Master of Social Work
II - Semester
349 23

SOCIAL WORK RESEARCH
AND STATISTICS
Authors
Dr. Ashvini Kumar Singh, Assistant Professor, Department of Social Work, Jamia Millia Islamia, Delhi
Dr. Ravindra Singh, Assistant Professor, Department of Social Work, Bhim Rao Ambedkar College, Delhi
Dr. Deepak Chawla, Distinguished Professor, Dean (Research and Fellow Programme), International Management Institute
(IMI), New Delhi
Dr. Neena Sondhi, Professor, International Management Institute (IMI), New Delhi
Dr. Siddhartha Sharma, Professor, Amrapali Group of Institutes, Haldwani
Dr. J.S. Chandan, Professor of Management, Medgar Evers College (City University of New York)
<table>
<thead>
<tr>
<th>Syllabi</th>
<th>Mapping in Book</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BLOCK I: INTRODUCTION TO RESEARCH AND SOCIAL WORK RESEARCH, SCIENTIFIC METHOD AND RESEARCH APPROACHES</strong></td>
<td></td>
</tr>
<tr>
<td>Unit 1: Research: concept, objectives, characteristics, ethics, and qualities of good researcher; social research: meaning and objectives; social work research: meaning, scope, importance, limitations in social work research, and difference between social research and social work research;</td>
<td>Unit 1: Research (Pages 1-19)</td>
</tr>
<tr>
<td>Unit 2: Scientific method: meaning, characteristics, and process of scientific inquiry; relationship between theory method &amp; fact; types of research: pure, applied, and action research; participatory and evaluation research.</td>
<td>Unit 2: Scientific Method (Pages 20-26)</td>
</tr>
<tr>
<td>Unit 3: Research approaches: qualitative research: meaning, scope, characteristics, strategies, sampling and design, types of qualitative research: ethnography, focus group discussion, life history and content analysis; use, limitations, and obstacles in qualitative research, quantitative research: meaning, type, difference between qualitative and quantitative research.</td>
<td>Unit 3: Research Approaches (Pages 27-49)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>BLOCK II: SELECTION OF THE PROBLEM, THEORY AND HYPOTHESIS</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 4: Selection of problem: criteria and sources; surveying the field; literature review and developing the bibliography: purpose; using library and internet; library ethics; abstracting and plagiarism; defining the problem: need and significance of the problem; basic research questions: meaning and importance; research objectives.</td>
<td>Unit 4: Selection of the Problem for Research (Pages 50-66)</td>
</tr>
<tr>
<td>Unit 5: Theory: meaning and use; inductive and deductive theory construction; concepts, indicators, and variables: meaning; types of variables; formal and operational definitions; measurement: meaning, levels of measurement; nominal ordinal, interval, and ratio</td>
<td>Unit 5: Role of Theory in Research (Pages 67-79)</td>
</tr>
<tr>
<td>Unit 6: Hypothesis: meaning, sources, characteristics, functions and types; assumptions and limitations; attributes of a sound hypothesis; hypothesis testing; level of significance; critical region; Type-I and Type-II errors.</td>
<td>Unit 6: Hypothesis (Pages 80-109)</td>
</tr>
</tbody>
</table>
**BLOCK III: RESEARCH DESIGN, TOOLS AND METHODS OF RESEARCH**

**Unit 7:** Research design: meaning and types - exploratory, descriptive, diagnostic, experimental, and single subject research designs; universe and sampling: meaning, need, principles, types and techniques, and advantages and disadvantages.

**Unit 8:** Tools/instrument: steps involved in tool construction; validity and reliability: meaning and types; use of scales (developed by WHO/ILO, etc.); scaling procedures (Thurston, likert, bogardus, and semantic differentials); interview guide, code book, pilot study, and pre-test; sources of data: primary and secondary data.

**Unit 9:** Methods: quantitative - interview: meaning and types; questioners: meaning and types; participatory and rapid appraisal techniques; qualitative - in-depth interview, observation and types and document review; mixed and multi method & triangulation.

**BLOCK IV: DATA PROCESSING, REPORT WRITING IN RESEARCH**

**Unit 10:** Data processing; transcription, data processing; presentation of data: tabular and graphical presentation; data analysis: univariate, bivariate, and multivariate analysis; interpretation: meaning, techniques, and precautions.

**Unit 11:** Report writing: content and format; mechanics of writing research reports and precautions; research abstracts; footnotes, referencing, and bibliography: meaning and differences; methods of referencing; preparation of research project proposal; agencies involved in social work research.

**BLOCK V: STATISTICS, DISPERSION AND COMPUTER APPLICATIONS**

**Unit 12:** Statistics- meaning, use, and its limitations in social work research; measures of central tendency: arithmetic mean, median, and mode

**Unit 13:** Dispersion: range, quartile deviation, standard deviation and co-efficient of variation; tests of significance: “t” test, f test and chi-square test; correlation: meaning, types, and uses; Karl Pearson’s coefficient of correlation and rank correlation.

**Unit 14:** Computer applications: use and application of computer in social work research with special reference to excel, etc.
INTRODUCTION

BLOCK I: INTRODUCTION TO RESEARCH AND SOCIAL WORK RESEARCH, SCIENTIFIC METHOD AND RESEARCH APPROACHES

UNIT 1 RESEARCH 1-19
1.0 Introduction
1.1 Objectives
1.2 Research: Concept, Objectives and Characteristics
   1.2.1 Principles of Research
   1.2.2 Objectives of Research
   1.2.3 Ethics of Research and Qualities of a Good Researcher
1.3 Social Research: Meaning and Objectives
   1.3.1 Basic Elements of Social Research
1.4 Social Work Research: Meaning, Scope and Importance
   1.4.1 Importance of Social Work Research
   1.4.2 Types of Research in Social Work
1.5 Differences between Social Research and Social Work Research
1.6 Answers to Check Your Progress Questions
1.7 Summary
1.8 Key Words
1.9 Self Assessment Questions and Exercises
1.10 Further Readings

UNIT 2 SCIENTIFIC METHOD 20-26
2.0 Introduction
2.1 Objectives
2.2 Meaning and Characteristics of Scientific Method
2.3 Process of Scientific Inquiry
2.4 Relationship between Theory Method and Fact
2.5 Types of Research: Pure, Applied and Action
2.6 Participatory and Evaluation Research
2.7 Answers to Check Your Progress Questions
2.8 Summary
2.9 Key Words
2.10 Self Assessment Questions and Exercises
2.11 Further Readings
UNIT 3  RESEARCH APPROACHES

3.0 Introduction
3.1 Objectives
3.2 Qualitative Research: Meaning, Scope and Characteristics
  3.2.1 Distinguishing Qualitative from Quantitative Data Methods
  3.2.2 Sampling and Design
3.3 Types of Qualitative Research
  3.3.1 Focus Group
  3.3.2 Content Analysis
  3.3.3 Ethnography and Life History
  3.3.4 Limitations and Obstacles in Qualitative Research
3.4 Answers to Check Your Progress Questions
3.5 Summary
3.6 Key Words
3.7 Self Assessment Questions and Exercises
3.8 Further Readings

