3.5 THE END

The end of the report consists of references and appendices. References come at the end after the last chapter of the report. The last section labelled references appears at the top of a new sheet of paper. The reference section is a list of the works that have been cited in the report/thesis. All references quoted in the text are listed alphabetically according to the last name of the authors. The works of the same author should be listed according to the date of publication with the earliest appearing first. It is different from a footnote in the sense that the latter is a specific reference to only one or more citations on a particular page.

3.5.1 Bibliography and References

Research reports present both bibliographies and references. Although many researchers use these terms interchangeably, the two terms have definite and distinct meanings. A *bibliography* is a list of titles – books, research reports, articles, etc. that may or may not have been referred to in the text of the research report. *References* include only such studies, books or papers that have been actually referred to in the text of the research report. Whereas research reports should present references, books meant for larger circulation may be listed in bibliographies that should include all such titles as have been referred to.

There are mainly two style manuals detailing general form and style for research reports. These are:

- American Psychological Association (2009). *Publication Manual*, 6th ed. Washington, DC: American Psychological Association (First published in 1929).
- University of Chicago (2003). *The Chicago Manual of Style*, 15th ed., Chicago: University of Chicago Press.

Style of Referencing

The style of reference as prescribed by the funding institution/journal/degree awarding body should be strictly followed. However, generally, author (date) style or author (number) style is followed for in-text reference, where author is the surname, date is year of publication, and number is a numerical in sequence. In the latter case, the references at the end are ordered according to sequence, while in the former, all the references are ordered alphabetically. We recommend you to follow standard style manual for giving reference to various categories of documents. However, we present to you, in brief, a generic style for giving reference in your research report.

For example, entries in a reference section may look like the following:

Dhanarajan, G., (1998) “Access to Learning and Asian Open Universities: In Context” *Paper presented at the 12th Annual Conference of Asian Association of Open Universities, The Open University of Hong Kong, Hong Kong SAR, China, 4-6 Nov., 1998 (Conference Paper).*

Gannicott, K., & Throsby, D. (1994) *Educational Quality and Effective Schooling*, Paris: UNESCO. **(Book- Two author).**

Jedge, Olugbemi J. (1995) Anxiety levels and factors which engender them among tertiary distance learners, *Indian Journal of Open Learning* 4(1), 1-6. **(Journal paper)**

Koul, B.N., Singh, B., & Ansari, M.M. (1988) *Studies in Distance Education*, New Delhi: IGNOU & AIU. **(Book- Three author).**

Kumar, K. L. (1995) *Educational Technology*, New Delhi: New Age Publishers **(Book- Single author).**

Ministry of Human Resource Development (1995). *DPEP: Guidelines, Department of Education*, MHRD, Government of India, New Delhi. (**Govt. Publication**).

Mukhopadhyay, M., (ed.) (1990). *Educational Technology: Challenging Issues*, New Delhi: Sterling Publishers. (**Edited Book**).

Mukhopadhyay, M. (1998). "Teacher Education and Distance Education: The Artificial Controversy", in Buch, Piloo M., (ed.) *Contemporary Thoughts on Education*, Baroda: SERD. (**Chapter in Book**)

Parhar, M. (1993). *Impact of Media on Student Learning*, Unpublished Doctoral Dissertation, New Delhi: Jamia Millia Islamia. (**Doctoral Dissertation**)

Referring Web Based Documents

Computers have brought revolution in all sectors of development including education. Computers were conventionally used for data storage, processing and retrieval. Now through Internet, information can be accessed from any part of the world. As researchers, reviewing the relevant literature related to the problem under study is almost a magnum opus. These days Internet is a rich academic and professional resource. World Wide Web (WWW) is the easiest and most popularly used browsing mechanism on the Internet. Here we will very briefly explain as how to write the references when you quote from any website and other Internet-based materials. Table 2 gives some examples.

Table 2: Example of references for Internet-based materials

Type of documents	Reference example
Ftp site	Bruckman, Amy. "Approaches to Managing Deviant Behavior in Virtual Communities." <ftp://ftp.media.mit.edu/pub/asb/papers/deviance-chi-94> (4 Dec. 1994)
Personal e-mail	Sharma, R.C. (sharma_rc@yahoo.com). 10 Jun. 2002, <i>Learning Management Systems</i> . E-mail to S. Mishra (smishra@cemca.org).
Online Journal article	Oren, Avigail, Mioduser, David & Nachmias, Rafi (April, 2002). The Development of Social Climate in Virtual Learning Discussion Groups. <i>International Review of Research in Open and Distance Learning</i> : 3, 1. Retrieved November 19, 2002, from http://www.irrodl.org/content/v3.1/mioduser.html
Article also available online	Naidu, Som (2001). Scaffolding Learning in Open, Distance and Flexible Learning Environments, <i>Global E-Journal of Open, Flexible & Distance Education</i> , 1 (1), 84-91. Retrieved November 19, 2002, from http://www.ignou.ac.in/e-journal/contents/somnaidu.htm