BLOCK II: SELECTION OF THE PROBLEM, THEORY AND HYPOTHESIS

UNIT 4  SELECTION OF THE PROBLEM FOR RESEARCH

4.0 Introduction
4.1 Objectives
4.2 Selection of Problem: Sources and Criteria
  4.2.1 Sources of Research Problems
  4.2.2 Criteria of Research Problem Selection
4.3 Literature Review in Research
  4.3.1 Procedure of Literature Review
  4.3.2 Using Library and Internet for Literature Review
4.4 Defining the Research Problem
4.5 Research Questions
4.6 Surveying the Field
  4.6.1 The Planning Phase
  4.6.2 Design and Development
  4.6.3 Implementation
  4.6.4 Survey Evaluation
4.7 Answers to Check Your Progress Questions
4.8 Summary
4.9 Key Words
4.10 Self Assessment Questions and Exercises
4.11 Further Readings
9.4 Participatory and Rapid Appraisal Techniques
  9.4.1 Phenomenology
  9.4.2 Ethnography
  9.4.3 Participatory Research Design
9.5 Observation and Types of Document Review
9.6 Mixed and Multi-Method
9.7 Triangulation
9.8 Answers to Check Your Progress Questions
9.9 Summary
9.10 Key Words
9.11 Self Assessment Questions and Exercises
9.12 Further Readings

BLOCK IV: DATA PROCESSING, REPORT WRITING IN RESEARCH

UNIT 10 DATA PROCESSING 191-206

10.0 Introduction
10.1 Objectives
10.2 Meaning, Importance and Process of Data Analysis
  10.2.1 Editing of Data
  10.2.2 Coding of Data
  10.2.3 Classification of Data
  10.2.4 Tabulation of Data
  10.2.5 Graphical Presentation
10.3 Types of Analysis
  10.3.1 Univariate, Bivariate and Multivariate Analysis
10.4 Answers to Check Your Progress Questions
10.5 Summary
10.6 Key Words
10.7 Self Assessment Questions and Exercises
10.8 Further Readings

UNIT 11 REPORT WRITING 207-227

11.0 Introduction
11.1 Objectives
11.2 Overview of Writing Research Reports
  11.2.1 Contents of a Research Report
  11.2.2 Format of a Research Report
  11.2.3 Precautions While Writing Research Report
11.3 Preparation of Research Project Proposal
11.4 Agencies Involved in Social Work Research
UNIT 14  COMPUTER APPLICATIONS  310-320

14.0 Introduction
14.1 Objectives
14.2 Social Work Research before the Evolution of Computers
14.3 Use of Computer Applications and Social Work Research
   14.3.1 MS Word
   14.3.2 MS Power Point
   14.3.3 MS Excel
   14.3.4 Statistical Packages for Social Sciences
14.4 Websites and Online Encyclopedia
14.5 Answers to Check Your Progress Questions
14.6 Summary
14.7 Key Words
14.8 Self Assessment Questions and Exercises
14.9 Further Readings
Social Work Research and Statistics includes quantitative and qualitative information pertaining to both the activities of social work agencies and to the state of affairs that they strive to improve. A decade ago, there was not much organized statistical data in social research and social work; but in recent years, there has been persistent stress on the importance of the use of statistics in this domain. In the present times, large amounts and different types of critical data are being produced to describe services and record trends of activities of a variety of social research works.

There has been significant advancement in not only enhancing the assortment of data compiled, but also in increasing its volume, through social research work. Social work statistics data is partly derived from recent records of persons in service, personnel, income, expenditures, etc. The value of such statistics is enormous and enables them to be used beyond administrative purposes, when they are combined with information routed from other agencies. The participation of both public and private agencies has been critical in this advancement. However, since collecting and publishing statistics involves considerable expenditure, the major portion of this work is conducted by government agencies. This is equally true for other associated statistics related to academics, health, labour and commerce.

This book is written with the distance learning student in mind. It is presented in a user-friendly format using a clear, lucid language. Each unit contains an Introduction and a list of Objectives to prepare the student for what to expect in the text. At the end of each unit are a Summary and a list of Key Words, to aid in recollection of concepts learnt. All units contain Self-Assessment Questions and Exercises, and strategically placed Check Your Progress questions so the student can keep track of what has been discussed.
BLOCK - I
INTRODUCTION TO RESEARCH AND SOCIAL WORK RESEARCH, SCIENTIFIC METHOD AND RESEARCH APPROACHES

UNIT 1 RESEARCH

Structure
1.0 Introduction
1.1 Objectives
1.2 Research: Concept, Objectives and Characteristics
   1.2.1 Principles of Research
   1.2.2 Objectives of Research
   1.2.3 Ethics of Research and Qualities of a Good Researcher
1.3 Social Research: Meaning and Objectives
   1.3.1 Basic Elements of Social Research
1.4 Social Work Research: Meaning, Scope and Importance
   1.4.1 Importance of Social Work Research
   1.4.2 Types of Research in Social Work
1.5 Differences between Social Research and Social Work Research
1.6 Answers to Check Your Progress Questions
1.7 Summary
1.8 Key Words
1.9 Self Assessment Questions and Exercises
1.10 Further Readings

1.0 INTRODUCTION

Research, in the layman’s terms, means the search for knowledge. Scientific research is a systematic and objective way of seeking answers to certain questions that require inquiry and insight or that have been raised on a particular topic. The purpose of research, therefore, is to discover and develop an organized body of knowledge in any discipline. Research is a journey of discovery. It is a solution-oriented inquiry that must be objective and repeatable. It should inspire and guide further studies and should foster applications. Research will provide practical benefits if it can provide advanced understanding of a discipline or suggest ways to handle some situations that we confront.

Scientific research involves controlled observations, analysis of empirical data and interpretation of findings. This can further lead to the development of concepts, generalizations, etc., on the basis of which theories could be formulated. Such an investigation could help in determining cause and effect relationship. The ultimate aim of social science research is the control and prediction of behaviour.
We may sometimes wonder how researchers come up with ideas for a research project. They do so mostly when they face problems in the field. Since most researchers are engaged in social, human or health service programmes, they would automatically take up such issues that help them improve their fields of activity. Some of these ideas would probably strike us as silly; for example, researchers in the health care field would probably research a topic such as 'problems of back injury in nurses'. This may not strike us as extremely important as far as the health care sector goes, but if we reflect on this for a moment, we would understand, that this is a valid idea to research. A nurse is always lifting and carrying patients, moving heavy equipment, standing for hours on end. So, inevitably some of them would end up injuring their backs. These might lead to absenteeism; nurses with major injuries may even enroll for expensive treatment. The nursing industry figures that this is a problem that may cost it millions of dollars worldwide. Thus, though initially we felt that this is of no primary importance to the health care sector, we eventually realize that research is required on it.

Another source for research ideas is when researchers regularly update themselves by reading available literature and then extrapolating ideas from current researches in their respective fields of study. Government agencies and even private organizations often bring out 'request for proposals' for researchers. These are basically descriptions of problems that the agency would like researchers to work on. Sometimes, researchers come up with their own ideas of research which are influenced by their educational backgrounds, upbringing, culture, geographical influences, etc.

Every researcher should have the necessary training in gathering data, organizing materials suitably and engaging in field or laboratory work. He should also have the competence in using statistics for treating the data and the ability to interpret the collected data meaningfully. Research needs discipline, the right mental makeup, the ability to manage time effectively, objectivity, logical thinking, the capacity to evaluate the results of the research and ability to carefully assess the findings that are found by the research. Research data allows people to make informed decisions by extrapolating the findings from the field or laboratory on to real life situations. This is the practical application of the findings generated by research.

Research is also a way of preparing the mind to look at things in a fresh or different way. Out of such an orientation would come new and innovative observations about everyday events and happenings. This is how originality comes about in research. Some of the most outstanding discoveries have been made in the most serendipitous manner. Some outstanding results have been obtained by researchers who had kept their minds open and free of clutter. This enabled them to see startlingly new connections.
1.1 OBJECTIVES

After going through this unit, you will be able to:

- Define research
- State the qualities of a good researcher
- Briefly mention the meaning and objectives of social research
- Discuss the scope and importance of social work research
- Differentiate between social research and social work research

1.2 RESEARCH: CONCEPT, OBJECTIVES AND CHARACTERISTICS

Research in common parlance refers to search for knowledge. One can also define research as a scientific and systematic search for pertinent information on a specific topic. In fact, research is an art of scientific investigation. According to the *Advanced Learner’s Dictionary of Current English*, ‘research is a careful investigation or enquiry, especially a thorough search for new facts in any branch of knowledge.’ Redman and Mory (1923) defined research as a ‘systematized effort to gain new knowledge.’ Some people consider research as a voyage of discovery that involves movement from the known to the unknown.

Research in a technical sense is an academic activity. Clifford Woody defined research as an activity that comprises defining and redefining problems, formulating a hypothesis; collecting, organizing and evaluating data; making deductions and reaching conclusions; and carefully testing the conclusions to determine if they support the formulated hypothesis. D. Slesinger and M. Stephenson, in the *Encyclopaedia of Social Sciences*, defined research as ‘the manipulation of things, concepts or symbols for the purpose of generalizing, extending, correcting or verifying the knowledge, whether that knowledge aids in the construction of theory or in the practice of an art.’ Research is thus an original contribution to the existing stock of knowledge making for its advancement.

1.2.1 Principles of Research

The basic principles of research include a systematic process to identify a question or problem, set forth a plan of action to answer the question or resolve the problem, and meticulously collect and analyse data. In conducting any research it is crucial to choose the right method and design for a specific researchable problem. All research is different. However, the following factors are common to all good pieces of research:

- It is based on empirical data.
- It involves precise observations and measurements.
- It is aimed at developing theories, principles and generalizations.
There are systematic, logical procedures involved.

- It is replicable.
- The findings of the research need to be reported.

### 1.2.2 Objectives of Research

The objective of any research is to find answers to questions through the application of scientific procedures. The main aim of any research is exploring the hidden or undiscovered truth. Even though each research study has a specific objective, the research objectives in general can be categorized into the following broad categories:

- **Exploratory or formulative research studies:** These are aimed at gaining familiarity with a particular phenomenon or at gaining new insights into it.
- **Descriptive research studies:** These are aimed at accurately portraying the characteristics of a particular event, phenomenon, individual or situation.
- **Diagnostic research studies:** These studies try to determine the frequency with which something occurs.
- **Hypothesis testing research studies:** These studies test a hypothesis and determine a causal relationship between the variables.

### 1.2.3 Ethics of research and qualities of a good researcher

Let us go through the qualities of a good researcher.

**Honesty**

Primarily, a researcher needs to honest in his actions. He should honestly report data, results, methods and procedures and publication status. He should not fabricate, falsify, or misrepresent data.

**Objectivity**

The researcher should strive to avoid bias in experimental design, data analysis, data interpretation, peer review, personnel decisions, grant writing, expert testimony, and other aspects of research where objectivity is expected or required.

**Integrity**

Another integral quality of a research is that he should keep his promises and agreements; act with sincerity; strive for consistency of thought and action.

**Openness**

The researcher should be transparent in sharing data, results, ideas, tools and resources. He should be open to receiving criticism and new ideas.

**Respect for Intellectual Property**

A good researcher needs to honour patents, copyrights and other forms of intellectual property. He should not use unpublished data, methods, or results
Research

He must give proper acknowledgement or credit for all contributions to research.

Confidentiality
He should protect confidential communication, such as papers or grants submitted for publication, personnel records, trade or military secrets, and patient records.

Social Responsibility
He should strive to promote social good and prevent or mitigate social harms through research, public education and advocacy.

Non-Discrimination
He should avoid discrimination against colleagues or students on the basis of sex, race, ethnicity, or other factors not related to scientific competence and integrity.

Competence
A good research should maintain and improve his professional competence and expertise by constantly improving his education and learning. Moreover, he should take steps to promote competence in science as a whole.

Legality
He should know and obey relevant laws and institutional and governmental policies.

Check Your Progress
1. State the essential factors of a good research.
2. What is the main objective of a research?

1.3 SOCIAL RESEARCH: MEANING AND OBJECTIVES

Social research is a systematic and scientific process, based on well-defined rules, applicable in certain circumstances, for achieving the objective of transforming an indeterminate situation into a determinate one. It may be defined as systematic investigation intended to add to available knowledge in a form that is communicable and verifiable. Social researches are generally carried out to acquire knowledge in connection with social life and social phenomena. Human beings are studied as members of the social system.

Social research investigates the interrelationships among various social facts. It also verifies new and old facts about social life and acquires knowledge about the control of social phenomena and laws that are formulated and promoted. These laws are concerned with social relationship and social phenomena, through social research.
When we observe certain objects or phenomena, often unaware of our biases, we do not question them and so we attribute our observations entirely to the objects or phenomena being observed. In this process, it is possible to arrive at the right decision on the basis of wrong reasons or vice versa.

According to Young (1960), social research is ‘a scientific undertaking, which by means of logical and systematized methods, aims to discover new facts and analyse their sequences, interrelationship, causal explanations and natural laws which govern them’.

Sleisinger and Stevenson (1934) define social research as ‘a method of studying, analysing and conceptualizing social life in order to extend, correct or verify knowledge, whether that knowledge aids in the construction of a theory or in the practice of an art’.

Moser (1961) explain social research as ‘a systematized investigation to gain new knowledge about social phenomena and problems’.

Bogardus (1953) opines that social research is ‘the investigation of the underlying processes, operative in the lives of persons who are in association’.

1.3.1 Basic Elements of Social Research

The basic elements of social research are discussed in this section.

Concept

A concept is a cognitive unit that means an abstract idea or a mental symbol at times referred to as a unit of knowledge. For example, light, temperature, sound, age, sex, accidents, etc., all these are class names applied to stimuli, subjects or responses of a specific kind. These are all examples of concepts which cannot be directly observed, but their instances can be located. There are other concepts like mental strength, drive, attitude, motivation, etc., whose instances too cannot be directly observed. The reason for this is that they are presumed to be located inside the organism. They are called ‘hypothetical constructs’.

A concept is a property, or a characteristic of some case, or unit of analysis in which one might be interested. It is essentially an idea about some aspect or phenomenon, for example, gender, self-esteem, bureaucracy, social classification, etc. A case (unit of analysis) is that defined entity that is sampled and scored, or measured, on variables of interest in a research project. A case is defined in terms of its major characteristics and their location in time and place. In sociology, a case is often a human individual, a group, an organization or a society. It can also be a social entity such as the father-child role relationship. In research, a sample or population of these cases is targeted for examination. Research involves special concepts such as total family income, self-employment and economic returns. These are generally technical terms that point to some phenomenon that is an important aspect of a topic to be researched. Such concepts must be defined carefully so that people specifically understand what they mean.
Concepts play an important role in research. In fact, research cannot be conducted without concepts. Every research is based on a concept, as research tries to establish relationships between two concepts, one of which is dependent on the other. Let us see an example of the topic of research as ‘Vitamins supplement growth in babies’. This is a hypothesis which needs to be tested (as we are hypothesizing that vitamins supplement growth in babies). The statement could be true or false. In this topic of research, as in any other research, we are dealing with concepts. One concept that we have identified is ‘vitamins’ and the other concept is ‘growth in babies’. According to hypothesis, the higher the dose of vitamins (up to a certain level), healthier the growth among babies. Here, we are dealing with two concepts, as already mentioned. One concept, ‘vitamin’, is an independent variable and the other concept, ‘growth in babies’ is a dependent variable.