Article in an internet newsletter	Forman, Davis C. (November 18, 2002). Careers in E-Learning: Taking the next step. <i>Learning Circuits</i> , Retrieved November 19 2002 from http://www.learningcircuits.org/2002/nov2002/forman.html
Stand alone article without date and author	GVU's 8th WWW user survey. (n.d.). Retrieved August 8, 2000, from http://www.cc.gatech.edu/gvu/sersurveys/survey1997-10/
Stand alone article without date	Wang, Libin and Wentling, Tim L. (n.d) The relationship between distance coaching and the transfer of training, Retrieved November 19, 2002 from http://learning.ncsa.uiuc.edu/papers/coach.pdf
Discussion list message	Mishra, Sanjaya. (15 Sep, 2000). 'Results of the quick Survey on Competencies for Web-based Instructional Designer', IFETS-DISCUSSION: 343 [Online]. Retrieved November 19, 2002 from http://ifets.ieee.org/past_archives/archiv_260200_070201/0644.html
Web images	<i>Frog Dissection</i> , (n.d.). [Online image]. Retrieved November 19, 2002 from www.fmarion.edu/~bio106lab/Resources/frog1.jpg
Book available online	Farrell, Glen (2001). The Changing Faces of Virtual Education, Vancouver: The Commonwealth of Learning, Retrieved November 28, 2002 from http://www.col.org/virtualed/virtual2pdfs/Virtual2_complete.pdf

Soure: Mishra (2002)

3.5.2 Appendices

Usually, the appendices present the raw data, the true copy of the tools used in the study, important statistical calculations, photographs and charts not used inside the text. These are ordered serially like Appendix-1, Appendix-2, or they can be serialized with capital letters (Appendix A, Appendix B) etc. to facilitate referencing within the text. The appendices provide reference facilities to readers and others interested in that particular field of investigation.

Activity

1. Take any report and check whether the references are written in the standard form. If not, try to rewrite them properly.

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2. Examine the appendices in the same report. Are all of them essential for the report. Comment.

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3.6 LET US SUM UP

In this Unit, we focused on research reporting as a professional activity. The purpose of writing the report depends on the reason behind undertaking the research study. It could be for obtaining a degree, or as a project report to be submitted to the funding agency, etc. Once submitted, the funding agency and the educational managers could utilize the findings and recommendations to achieve their objectives; other researchers may seek guidance from it; and lastly, the findings may be used for developing new theories in the discipline concerned.

A research report has three parts: the beginning, the main body and the end. The beginning includes: cover or the title page, acknowledgements, table of contents, the list of tables, and the list of figures. The main body normally contains an introduction, review of the relevant literature, objectives, hypotheses, research design (research methodology, population and sample, tools, procedure of collecting data), analysis and interpretation of data, the main findings and conclusion (that also includes its educational implications and suggestions for further studies). While discussing the main body, we have talked about the style of writing the report, style and placement of footnotes and references, the typing process and the format and placement of tables and figures. We closed the discussion with notes on the style, arrangement and placement of references and appendices which constitute the end of a research report.

3.7 CHECK YOUR PROGRESS: THE KEY

1. The major parts of the beginning of a research report are: cover/title page, acknowledgements, table of contents, list of tables, list of figures and list of abbreviations. The cover page gives us clear information about the subject/theme, author and the year of the research study as well as the organization for which or where the study has been conducted. Acknowledgements are words of appreciation from the researcher for those who have helped him/her while conducting the study. Table of contents indicates the main themes/areas studied, the methodology followed and the outcome of the study. List of tables, figures and abbreviations are useful as reference tools.
2. a) Review of literature helps the researcher to specifically define the problem for investigation, decide about the usefulness of the study and formulate his/her hypothesis.
 b) The conclusion of a research report sums up the findings, states what is new in the report concerned and indicates the direction for future studies as well as implications for implementation of recommendations, if any.

3.8 REFERENCES AND FURTHER READINGS

- American Psychological Association (2009). *Publication Manual*, 6th ed. Washington, DC: American Psychological Association (First published in 1929).
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UNIT 4 EVALUATING RESEARCH REPORTS

Structure

- 4.0 Introduction
- 4.1 Objectives
- 4.2 Criteria for Evaluation of Research Reports
 - 4.2.1 Introductory Chapter: Building the Rationale
 - 4.2.2 Review of Literature
 - 4.2.3 Objectives and Hypothesis
 - 4.2.4 Choice of Research Design
 - 4.2.5 Choice of Variables
 - 4.2.6 Research Instrumentation
 - 4.2.7 Sample
 - 4.2.8 Data Collection and Analysis
 - 4.2.9 Findings and Implications
 - 4.2.10 Summary and Conclusions
 - 4.2.11 References
 - 4.2.12 Annexures
 - 4.2.13 General Indicators
- 4.3 Format for Evaluation of Research Reports
- 4.4 Let Us Sum Up
- 4.5 Check Your Progress: The Key



4.0 INTRODUCTION

Just as a research exercise adopts a scientific process, there are scientific ways of evaluating it. Unless research is scientifically evaluated, the implications cannot be assessed properly. Also, the researcher's hard work will remain unacknowledged.

The purpose of research can be classified into three categories. These are:

- training in research,
- research for problem solving, and
- research in inquiry of truth or creation of knowledge.

There are definite patterns here. For example, most research projects, especially, projects at the post graduate and doctoral levels are mainly on training in research. The projects that are linked to MA(DE) courses of IGNOU are also intended to train a professional in research in open and distance education. Most of the action research and institutional projects aim at problem solving; the magnitude of the problem can vary from a classroom to the entire educational system. Research that generates knowledge or information is usually characterized by sustained work in a field for years and decades by one person or a group of senior professionals.

It should not be difficult to appreciate that the paradigm for the evaluation of research reports, for three different goals cannot be the same. Though research methodology has to be a common interest in all evaluation, it will be the main focus in the evaluation of a report where training is the goal. When it comes to research for knowledge creation, the emphasis on methodology becomes redundant not because methodological sophistication is not needed, but such researches are results of sustained efforts that are usually done meticulously and published in reputed journals. Whatever maybe the purpose of research, the quality of work needs to be assessed scientifically to understand the real value or worth of the research work. As a researcher in open distance education, you should be able to identify quality research work from others that are poorly planned, conducted and reported. It is also an essential skill of the researcher, as during literature review you should be able to give appropriate weight to the related works based on their quality. It is assumed that in social science research, the methodology is highly significant, and use of right research design lead us to right research results that are reliable, valid and useful. In this unit, we will discuss how to evaluate research reports in open and distance learning.