Concepts also help in understanding the cause and effect of relationships in research. Concepts are used in all types of researches. The example of vitamins and growth in babies shows the use of concepts (which are also variables) in experimental research. We can also examine the importance, or role of concept in other types of researches. In case study research, for example, the role of concept is equally important. It is an intensive study of a single group, incident or community.

Similarly, concepts are used in historical as well as descriptive researches. This is because in all types of researches, we are dealing with individuals, families, institutions, communities, etc., all of which are concepts. Thus, research is incomplete without concepts.

Constructs

In social sciences, it is often required to measure ideas that are not directly measurable. However, they can be measured by giving a description of precise qualities, which when considered one unit, define a construct. All these measures are based on definite knowledge and skills that can be gauged in combination. Therefore, by measuring these qualities as they have been defined, the psychological construct can also be defined and measured. In other words, an abstract idea or concept is formed in a person’s mind. This idea is a combination of a number of similar characteristics of the construct.

A construct is a verbal response evoked by objects of the class to which the concept applies. Some concepts such as temperature, sound, age, sex, etc., cannot be directly observed, but their instances can be located. Other concepts such as mental strength, drive, attitude, motivation, etc., can neither be directly observed nor can their instances be located as they are presumed to be located inside the organism. They are called ‘constructs’. A construct is a perception that means more than having been deliberately and consciously invented or adopted for a special scientific purpose.

Constructs play a very important role in building theories. Many theories such as the memory trace theory, the frustration aggression theory, etc., use
constructs. Constructs cannot be observed and thus, are called non-observables. They are also known as intervening variables. The concept of intervening variable was created to account for internal and directly unobservable psychological processes that in turn, account for behaviour. In other words, an intervening variable is an ‘in-the-head’ variable which cannot be seen, heard, or felt. It is inferred from the behaviour of an individual. Hostility is inferred from aggressive acts. When we display aggression, it reflects hostility. Learning is inferred from test scores. We exhibit learning when we perform well in test scores. Similarly, anxiety is inferred from skin response, heart beats, etc.

When we are nervous or anxious (maybe at the time of facing an interview, or before announcement of a result), the hair on our skin rises, our hearts start beating faster. In research, these reactions are known as invented constructs, the reality of which is inferred from human behaviour. For example, while studying the effect of motivation, a researcher is aware that motivation is an intervening variable; a construct invented by men to account for persistently motivated behaviour.

**Variables**

Any entity, the value of which never remains constant is known as a variable. A variable is a factor that varies and is not constant. For example, age can be regarded as a variable because its value changes for different people or for the same individual at different points of time. Similarly, country can be considered a variable because a person’s country can be assigned a value. Every research is based on variables, as research tries to establish relationship between two variables, one of which is dependent and the other is independent. Variables also help in understanding cause and effect relationship in a research. They are used in all types of researches. We have just given examples of the use of variables in an experimental research. We can also examine the importance or role of variables in other types of researches. In case study research, for example, the role of variables is equally important. A case study is one of the several ways of doing research. A case study is a method of exploring and analysing the life of a single social unit, be it a person, a family, an institution, a cultural group or even an entire single community. All these entities are variables.

Concepts such as ‘total family income’ are ideas an investigator has about the important characteristics of some entity such as a family. The concept must be clarified and defined, preferably explicitly, so that researchers can understand and share the phenomenon that is being studied. The concept of ‘total family income’ is defined to have a range of possible values. Thus, it is called a variable in a given piece of research. A variable is an indicator of some defined concept or characteristic of a case. A variable may also be defined as a property that takes on different values, as many measurable attribute of objects, things or beings. Examples of variables could be any concept such as age, income, community, intelligence, motivation, etc. The term variable more directly expresses a quantitative meaning. It means, ‘whatever varies’. The most intricate variations can be expressed in
terms of numbers, which are capable of indefinite divisions. A variable has, accordingly been defined as a symbol to which numerals or values are assigned.

Types of variables

Variables are of the following types:

(i) Dependent and independent variables: Researchers are studying the relationship between variables which are described as one of dependence. They are dependent and independent variables. Independent variable is the stimulus variable and dependent variable is the response variable. An 'independent variable' is the presumed cause of a dependent variable, which is the presumed effect.

(ii) Qualitative and quantitative variables: Qualitative variables are those which vary in kind and not in degree. Examples of qualitative variables are sex, race, religion, etc. They cannot be described in numbers. A quantitative variable, on the other hand is one whose values can be ordered in respect of their magnitude, that is, they can be described as being more or less, higher or lower, larger or smaller, etc. Examples of quantitative variables are intelligence, age, time, temperature, etc.

Quantitative variable can further be classified into two categories:
(a) Discrete or discontinuous, and
(b) Continuous.

The value of a discrete variable is a fixed quantity. For example, sex and family size are discrete variables. These can be stated in terms of indivisible quantity and not in terms of fractions like, 2.5 or 15.75 and so on. Discrete variables consist of two or more classes: dichotomous, those that consist of two categories (for example, sex has two categories: male and female) and, polychromous, those that consist of more than two categories (for example, intelligence can be categorized as high, average intelligence and low). A continuous variable is described as a 'quantitative variable which can be measured with an arbitrary degree of fineness'. For example, time is a continuous variable, since it can be measured in years, months, days, minutes, seconds, and so on.

Meaning of 'Theory'

A ‘theory’ is a set of statements or principles formulated to explain a group of facts or phenomena, especially one that has been repeatedly tested or is widely accepted and can be used to make predictions about natural phenomena. Technically speaking, a theory is built on a set of sentences which consist absolutely of true statements about the subject matter under consideration. Though, the truth of any one of these statements is based on the whole theory; the same statement may be true with respect to one theory and may not be true with respect to another.

Thus, theories are analytical tools for understanding, explaining and making predictions about a given subject matter. A theory is developed after checking the standard error of estimate which helps in increasing the reliability of a prediction.
This estimate is used to determine the dispersion of observed values. The theory of estimation is used to calculate the mathematical model for the data to be considered. It is used with known means and variance. Unbiasedness, consistency, efficiency and sufficiency are some of the properties of a good estimate. The theory of estimation is a very commonly used and popular statistical and research method and is used to calculate the mathematical model for the data to be considered. This method was introduced by the statistician R.A. Fisher, between 1912 and 1922. This method can be used in:

(i) Finding linear research models and generalized linear research models.
(ii) Exploratory and confirmatory factor analysis.
(iii) Structural equation modeling.
(iv) Data modelling in research analysis.
(v) Finding the result for hypothesis testing.

The method of estimation is used with known mean and variance. The sample mean becomes the maximum likelihood estimator of the population mean, and the sample variance becomes the close approximation to the maximum likelihood estimator of the population variance. A point estimate uses a single sample value to estimate the desired population parameter.

Theory serves research in many ways, a few of them are as follows:

- Theory narrows the range of facts to be studied. It helps to select a few relevant aspects of a phenomenon. For example, a cooperative society can be studied as an economic enterprise or as a social organization or as an medium for the welfare of weaker section. So we can say, a theory delimitates the study.
- Theory provides conceptual framework for a study.
- Theory summarize concisely what is already known about the object of study.
- Theory states a general uniformity beyond the immediate observations.
- Theory helps in extrapolation from the known to unknown.

Check Your Progress

3. What is a construct?
4. Name the types of variables.

1.4 SOCIAL WORK RESEARCH: MEANING, SCOPE AND IMPORTANCE

Social work primarily deals with human behaviour, which is by and large complex and dynamic in nature. One cannot, therefore investigate under guided conditions as in natural and physical sciences. This creates many problems for the researcher.
such as problems of subjectivity, individualistic generalizations, etc. The problem arising from the nature and content of social work do not seriously diminish the importance of scientific methods for social workers. Notwithstanding inherent limitations, scientific methods can be used to study problems related to social work, as far as they help to arrive at valid generalizations.

In social work research, scientific methods are applied to produce knowledge that social workers need, to solve problems faced by them in the practice of social work. It provides information that can be taken into consideration by social workers, prior to making decisions. These decisions affect their clients, programmes or agencies by use of alternative intervention techniques or change or modification of programme-client objectives, etc.

Knowledge of social work research is useful in appraising the effectiveness of methods and techniques of social work. Social work research starts with identification of the problem and setting of goals. This is followed by the process of assessment (or need assessment) of the client’s problems. During these initial stages, the researcher strives to obtain a clear and specific understanding of the problem, using assessment tools such as interviewing (Monette, et. al., 1986). After the problem is identified and needs are assessed, the next step is to set goals to be achieved. Goals are required to be specific, precisely defined and measurable in some way. The third step in the process is to have a pre-intervention measurement, which is used as basis with which to compare the client’s condition after the intervention is introduced. The next stage in the process is to introduce intervention. Here, it is important to note that only a single, coherent intervention be applied during any intervention phase. In the last stage, we assess the effects of intervention by comparing the two measurements, that is, pre-intervention measurement and measurements during intervention.

The objective of social work research is to produce knowledge that can be helpful in planning and executing social work programmes. On the other hand, the objective of social research is to accumulate knowledge for understanding the social life of human beings. Social work research is an applied research directed toward the acquisition of knowledge, in order to control or change human behaviour. Social research may be basic as well as applied. Social work research serves the goals of social work, whereas social research has no specific goal. It increases the knowledge of any social sciences. Social work research helps social workers in dealing with social problems or problems related to their clients (individual, group or community).

Social work research may be defined as systematic investigation into the problems, in the field of social work. The study of concepts, principles, theories underlying social work methods and skills are the major concern of social work research. Social work research involves study of the relationship of social workers with their clients, individuals, groups or communities on various levels of interaction or therapy, as well as their natural relationships and functioning within the organizational structure of social agencies. Theoretically, social work research re-examines the special body of knowledge; concepts and theories. On the other
hand, in the area of social work practice, it tries to evolve systematic theory and valid concepts to know the efficacy of different methods, interventions of social work as to search for alternate innovative interventions and treatments. Social work research, therefore, concerns itself with the problems faced by social workers. It encompasses those questions which are encountered in social work practices or in planning or administering social work services, which can be solved through research and are appropriate for investigation. Social work research utilizes the same scientific methods and techniques, as social research.

According to Genevieve W. Cater, ‘social work research is an organized and vital study of questions in the area of social welfare, with the aim of producing answers to the problems of social work and for offering and taking a broad view of social work knowledge and concepts’.

Friedlander (1957) explains that ‘social work research is the systematic, critical investigation of questions in the social welfare field with the purpose of yielding answers to problems of social work, and of extending and generalizing social work knowledge and concepts’.

According to MacDonald (1957): ‘Research in social work may be taken to encompass those questions, which are encountered in social work preplanning, or administering social work practice, or in planning or administering social work services. These questions can be resolved through research and are appropriate for investigation under social work auspices’. Research in social work has been defined by Fletcher (1949) as ‘the scientific testing of the validity of social work functions and methods’.

In a broad sense, social work research is the application of research methods to solve problems that social workers face in the practice of social work. It provides information that can be taken into consideration by social workers, prior to making decisions that affect their clients, programmes or agencies such as use of alternative intervention techniques or change or modification of programme/client/objectives, etc. Some of the situations which call for application of social work research methods and techniques are discussed below:

1.4.1 Importance of Social Work Research

All progress is born of inquiry. The cost of needs has to be equated with credible revenues. Research is the most important need of this domain. It can help in devising optional policies and can also inspect the results of each of these options. Every research may not comprise decision-making, but it definitely helps a policymaker in taking decisions.

The government is required to set up programmes to deal with every aspect of the country’s subsistence and the majority of these are linked to economic and social conditions in a direct or indirect way. Social work research facilitates the use of systematically framed facts and explanations which help solve social problems and enhance human functioning. Two main purposes of social work research are:
(i) To achieve a better fit between human needs and welfare goals
(ii) To increase the chances of achieving these goals

MacDonald’s view is that the function of social work research is to contribute to the development of a dependable body of knowledge, to serve the goals and means of social work in all its ramifications.

Fletcher has mentioned the following objectives of social work research:

- Social work is a practice profession. As such, the major objective of social work research is to search for answers to questions raised, regarding interventions or practice effectiveness.
- In other words, social work research attempts to provide knowledge about what interventions or treatments really help or hinder the attainment of social work goals.
- In addition, it also helps in searching for answers to problems or difficulties faced by social work practitioners, in the practice of their profession.
- It helps in building a knowledge base for social work theory and practice.
- Social work research also deals with problems faced by professional social workers, social work agencies and community in its concern with social work functions. In other words, in social work research the problems to be investigated are always found in the course of doing social work or planning to do it (Dasgupta, 1968).

Social work research offers an opportunity for all social workers to incorporate differences in their practice. There is no doubt about the fact that a social worker will be a more effective practitioner, guided by the findings of social work research. Thus, social work research seeks to accomplish the same humanistic goals, as does a social work method. Social work research deals with those methods and issues, which are useful in evaluating social work programmes and practices. It explains the methodology of social research and illustrates its applications in social work settings.