4.1 OBJECTIVES

After the completion of this Unit you should be able to:

- List the major items for evaluating a research report,
- Explain the scientific criteria for evaluating a research report,
- Critically assess the validity of the mechanism of evaluating research reports, and
- Actually evaluate a research report and submit assessment.

4.2 CRITERIA FOR EVALUATION OF RESEARCH REPORTS

An understanding of the criteria for evaluation of research report is reinforcement of the understanding of the entire process, techniques and tools of research. Evaluation of research reports is carried out for various purposes including award of degree in the case of research leading to a Master degree like MA(DE) or M.Phil/Ph.D. As in any evaluation, we need a set of criteria for evaluating the quality of a research report. It is necessary, because the criteria help us to:

- Judge the adequacy of the research report;
- Guide the researcher to undertake research in a planned manner;
- Identify previous research that may require further validation by using different tool or a different setting; and
- Guide the preparation of a good research report.

In this section, we will discuss various components of a research report and identify the issues that need to be considered while evaluating a research report.

4.2.1 Introductory Chapter: Building the Rationale

As mentioned earlier, the first chapter is the introduction. Introduction is the best section to learn about the researcher, particularly, in case of social and behavioural sciences, to which education and distance education belongs. It is important to understand the researcher's affiliations and the purpose for which the study was undertaken.

Another important point is to understand whether the researcher has a commitment to a particular point of view. Whenever a researcher tries to support an assumption or a hypothesis from a particular point of view, there is a likelihood of bias. At times, the researcher gets emotionally involved and brings in a bias which is easy to detect. In case you come across a study which clearly states that the study is to prove something, it is clear that the researcher already holds a strong point of view and is only trying to prove himself/herself correct. Much of this can be understood from the emotionally charged language of the investigator in the report.

Another important source of a bias is the researcher's strong socio-cultural affiliation. For example, in a multi-cultural or a multi-lingual society, his/her strong personal affiliation may affect the process of research.

An easy way for identifying any biases in a study is to look into the researcher's efforts in collecting research and thematic literature. For example, a particular area of research may have quite a range of references and the studies might contradict one another in terms of findings. Of these, the researcher may choose only such studies that support his or her point of view instead of referring to the contradictions.

As a reviewer, you may first like to identify if there is any bias; also the extent of the bias and its likely impact on the research process and findings.

The second important point for investigation, particularly in the introductory chapter, is the kinds of argument being built up to justify the relevance of the study.

It is expected that the introductory chapter provides a broad overview which indicates the candidate's understanding of the broad framework in which the educational system operates and in which the specific area of his or her research is located. Further, from this broad spectrum the researcher should be able to narrow down to the problem under investigation. In this process, a good research report will quote information and data from previous research.

Thus, the entire chapter should be seen from several angles.

- The broad framework of education or related area of education laid out,
- The strength of arguments to justify the study – selection of the problem,
- Skill in narrowing down to the identification of the problem, and
- The presence of biases issues.

Finally, the test of the quality of an introductory chapter is its ability to convince the reader and the reviewer that the problem chosen is

- Relevant,
- Important,
- Timely,
- Researchable, and
- Within the competence of the researcher.

Should these criteria be fulfilled, the chapter on **introduction** should be considered to have done well.

4.2.2 Review of Literature

Researchers follow two alternative paths so far as review of research literature is concerned. Some researchers review literature as a part of the introductory chapter to build up the required rationale. However, many researchers provide a separate chapter on the review of research literature. Research reports/papers comprise three major elements:

- an introduction justifying the research,
- methodological details and
- findings and their implications.

A competent reviewer should touch upon all the three elements, though most reviewers use only findings. Very few researchers look into findings as well as the research methodology in their reviews. From the angle of findings, major objectives of a review are:

- **To find gaps in research:** For example, if one could conceptually map out a broad area of research and see what researches have already been conducted, the exercise will automatically provide the gaps. Within a broad research area, a number of variables are likely to be impacting a particular phenomenon or process in education. Some variables may have been and some others, may not have been studied. Those variables which have not been studied are the indicators of gaps.
- **To identify the areas of overlap:** There will be areas in which several studies have been conducted in one and the same way. The same variables have been used time and again in the research projects that are more or less similar. These are the cases of overlap. Review of literature will allow us to understand and identify such overlaps.
- **To identify contradictions:** It is quite likely that researches conducted in one and the same area provide contradictory results. For example, there are contradictory results as to what happens to students who participate in Personal Contact Programmes in a distance education programme and who do not. A number of studies indicate that it has no impact on the performance of learners. On the other hand, there are certain studies which indicate that those who participate in PCPs perform better. The review of research literature also brings these contradictions to surface. A researcher may then conclude whether or not research on a specific issue is conclusive.

Now, these are the three components (from the angle of findings) which should help in crystallizing the problem of research.

As a reviewer, you need to check out whether the researcher has indeed identified

- Gaps
- Overlaps and
- Contradictions.

If so, he/she has done his/her job. However, within that broad framework, you may have to make a qualitative assessment of how effectively the researcher has argued the cases of gaps, overlaps and contradictions.

The second major purpose of review is to derive guidelines for the methodology of research. From the methodology perspective, the review of research literature should help the researcher to be able to derive implications for

- Sample – sampling technique, sample size, etc.
- Research designs,
- Variables to be studied,
- Scaling technique,
- Research instruments,
- Data collection,
- Statistical or qualitative techniques for data analysis.