Substantive part of social work practice is concerned with the micro-level practice such as, working with individuals, groups, or a community. Social work research has to take into consideration the limitations of micro level design of study and techniques. Social work research is basically a practice-based research, which mostly draws its inferences through inductive reasoning. That is, inferring something about a whole group or a class of objects from the facts or knowledge of one or few members of that group/class. Thus, in practice-based research, inductive reasoning carries us from observation to theory through intervention/assessment. Practitioners, for example, may observe that delinquents tend to come from families with low socio-economic status. Based on the assumption that the parent-child bond is weaker in low socio-economic families and that such parents therefore have less control over their children, the practitioners may inductively conclude that a weak parent-child bond leads to delinquency.
1.4.2 Types of Research in Social Work

Phillip Klein has mentioned the following classifications of the type of research in social work:

(i) Studies to establish identify and measure the need for service
(ii) Studies to measure the services offered, as they relate to needs
(iii) Studies to test, gauge and evaluate the results of social work operation
(iv) Studies to test the efficacy of specific techniques of offering service
(v) Studies in the methodology of research

Friedlander has mentioned the following types of studies:

- Studies to establish and measure factors that produce social problems and call for social services.
- Studies of the history of charitable institutions, social welfare legislation, social welfare programmes and social work concepts.
- Studies of the exceptions, perceptions and situation evaluations of social workers.
- Studies of intentions, goals and self-images of social workers.
- Studies of intentions, goals and self-images of social workers.
- Studies of the relationship between the social workers’ expectations, his intentions and his actions.
- Studies about the content of social work processes.
- Studies that test the adequacy of available social services, with respect to the needs of individuals, groups and the community.
- Studies that test, gauge and evaluate the effects of social work operations and investigate the competence required for social work practice.
- Studies of client’s expectations, goals, perceptions and evaluation of situations.
- Studies of formal and informal definition of the role of social work practice.
- Studies of formal and informal definition of the role of social workers, their interrelationships, etc.
- Studies of the values and priority preferences of social groups in the community upon which social welfare practice relies for support and development.
- Studies of the patterns of interaction between different components in social agency settings and of their influence on clients and agency staff.
- Studies of the methodology of social work research. It has been recognized that social work research needs to develop and define its own conceptual tools, selecting and adapting concepts from the social sciences.
Limitations in social work research

Few of the limitations in social work research are the following:

- All the members of the society have their distinct values and the social researcher gets influenced by them.
- A social work researcher has to go through the responses of various individuals which at times might be positive or negative.
- A social work researcher might have to do rigorous field work and few of them might not find this easy to do.

Check Your Progress

5. Define social work research.
6. State the main purposes of social work research.

1.5 DIFFERENCES BETWEEN SOCIAL RESEARCH AND SOCIAL WORK RESEARCH

Social work research is not completely identical to social research. In fact, there are many similarities between this process and the traditional research process. The process, however, has some additional steps designed to suit the objectives of social work research. By following the process, social work researchers are in a position to know precisely the intervention that was applied and the effect produced. The process also links research and practice. In social work research, the problems to be investigated are always found in the course of doing social work or planning to do it. It is obvious that in social work research, the study of a problem is done from the point of view of social work and that of professional social work. The designing of research problems, data collection and their interpretation will have to be attempted in a manner that would be useful to professional social workers, which would add new knowledge to the social work theory and practice and improve the efficiency of professional social workers.

Social work research draws its inferences from productive reasoning. The main differences between social science research and social work research are as follows:

(i) Social work researches are generally concerned with practical problems, while social researches may be concerned with any aspect of social life.

(ii) Social work research is aimed at producing knowledge that supports the functions of planning and executing social work programmes, whereas the objective of social research is to accumulate the knowledge for understanding the social life of human beings.

(iii) Social work research is an applied research, which is directed towards the acquisition of knowledge in order to control or change human behaviour. Social research may be basic or applied.
Social work research serves the goals of social work, whereas social research has no specific goals. Social work research helps social workers in dealing with social problems or problems relating to their clients (individual, group or community). Social research may be helpful to social work as it helps in increasing the knowledge of human behaviour.

**1.6 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS**

1. The essential factors of a good research are the following:
   - It is based on empirical data.
   - It involves precise observations and measurements.
   - It is aimed at developing theories, principles and generalizations.
   - There are systematic, logical procedures involved.
   - It is replicable.
   - The findings of the research need to be reported.

2. The main objective of a research is to find answers to questions through the application of scientific procedures.

3. A construct is a verbal response evoked by objects of the class to which the concept applies. Some concepts such as temperature, sound, age, sex, etc., cannot be directly observed, but their instances can be located.

4. The types of variables are:
   - i. Dependent and independent variables
   - ii. Qualitative and quantitative variables

5. Social work research may be defined as systematic investigation into the problems, in the field of social work. The study of concepts, principles, theories underlying social work methods and skills are the major concern of social work research.

6. The main purposes of social work research are the following:
   - (i) To achieve a better fit between human needs and welfare goals
   - (ii) To increase the chances of achieving these goals

**1.7 SUMMARY**

- Research, in the layman’s terms, means the search for knowledge. Scientific research is a systematic and objective way of seeking answers to certain questions that require inquiry and insight or that have been raised on a particular topic.
Scientific research involves controlled observations, analysis of empirical data and interpretation of findings. This can further lead to the development of concepts, generalizations, etc., on the basis of which theories could be formulated.

Another source for research ideas is when researchers regularly update themselves by reading available literature and then extrapolating ideas from current researches in their respective fields of study.

Research in common parlance refers to search for knowledge. One can also define research as a scientific and systematic search for pertinent information on a specific topic.

The basic principles of research include a systematic process to identify a question or problem, set forth a plan of action to answer the question or resolve the problem, and meticulously collect and analyse data.

Social research is a systematic and scientific process, based on well-defined rules, applicable in certain circumstances, for achieving the objective of transforming an indeterminate situation into a determinate one.

Social research investigates the interrelationships among various social facts. It also verifies new and old facts about social life and acquires knowledge about the control of social phenomena and laws that are formulated and promoted.

A concept is a cognitive unit that means an abstract idea or a mental symbol at times referred to as a unit of knowledge. For example, light, temperature, sound, age, sex, accidents, etc., all these are class names applied to stimuli, subjects or responses of a specific kind.

In social sciences, it is often required to measure ideas that are not directly measurable. However, they can be measured by giving a description of precise qualities, which when considered one unit, define a construct.

Constructs play a very important role in building theories. Many theories such as the memory trace theory, the frustration aggression theory, etc., use constructs.

Any entity, the value of which never remains constant is known as a variable. A variable is a factor that varies and is not constant. For example, age can be regarded as a variable because its value changes for different people or for the same individual at different points of time.

A ‘theory’ is a set of statements or principles formulated to explain a group of facts or phenomena, especially one that has been repeatedly tested or is widely accepted and can be used to make predictions about natural phenomena.

The method of estimation is used with known mean and variance. The sample mean becomes the maximum likelihood estimator of the population mean.
and the sample variance becomes the close approximation to the maximum likelihood estimator of the population variance.

- Social work primarily deals with human behaviour, which is by and large complex and dynamic in nature. One cannot, therefore, investigate under guided conditions as in natural and physical sciences.
- Social work research offers an opportunity for all social workers to incorporate differences in their practice. There is no doubt about the fact that a social worker will be a more effective practitioner, guided by the findings of social work research.
- Substantive part of social work practice is concerned with micro-level practice, such as working with individuals, groups, or a community. Practice-based research has to take into consideration the limitations of micro level practice.
- Social work research is not completely identical to social research. In fact, there are many similarities between this process and the traditional research process.

### 1.8 KEY WORDS

- **Research**: It implies the quest for knowledge.
- **Social research**: It may be defined as systematic investigation intended to add to available knowledge in a form that is communicable and verifiable.
- **Scientific research**: It involves controlled observations, analysis of empirical data and interpretation of findings.

### 1.9 SELF ASSESSMENT QUESTIONS AND EXERCISES

**Short Answer Questions**

1. State the objectives and characteristics of research.
2. Mention the ethics and qualities of a good researcher.
3. What are the objectives of social research?
4. What are the limitations in social work research?

**Long Answer Questions**

1. Examine the importance of social work research.
2. Differentiate between social research and social work research.
1.10 FURTHER READINGS


UNIT 2 SCIENTIFIC METHOD

2.0 INTRODUCTION

Science is always a work in progress and its conclusions are always tentative. But just as the word ‘theory’ means something special to the scientist, so does the word ‘tentative’. The conclusions of science are not tentative in the sense that they are temporary until the real answer comes along.

Scientific conclusions are well founded in their factual content and thinking and are tentative only in the sense that all ideas are open to scrutiny. In science, the tentativeness of ideas such as the nature of atoms, cells, stars or the history of the Earth refers to the willingness of scientists to modify their ideas as new evidence appears.

In this unit, you will study about the meaning and characteristic of scientific method, process of scientific inquiry, relationship between theory method and fact, types of research, participatory and evaluation research.

2.1 OBJECTIVES

After going through this unit, you will be able to:

- State the meaning and characteristics of scientific method
- Discuss the process of scientific inquiry
- Analyse the relationship between theory method and fact
- Explain the types of research
- Define participatory and evaluation research
2.2 MEANING AND CHARACTERISTICS OF SCIENTIFIC METHOD

Methodologically, science can be defined as an approach to acquire knowledge, which follows certain explicit rules and procedures. Further, the results of the acquired knowledge are evaluated in the light of the method used to achieve that knowledge. The process of study, which involves these steps, is science. A scientific method refers to a body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge. For being referred to as scientific, the basis of a method of inquiry must be the empirical and measurable evidence that has been gathered, with respect to specific principles of reasoning. The Oxford English Dictionary says that a scientific method is: ‘A method or procedure that has characterized natural science since the 17th century. It consists of systematic observation, measurement, experiment and formulation, testing, and modification of hypotheses.’

Ostle and Mensing defined a scientific method as ‘the pursuit of truth, as determined by logical considerations’. The basic criterion of science is to attain interrelated facts in an organized way. According to George Lundberg (1946), a scientific method consists of three basic steps, (i) systematic observation, (ii) classification and (iii) interpretation of data. Through these steps, a scientific method does not only verify facts, but it also establishes a confidence in the validity of conclusions. The definition requires more explanation. First, when Lundberg (1946) said that scientific method is a systematic observation, he meant in effect, that scientific investigation is not ordered, it aims only at discovering facts as they actually are and not as they are desired to be and as such, investigators can be confident about their conclusions. Second, a scientific method is concerned with ‘classes of objects’ and not ‘individual objects’. Universality and predictability are other features of a scientific method. The method makes it possible to predict about a phenomenon with sufficient accuracy.

2.3 PROCESS OF SCIENTIFIC INQUIRY

The objective of a scientific inquiry is to acquire knowledge in the form of testable explanations that can predict the results of future experiments. The more enhanced an explanation is at making predictions, the more beneficial it is in proving the predictions that it is correct. The most successful explanations that elucidate and formulate accurate predictions for broad range of conditions are termed as scientific theories. The power of a theory is related to how long it has persisted without distortion of its core principles.
Scientific Enquiry Skills

There are many scientific enquiry skills that must be observed in order to develop scientific theory. Some of which are as follows:

- Raising/asking questions
- Ways of enquiry
- Predicting and hypothesizing
- Making careful observations
- Using tools accurately and safely
- Making a record of evidence to present their findings
- Considering significant evidences
- Evaluating reliable evidences and findings accurate results
- Developing ideas from evidence

The same is the case with social sciences. The scientific method can also be applied to subjects in social sciences.

2.4 RELATIONSHIP BETWEEN THEORY, METHOD AND FACT

Science refers to organized knowledge, but this knowledge and these facts are seldom conclusive. New experiences and additional information constantly change previous findings and replace them with generalizations that confirm the latest bodies of findings.

A scientific enquiry is an investigation or experiment carried out to dispel or confirm various scientific theories. Most scientific enquiries are done practically in laboratories with specialized equipment.

The scientific method is based on techniques used to investigate phenomena, acquire new knowledge or correct and integrate previous knowledge. Any method is termed scientific when the inquiry is based on experiential and computable evidences subject to specific principles of reasoning. As per the Oxford English Dictionary, ‘The scientific method is a method or procedure that has characterized natural science since the 17th century, consisting in systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses.’

The key characteristic of the scientific method is that researchers can support a theory when the predictions given for any specific theory are confirmed and challenge a theory when its predictions prove false, even though procedures differ from one field of inquiry to another. Theories that include extensive domains of inquiry may combine many independently derived hypotheses together in a logical
and supportive structure. Theories are developed on the basis of scientific inquiry and are normally intended to be objective so as to reduce biased interpretations of results. The overall process of theory development involves making assumptions by defining hypotheses and deriving predictions as logical consequences. The experiments are then carried out based on those defined predictions to establish whether the original assumption was correct. The scientific method steps are used to establish a theory.

2.5 TYPES OF RESEARCH: PURE, APPLIED AND ACTION

Research can be either fundamental (basic or pure) or action-oriented (applied) research. Fundamental research focuses on finding generalizations and formulating theories. It is the research done for knowledge enhancement; the research which does not have immediate commercial potential; and the research which is done for human welfare, animal welfare and plant kingdom welfare. For example, research on the institution of marriage came into being is an example of basic or fundamental research. Here the main motivation is to expand man’s knowledge and not to create or invent something. Basic research lays down the foundation for the applied research.

Applied research is designed to solve practical problem of the modern world, rather than to acquire knowledge for the sake of knowledge. Its goal is to improve the human condition. It focuses on analysis and solving social and real life problems. This research is usually conducted on large scale basis and is expensive. Thus, it is often conducted with the support of some financing agency like government, public corporation, World Bank, UNICEF, UGC, etc. Examples of applied research topics include persuasion, eyewitness memory, clinical treatments of psychological disorders, behavioral interventions for children with autism, decision making, etc.

2.6 PARTICIPATORY AND EVALUATION RESEARCH

Participatory research

Participatory research comprises a range of methodological approaches and techniques, all with the objective of handing power from the researcher to research participants, who are often community members or community-based organisations. In participatory research, participants have control over the research agenda, the process and actions. Most importantly, people themselves are the ones who analyse and reflect on the information generated, in order to obtain the findings and conclusions of the research process.
Participatory research involves inquiry, but also action. People not only discuss their problems, they also think about possible solutions to them and actions which need to be taken. The research conducted by the Participatory Research Group (PRG) aims to influence decision-making processes and impact peoples’ lives locally and nationally. The challenge is that the views of the most marginalised people are by definition largely absent in public forums, which further excludes them and in turn amplifies the perspectives of the more powerful groups. Bringing these people and perspectives into policy processes is not a straightforward task. Participatory research is one way that these perspectives can be articulated, and yet there are many challenges in how to do this well.

Evaluation research

It can be defined as a type of study that uses standard social research methods for evaluative purposes, as a specific research methodology, and as an assessment process that employs special techniques unique to the evaluation of social programs.

Check Your Progress

1. What is the objective of a scientific inquiry?
2. What is the key characteristic of the scientific method?

2.7 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. The objective of a scientific inquiry is to acquire knowledge in the form of testable explanations that can predict the results of future experiments.
2. The key characteristic of the scientific method is that researchers can support a theory when the predictions given for any specific theory are confirmed and challenge a theory when its predictions prove false, even though procedures differ from one field of inquiry to another.