Now, while you evaluate a report, you may like to check whether the researcher has adequately analyzed and reflected on the previous research studies from the various aspects of research methodology listed above. Further, does he/she indicate his/her decision to choose the research designs, variables, etc. backed up by previous studies. If so, the purpose of review has been well achieved. If not, it is merely a ritual.

There is no one way of reviewing literature. There are at least four basic patterns.

- One and the most elementary pattern is where a researcher presents the findings of a study against the name of the author in one paragraph. The second paragraph refers to another, and third to yet another researcher and so on. In such a case, the researcher does not interlink one study with another.
- The second type of review is when a reviewer refers to a particular set of findings and provides a few references of those who contributed to that particular finding in brackets. In this case, he/she basically clusters studies around a finding (say, relationship between two variables) or around a common mission. Still, the research does not compare any two sets of findings or any two sets of researchers.
- The third pattern is when a reviewer describes a phenomenon investigating various researches as a support.
- The fourth and better approach is when a researcher develops a conceptual framework of his/her research in a particular field. The conceptual framework is built on the theoretical literature and creative argumentation. Within this framework, the researcher maps out the previous research. Fitting it into a conceptual framework allows him/her to compare and contrast issues and findings, identify the gaps, overlaps, contradictions and also derive methodological implications.

Obviously, the four patterns are in a taxonomic structure. As such, you, as an *evaluator of a report*, will award higher credit to the researcher who uses pattern four and least to the one who resorts to pattern one for reviewing research literature.

The other quality of a good literature review is its exhaustiveness. What is the scope of the review in terms of the period and extent of journals and databases covered? How the literature search was conducted to ensure that the review is comprehensive and not significant work has been missed? The research should mention these in the literature search to explain the inclusion and exclusion criteria and their rationale. While the quality of a literature review can be judged from its presentation and nature of argumentation in a conceptual framework, the earliest and latest references adds to the reputation of the researcher as to have followed rigour in the research work.

So, as an evaluator, you will assess whether any significant related work has been missed by the researcher. If yes, then the review is not of high quality.

Activity I

Examine any research report/dissertation or a thesis available to you. Read the chapter on Review of Literature. Try to evaluate the chapter and write your comments.

4.2.3 Objectives and Hypotheses

All research studies have a section on objectives and hypothesis. It is important to examine whether the researcher has raised very clearly the questions to which he/she is looking for a solution. These questions should be explicit — the researcher should categorically put down the questions on paper. This set of questions can be converted into objectives.

Objectives are the foundations of a research project. Eventually the objectives guide the entire process of research. The major attributes of well written objectives are -

- **Clarity of expression and direction** – The objectives must have been stated clearly enough to indicate what the researcher is trying to investigate. It is equally important to avoid overlaps in stating objectives.
- **Measurability** – The objectives must be stated in a manner that they are measurable; in case of qualitative research it should be possible to at least codify the data and information so that assessment can be made whether the objectives have been achieved or not.
- **Comprehensiveness** – The objectives provide the guiding framework for a research project. Hence, the statement of objectives should be comprehensive enough to cover each and every aspect of the research study. Stating differently, nothing should be outside the purview of the stated objectives.
- **Judiciousness** – Another important attribute is the judiciousness in and justifiability of choosing and stating objectives. For example, many young scholars, in their post graduate dissertations and doctoral theses mention “recommending future research” as one of the objectives. In all fairness, this is not feasible. Similarly, in a short time-bound project, a research objective that actually calls for sustained and long-term study becomes less feasible.

Thus, an evaluator, while evaluating the research objectives needs to examine clarity of expression, measurability, and comprehensiveness of the objectives and judiciousness in choosing and stating them.

Hypotheses, as you have read, “is a statement of causal or non-causal relationship of two or more variables under study.” The proposition of a hypothesis is derived from theoretical constructs, previous research and logical analysis. More often than not, the researcher mentions the literature that leads to the formulation of hypothesis. *One important task of the evaluator is to check whether the researcher has provided sound back-up from*

the previous research and findings and important theoretical analyses to justify his/her formulation of hypotheses.

Hypotheses are stated either in null or directional form. Null form, does not presuppose any specific relationship, e.g. 'there will be no relationship between academic achievement and intelligence of the students'. On the contrary, directional hypotheses presuppose relationship, e.g. 'distance learners who study self-instructional material will perform better than those who study through conventional textual material'. When a null hypothesis is tested, it may point to a positive, neutral or negative relationship that can be used to derive conclusion. When a directional hypothesis is tested, it produces one of the two results – true or false. If it is false, it does not automatically show that the reverse is true.

For the purpose of evaluation, it is important to examine whether

- The choice of hypotheses – null or directional, was logical and whether the researcher has adequately argued out his/her case;
- The hypotheses are testable;
- The hypotheses are stated clearly indicating one to one relationship between two (or more) variables; and
- In case of a multi-variate situation, the relationship of the cluster of independent variables vis-à-vis the criterion variable is well defined.

4.2.4 Choice of Research Design

There are several research methods and designs that can be chosen by a researcher to achieve the objectives and test the hypotheses. While evaluating a research report, it is important to assess whether the chosen design is competent to respond to the research objectives and questions laid down. For example, if the objective is to test the impact of a broad treatment to a group of learners, it has to follow an experimental design. Similarly, if the objective is to assess the status of certain psycho-social variables in a given sample of population, it would require survey methodology. Within a survey, if the purpose is simply to describe their status and not to compare them with any standard norm or not even develop a norm, the design can be descriptive.

Hence, in evaluating research, it is necessary to check the choice of appropriate research design against the objectives. Another means of evaluating the applicability and befittingness of the research design is to check it against the hypothesis. If the hypothesis to be tested, is formulated in terms of relationships, the study has to adopt a methodology, e.g. survey, by which relationships can be tested. Compared to it, if the hypothesis is to test the performance of two different groups against a particular type of treatment, the research design has to provide for that opportunity by adopting an experimental design. Depending on the nature of the groups, the treatment, the size of the sample and also the nature of that experiment, one would adopt a pre-experimental, quasi experimental or true experimental design, or even post-experimental research.

Thus an evaluator of a research report needs to examine the appropriateness of the choice of research design vis-à-vis the research objectives. The details of the design, e.g. type of experimental design etc. too have to be evaluated. Equally important is the argument put forward by the researcher in deciding the research design.

4.2.5 Choice of Variables

Choice of variables is an important step in a research project. There can be at least three sets of variables, *namely*, independent, dependent and intervening variables. There are also other ways of classifying variables like socio-economic, demographic, psychological, organizational, etc. The later classification is relevant with regard to basic content of research whereas the former is directly linked to research methodology – how you deal with them while analyzing research data.

Here, we shall concentrate on the first set. The important point to evaluate in the choice of variables is the formulation of the dependent or the criteria variables. This is particularly important in experimental research where the impact of other variables on the criterion variable is assessed.

In order that the research makes a meaningful contribution, it is important to choose the independent variables as meticulously as possible. The choice of independent variables depends upon more than one consideration. One of the considerations is the existing knowledge on the basis of previous research which shows that certain types of variables are indeed related and predict the variation of the criterion variable. The second important consideration is the assumption of the researcher – that there are particular sets of variables that are likely to be related to the dependent variables.

The third set of variables is the intervening variables. These are often ignored in research, although these actually intervene and influence the relationship between the independent and the criterion variables. On the basis of the research literature, the researcher is expected to identify such variables that are likely to influence the relationship under test.

Besides the identification and classification of the variables, it is important that variables are measurable. Further, all variables may not have standard definitions. In such a case, it is expected that the researcher shall provide operational definitions and also indications of their measurability.

Hence, an important consideration in evaluation is how meticulously the variables have been identified and classified under the three categories mentioned above. The second important consideration in this case is whether the researcher has provided operational definitions of at least such variables as do not have a standard meaning in the literature. The third important consideration is whether there are clear indications of the measurability of variables.

Check your Progress 1

Give brief answers to the following questions.

- A. List the major attributes of well written objectives in a research report.
- B. List the points which an evaluator should keep in mind while evaluating the variables used in a research exercise.

Notes: (a) Space is given below for your answers.

(b) Compare your answer with the one given at the end of the Unit.

A)

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B).....

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4.2.6 Research Instrumentation

Several types of research instruments have been discussed in the blocks and units of this course. These are psychological tests, achievement tests, questionnaires, opinionnaires, information blanks, inventories, interview schedules, etc. For the purpose of evaluating a research report, the important consideration is whether the instrument chosen or developed is appropriate for measuring the variables or not.

It is important to note that a research instrument is for the measurement of variables. Every variable has certain attributes of its own, amenable to measurement by different types of scaling, namely, nominal, ordinal, ratio and interval. Similarly, there are variables which are amenable only to rigorous standardized tests, like those of intelligence, reasoning ability, etc. There are others which can be measured through inventories or questionnaires. Then there are variables which necessitate the use of interviews with probing questions to be able to go into the details of a process. The common mistake in this area is the use of incompatible instruments vis-à-vis the variables being measured; for example, researchers may use a questionnaire to measure attitude. Sometimes researchers use questionnaires for conducting interviews as if a questionnaire is no different from an interview schedule. More often than not, interviewing is called for when a lead question leads to 'Yes' and/or 'If No' kind of situation.

The points to be borne in mind while evaluating research instruments are the following:

1. Whether the researcher has chosen an instrument that can actually measure the variables.
2. Whether the research instrument has been picked up from an existing stock or has been constructed by the researcher. In case of the former, whether the researcher has checked its validity, and reliability and the sample on which the original study was conducted. Whether the standardization on the original sample is valid for the sample on which the researcher has used the instrument and drawn inferences. In case the researcher has developed the instrument on his/her own, has care been taken to check the attributes of the tool, a dependable research instrument, be it a questionnaire, inventory or an interview schedule. As an evaluator, you may like to check the reliability and validity of the instruments used to ascertain the appropriateness of the instruments.
3. Whether the researcher has tested the feasibility of the use of instrument. For example, a questionnaire is not a feasible instrument for the illiterates unless the researcher himself/herself records the responses. Similarly, a research instrument that requires considerable time to respond is unlikely to be responded by those who run short of time e.g. executives.
4. Besides these three criteria, research instruments can be examined from the angle of language, communication, provision of recording response by the respondents, etc.

4.2.7 Sample

There are two major issues that need to be considered with respect to samples, namely,

- Sample Size
- Sampling Technique and Type of the Sample.

The size of the sample depends on the nature of objectives of a research project and the research design. For example, in case of rigorous experimentation, it is not only difficult to

handle large samples, but also not necessary. Similarly, for surveys and such other status studies, samples have to be large. The main consideration here is that there has to be an optimum size of the sample beyond which it is waste of research resources. For this purpose use of sample size determination formulae and standard tables help the researchers to be objective.

As an evaluator what is to be considered is: whether the sample size is large enough for the study and the sample size has been determined scientifically?

Another important aspect is the technique of choosing a sample. There are several techniques of choosing a sample, *namely*, randomization, stratified randomization, clustering, etc. In purposes of exploring a new phenomenon primarily for understanding and learning, one may use purposive sampling. Since it is a purposive sample, it is obviously not randomized. It does not have the value of generalization but can be used for generating the first set of information. The important point is to check whether there is a case for using purposive sampling. A random sample is often quoted as the ideal sample; it is necessary for generalization and the creation of new knowledge. In practical terms, strict randomization is more often used in statistical quality control in production industry. However, a modified version like stratified randomization is used in educational and social research. It provides a sound basis for generalization. Many a times, it has been observed that researchers do not use randomization, but state that random sampling method has been used. For example, distribution of a questionnaire in a gathering of 500 people and getting a return of 350 responses is not a random sampling.

The important point to check here is whether the researcher has identified the right and relevant criteria for stratification and sub-stratification of the population; and then developed a sampling frame to choose a stratified random sample, using appropriate randomization.

It is also important to look into the argument that is put forward by the researcher justifying the method of selection of the sample. There are studies where the researcher started with a particular sample size, but ended up with a considerably reduced one. In such events, although the sampling technique may have been technically correct, the researcher miscalculated the feasibility of involving the sample in the research. As a result, beginning with a stratified large whole sample, the researcher ends up with a small sample by default or with a residual sample. This may require a change in the statistical analysis of the data.

An evaluator needs to carefully evaluate the explanation provided by the researcher and the way he/she proposes to cope with it.

4.2.8 Data Collection and Analysis

Along with the quality of research instruments and the sampling technique, the quality of the outcome of research also depends on the quality of data itself. In turn, the quality of data is determined by the procedure of data collection. The indication of the quality of data lies

in the dependability of the information collected from the sample. A normally observed problem associated with data collection is on the spot collection that provides a definite return of responses, but not necessarily quality responses because the respondent is likely to respond mechanically. When the researcher sends the instrument by mail or leaves it to the respondent to respond, there is a large amount of loss because only a small percentage of the prospective respondents respond. The data thus generated are not of the pre-determined sample but of the positive type of respondents in the sample, that does not include data from the 'non-respondents'.

Generally speaking, in a research exercise that requires primary data, it is better to collect the data personally. In case of secondary data, it is important to check the sources of data and their trustworthiness.

The points to check here are whether the researcher has categorically recorded the details of data collection:

- research instruments administered personally or by a representative or by mail,
- sources and authenticity of secondary data, and
- the kind of problems that the data might have in terms of quality.

Data analysis can be either qualitative or quantitative. Although qualitative research and qualitative analyses are gaining momentum, a large majority of research depends on quantitative methods and statistical procedures. *A major point in evaluating research is to check whether the researcher has chosen qualitative methods where the data are qualitative and objectives and hypothesis do not demand a quantitative analysis. Similarly, whether the researcher has chosen a quantitative technique where a qualitative answer is not required.*

Within quantitative research, statistics can be *parametric* or *non-parametric*. The point for evaluation is whether the researcher has justified the choice of the broad option between parametric and non-parametric tests. The size of the sample is another determinant in choosing the statistical tests as a small sample often warrants non-parametric tests. Within the parametric and nonparametric tests there is a wide range of options. *Whether the researcher has chosen the right test is another important point to consider.* For example, within the application of simple central tendencies, it has to be seen whether the researcher has chosen *mean* where it is indeed the appropriate application or whether he/she has mechanically used a *mean* where a *median* or a *mode* would have been the more appropriate choice. *If the choice of statistics has been correct, the next point to look into is the correctness of calculations.* Of course, with the increasing use of computer, this problem has reduced. Given the development of the use of computers and availability of ready-made statistical computing software and other packages, *it is important to examine whether the researcher has used a computer for data analysis.* If not, the evaluator may have to calculate the values himself or herself.

Check your Progress 2

List the points for evaluating the chapter on Data Collection and Analysis.

Notes: (a) Space is given below for writing your answer.

(b) Compare your answer with the one given at the end of the Unit.

(a)

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(b)

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4.2.9 Findings and Implications

Having dealt with the issues pertaining to introduction, review of related literature, methodology, we now concentrate on results.

The final outcome and hence, the value of a research project lies in its findings, i.e., results and their interpretation. The findings are presented not only in the descriptive form but also in the form of tables and graphic representations. The evaluator needs to examine whether a table or a graph has been used wherever it was required. Similarly, if a table or a graphical presentation has been provided, it has to be seen whether it has been given a title and followed up with an explanation. The second important point to check is whether the researcher has related the graphic presentation with the corresponding tabular presentation and ensured that there is no contradiction between the two.

Along with the results, it is necessary to provide an interpretation and implications of the results. These are usually drawn for the purpose of policy formulation, planning and execution in education. In order to do so, a researcher often refers to previous studies to derive support for his or her findings. He/she is also expected to reflect previous studies that contradict his/her findings. *The important issue of evaluation here is to critically examine the way a researcher interprets the findings:*

- Whether the interpretation has been related to the introductory chapter where the researcher built up the rationale for his/her research.
- Whether the argument built up in each chapter is adequately reflected in the interpretation of the results.

In other words, this is where an evaluator examines the analytical skill of a researcher, the skill of extrapolation, the skill of observing and explaining relationships between two or more variables, etc.

4.2.10 Summary and Conclusions

This is a common chapter in all research studies. It provides a quick glimpse of the entire research project. Brevity with comprehensiveness is the rule of the game for this chapter. An evaluator often examines within the small space of a summary how a researcher has built the rationale, how he/she has documented the objectives, hypotheses, research methodology and findings.

Activity II

Read the chapter on summary and conclusion of any research report. List your comments and check with the points given in the unit.

4.2.11 Referencing

Referencing is an important skill. Most research students make mistakes as they lack both the skill and the seriousness of purpose vis-à-vis referencing. In fact, many evaluators go straight into the section on references. It is easy to check because there are some definite internationally recognized forms. One comes across many research theses where a researcher mentions only the authors and the names of the books. He/she skips the place, publisher and even the year of publication, little realizing that an evaluator or a future reader of the thesis would not be able to refer to any book or study without the details about the publisher and the year of publication. *At the very elementary level, it is necessary to check whether all the information has been provided. It has also to be checked whether the information provided is in one of the standard forms. It has to be seen if the references are indexed*, in case they are not numbered in the text. Similarly, if the references are numbered in the text, it has to be seen whether the references appear serially according to their appearance in the text. As a matter of practice, as an evaluator goes through the text of the report and comes across a reference in the text, he/she should immediately check whether there is a corresponding entry in the reference. This helps him/her to identify the missing references and common mistakes in the spellings of names and years of publications.

There is a difference between a bibliography and references. Research reports require references and not a bibliography. Many students commit the mistake of providing references under the heading of bibliography. In text references not listed at the end of the chapter or thesis is a strong negative point of a quality research work.

4.2.12 Annexures

Last but not the least, an important component of a research report is annexures. Annexures usually contain the research instruments, sampling frame, instructional material that might have been used for experimentation, etc. Annexures are also serialized. The main purpose of the annexures is that an evaluator can check the actual quality of the research instrument and material that have been used by the researcher. Annexures need to be fully documented and also serialized as indicated in the content of the research report. *Thus the check points are the comprehensiveness and serialization of the annexures.*

Check your Progress 3

State the points on which the Annexures of a research report are evaluated.

Notes: (a) Space is given below for your answer

(b) Compare your answer with the one given at the end of the Unit.

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4.2.13 General Indicators

Besides the important points we discussed in the preceding pages, there are issues that need to be considered such as language, typographical errors, presentation, etc. Some of these issues are:

- Language and expression including correctness of syntax, spelling, etc.
- Typing, word processing and printing of the report – readability including margins, line spacing, type font and size, placement of tables, diagrams, illustrations and graphs.
- Binding and overall get up.

4.3 FORMAT FOR EVALUATION OF RESEARCH REPORTS

In this section, we shall present a format for evaluation of research report to help you assess the quality of the report using a set of criterion, and calculate score as 'quality index'. Though this is a more quantitative way of evaluating research reports, we also recommend you to consider the issues discussed in the preceding section, and write a qualitative report. The qualitative description and the statistical 'quality index' should match.

In order to use the format, we suggest you to go through each criterion, and give relevant score in the box. If a particular criterion is not applicable for a research report, you must mention the same. While calculating the maximum score for evaluation, you must subtract the scores for the criteria that are not applicable for the specific research report. Add the total scores given by you for the different criteria, and then use the following formula for calculating "Quality Index".

Research Report Quality Index = $(\text{Score obtained}) \times 100 / \text{Maximum Actual Score}$

Suppose all the criteria were included in evaluating a research report, then the Maximum Actual Score would be 65. If the report gets a grand total score of 48, then the Research Report Quality Index score is 73.84.

If the Maximum Actual Score taken into consideration is 55, and the grand total score in all the categories is 48, the Research Report Quality Index score is 87.27.

4.4 LET US SUM UP

In the last few pages, we have dealt with various issues related to the evaluation of research reports and have given some vital practical methods of evaluating them. We classified research reports into three categories – research for training, research for problem solving and research for knowledge generation. We have also mentioned that there are no water-tight compartments these categories of research. Variation is on emphasis, e.g. in the case of research for training, emphasis is laid on proper use and application of research methodology. It is also anticipated that as a researcher moves from the maiden research effort to the second, third and so on, his/her methodological skills will improve. But for any research, importance of methodology cannot be underestimated. We conclude this Unit with a Research Report Evaluation Proforma which by and large covers all the major points enumerated in the text of this Unit.

Research Report Evaluation Proforma				
	Criteria	Score Rule (points)	Not Applicable (NA)	Score
1	Introduction	Max Score= 6		
1.1	Is the problem clearly stated?	Yes (1)/ No (0)		
1.2	Is the problem selected appropriate?	Yes (1)/ No (0)		
1.3	Is the problem relevant?	Yes (1)/ No (0)		
1.4	Is the problem important?	Yes (1)/ No (0)		
1.5	Is the problem researchable?	Yes (1)/ No (0)		
1.6	Are the related areas of the problem discussed satisfactorily?	Yes (1)/ No (0)		
	Sub-Total	Actual Max=		
Comments:				
2	Review of Literature	Max Score= 9		
2.1	Does the review identify gaps?	Yes (1)/ No (0)		
2.2	Does the review identify overlaps?	Yes (1)/ No (0)		
2.3	Does the review identify contradictions?	Yes (1)/ No (0)		
2.4	Is the coverage of the review adequate?	Yes (1)/ No (0)		
2.5	Is the review up-to-date?	Yes (1)/ No (0)		
2.6	What is the level of the review?	Chronological (1)/ Findings oriented (2)/ Phenomenon-based (3)/ Conceptual Framework (4)		
	Sub-Total	Actual Max=		
Comments:				
3	Objectives and Hypotheses	Max Score= 12		
3.1	Are the objectives stated clearly?	All (2)/ Some (1)/ None (0)		
3.2	Are the objectives measurable?	All (2)/ Some (1)/ None (0)		
3.3	Are the objectives comprehensive?	All (2)/ Some (1)/ None (0)		
3.4	Are the hypotheses measurable?	All (2)/ Some (1)/ None (0)		
3.5	Are the hypotheses clearly stated?	All (2)/ Some (1)/ None (0)		
3.6	Are the hypotheses logical?	All (2)/ Some (1)/ None (0)		
	Sub-Total	Actual Max=		
Comments:				

4	Research Design	Max Score= 3		
4.1	Does the choice of research design vis-à-vis the research objectives appropriate?	Yes (1)/ No (0)		
4.2	Are the reasons for the choice of the design given?	Yes (1)/ No (0)		
4.3	Has the methodology been explained in an understandable way to help replication of the work?	Yes (1)/ No (0)		
	Sub-Total	Actual Max=		
Comments:				
5	Variables	Max Score= 3		
5.1	Are the variables rightly identified?	Yes (1)/ No (0)		
5.2	Are the variables operationally defined?	Yes (1)/ No (0)		
5.3	Are the variables measurable?	Yes (1)/ No (0)		
	Sub-Total	Actual Max=		
Comments:				
6	Research Instruments	Max Score= 5		
6.1	Does the instrument selected measure the variables accurately?	Yes (1)/ No (0)		
6.2	Has the feasibility of the instrument been tested?	Yes (1)/ No (0)		
6.3	Is the language used in the research instruments comprehensible?	Yes (1)/ No (0)		
6.4	Are the instruments reliable?	Yes (1)/ No (0)		
6.5	Are the instruments valid?	Yes (1)/ No (0)		
	Sub-Total	Actual Max=		
Comments:				
7	Sample	Max Score= 3		
7.1	Is the size of the sample appropriate?	Yes (1)/ No (0)		
7.2	Is the technique of choosing the sample appropriate?	Yes (1)/ No (0)		
7.3	Is the sample representative of the population?	Yes (1)/ No (0)		
	Sub-Total	Actual Max=		
Comments:				

Data Analysis

8	Data Collection and Analysis	Max Score= 4		
8.1	Has the researcher collected the primary data personally?	Yes (1)/ No (0)		
8.2	Are the secondary data sources authentic and reliable?	Yes (1)/ No (0)		
8.3	Are the statistical tests used appropriate?	Yes (1)/ No (0)		
8.4	Is the quantitative/qualitative data analysis effective?	Yes (1)/ No (0)		
	Sub-Total	Actual Max=		
Comments:				
9	Findings and Implications	Max Score= 5		
9.1	Are the findings logically presented?	Yes (1)/ No (0)		
9.2	Do the tables/graphs have appropriate titles?	Yes (1)/ No (0)		
9.3	Are the tables/graphs explained in the text?	Yes (1)/ No (0)		
9.4	Are the findings related to the discussion in the introductory chapter?	Yes (1)/ No (0)		
9.5	Are the hypotheses/objectives of the research addressed adequately?	Yes (1)/ No (0)		
	Sub-Total	Actual Max=		
Comments:				
10	Summary and Conclusions	Max Score= 3		
10.1	Is the summary presented comprehensive?	Yes (1)/ No (0)		
10.2	Are the conclusions supported by data?	Yes (1)/ No (0)		
10.3	Are there recommendations for future research?	Yes (1)/ No (0)		
	Sub-Total	Actual Max=		
Comments:				
11	Referencing	Max Score= 5		
11.1	Are the in-text references available at the end?	All (2)/ Some (1)/ None (0)		
11.2	Are the references accurately presented?	All (2)/ Some (1)/ None (0)		
11.3	Are the references show uniformity?	Yes (1)/ No (0)		
	Sub-Total	Actual Max=		
Comments:				

12	Annexures	Max Score= 3		
12.1	Are the annexures comprehensive?	Yes (1)/ No (0)		
12.2	Are the annexures presented systematically?	Yes (1)/ No (0)		
12.3	Do the annexures give original data?	Yes (1)/ No (0)		
	Sub-Total	Actual Max=		
Comments:				
13	General Indicators	Max Score= 4		
13.1	Is the research report without major typing mistakes?	Yes (1)/ No (0)		
13.2	Is the research report presented well (margin, typesetting, tables, etc)?	Yes (1)/ No (0)		
13.3	Is the binding of the research report proper?	Yes (1)/ No (0)		
13.4	Is the title description accurate and of a reasonable length?	Yes (1)/ No (0)		
	Sub-Total	Actual Max=		
	Comments:			
	Grand Total	Grand Actual Max=		
General Comments:				

4.5 CHECK YOUR PROGRESS: THE KEY

1. a. Clarity of expression and direction
 - Measurability
 - Comprehensiveness
 - Judiciousness
- b. The points which a researcher should keep in mind while evaluating the variables in a research report are:
 - Formulation of variables
 - Classification of variables
 - Whether the variables are operationally defined
 - Measurability of variables
2. a) Administration of Research Instruments
 b) Authenticity of the Data
 c) Kinds of Test used
3. a) Whether the Annexures are in proper Serial Order
 b) Comprehensiveness of Annexures



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Dear Student,

While studying the units of this block, you may have found certain portions of the text difficult to comprehend. We wish to know your difficulties and suggestions, in order to improve the course. Therefore, we request you to fill out and send us the following questionnaire, which pertains to this block. If you find the space provided insufficient, kindly use a separate sheet.

Questionnaire

Enrolment No.

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1. How many hours did you need for studying the units?

Unit No.	1	2	3	4	5
No. of Hours					

2. Please give your reactions to the following items based on your reading of the block:

Items	Excellent	Very Good	Good	Poor	Give specific examples, if poor
Presentation Quality					
Language and Style					
Illustrations Used (diagrams, tables, etc.)					
Conceptual Clarity					
Check your Progress Questions					
Feedback to CYP Questions					

3. Any other comments:

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