2.8 SUMMARY

- Methodologically, science can be defined as an approach to acquire knowledge, which follows certain explicit rules and procedures.
- A scientific method refers to a body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge.
- According to George Lundberg (1946), a scientific method consists of three basic steps, (i) systematic observation, (ii) classification and (iii) interpretation of data.
Universality and predictability are other features of a scientific method. The method makes it possible to predict about a phenomenon with sufficient accuracy.

The objective of a scientific inquiry is to acquire knowledge in the form of testable explanations that can predict the results of future experiments.

Science refers to organized knowledge, but this knowledge and these facts are seldom conclusive.

A scientific enquiry is an investigation or experiment carried out to dispel or confirm various scientific theories.

The key characteristic of the scientific method is that researchers can support a theory when the predictions given for any specific theory are confirmed and challenge a theory when its predictions prove false, even though procedures differ from one field of inquiry to another.

Applied research is designed to solve practical problems of the modern world, rather than to acquire knowledge for the sake of knowledge.

Participatory research comprises a range of methodological approaches and techniques, all with the objective of handing power from the researcher to research participants, who are often community members or community-based organizations.

The research conducted by the Participatory Research Group (PRG) aims to influence decision-making processes and impact peoples’ lives locally and nationally.

2.9 KEY WORDS

- **Scientific method**: It refers to a body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge.

- **Scientific inquiry**: It is an investigation or experiment carried out to dispel or confirm various scientific theories.

- **Evaluation research**: It is not a methodology, but a class of research with a common feature of evaluating programs.

2.10 SELF ASSESSMENT QUESTIONS AND EXERCISES

**Short Answer Questions**

1. List the significant features of the scientific method.
2. What is the relationship between theory method and fact?
Long Answer Questions

1. Discuss the process of scientific inquiry.
2. Explain the types of research.
3. ‘Participatory research involves inquiry, but also action.’ Explain the statement.

2.11 FURTHER READINGS

UNIT 3 RESEARCH APPROACHES

Structure
3.0 Introduction
3.1 Objectives
3.2 Qualitative Research: Meaning, Scope and Characteristics
  3.2.1 Distinguishing Qualitative from Quantitative Data Methods
  3.2.2 Sampling and Design
3.3 Types of Qualitative Research
  3.3.1 Focus Group
  3.3.2 Content Analysis
  3.3.3 Ethnography and Life History
  3.3.4 Limitations and Obstacles in Qualitative Research
3.4 Answers to Check Your Progress Questions
3.5 Summary
3.6 Key Words
3.7 Self Assessment Questions and Exercises
3.8 Further Readings

3.0 INTRODUCTION

Research approach is defined as a plan and process that comprises the steps of broad assumptions to detailed method of data collection, analysis and interpretation. Hence, it is based on the nature of the research problem being addressed. Research approach is essentially divided into two categories: one is approach of data collection and the second, is approach of data analysis or reasoning.

This unit will apprise you of the meaning and characteristics of qualitative research and quantitative research. Moreover, the unit will also differentiate between quantitative research and qualitative research.

3.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss the meaning, scope and characteristics of qualitative research
- Explain the types of qualitative research
- Briefly mention the strengths and limitations of quantitative research
- Differentiate between qualitative and quantitative research methods
3.2 QUALITATIVE RESEARCH: MEANING, SCOPE AND CHARACTERISTICS

Ritu Kalmadi, editor of *Young Indian*, was driving down to her office at Bhikaji Cama Place, New Delhi, and was trying to beat the office rush at 10 a.m. She had a meeting with her creative team listed as her first appointment for the day at 11.30 a.m. They had to sit down and freeze the layout of the articles and columns for the new fortnightly magazine of Satrangi publications. The English magazine was targeted towards the 14 to 18-year-olds, typically residing in a metro. The traffic light had just turned red, so Ritu stopped and started thinking about how she would design a winner of a magazine. She had been the editor of a popular women’s magazine, so this assignment should not be tough. Her meanderings were broken by the loud blaring of a cacophonous horn. She looked back and saw a young girl of probably 15 or 16 yelling at her from a huge monstrous Scorpio. When Ritu opened her window and pointed towards the signal, the young, purple-streaked girl driver shouted ‘So move your jalopy you old cow! I wonder why senile buddhis like you get behind a wheel.’ Ritu was aghast. The young girl was probably as old as Manjari, her daughter, so she reprimanded her and said, ‘Young lady, mind your language,’ to which the reply was ‘Shut up and get lost’. Just then the light turned green and the Scorpio brushed dangerously close to her Accent, hooting and whizzing away.

Ritu took her car to the side and sat shaken for a moment. Was this the audience for which *Young Indian* was meant? Good Heavens! the team did not have a clue. The new-age teenager was beyond comprehension. What were her/his likes and dislikes? Whom did he/she look up to? Why were *Roadies* and *LoveNet* such favourite programmes with them? Did they have any kind of value system? What were their fears and insecurities? Was life only Facebook and friends or did these teenagers have any goals in life?

Questions galore and despite having the company of her daughter at home, Ritu was not sure whether she and her team even remotely understood the people for whom they were creating an offering. They required some serious in-depth understanding of the potential reader. Suddenly, she remembered her niece, who was pursuing a masters in psychology, telling her about inkblot tests and something called a TAT, which unravelled the personality of individuals. Maybe a sensitive analysis that attempted to create a typical persona of this new Indian teenager would help design a periodical specially meant for them.

Ritu started her car and realized that she still had a lot to learn. There would be more work required but it was also going to be exciting and challenging to unravel the subjective mysteries of the young mind. She had always swept aside the subconscious and latent explanations of why people act unpredictably, but maybe there was merit in what Sigmund Freud had prophesized. She reached office and sprinted across to the discussion room and opened the door. ‘Hi guys! Let’s leave the copy and become creative for a while. We need to do a little more
subjective and qualitative homework before we surge ahead. This is what I propose we do’.

Ritu is absolutely correct and wise in her approach. Numbers and chemical equations might be fine for predicting rainfalls and genetic constitutions. However, when one needed to strategize and deliver to the human mind, one had to go deeper and understand what makes him/her tick; and the best way to do this is through a qualitative analysis.

Primary data source available to the researcher is original, first-hand data. This might be qualitative or quantitative in nature (as shown in Figure 3.1). Qualitative research as an approach contributing to management thought took a very long time to be accepted as such. There was considerable interest generated when in 1825, JB Savarin published *The Physiology of Taste*, where he stated ‘Tell me what you eat and I will tell you what you are.’ Personality and human emotions and needs were being analysed in the area of organizational behaviour. However, the analysis was usually done by structured, quantitative, measurable techniques. William Henry (1956) with his Thematic Apperception Tests (TAT) provided subjective methods which could be used to analyse and interpret certain reasons behind why people think and behave in a certain way. This was perceived to have a lot of merit in understanding the employees in an organization and secondly, it could explain how brands were symbolic of their lives. No matter what is the management area one is using a qualitative approach, one has to begin with the most significant proponents of the movement—Glaser and Strauss (1967). In the *Discovery of Grounded Theory*, they challenged the positivists and used an inductive approach (based on simple real life observations) to understand various human and business processes and used these to formulate a formal theory. There have been a number of proponents of the movement who have taken this thought forward, developed and modified the method of capturing this fluid reality and attempted to make sense from the symbolic behaviour and words used by the individuals, organizations and policy-makers. Locke (2001) an active supporter of the theory, vouches for the use of this theory in the field of management as it is able to make sense of the complexity of the phenomena observed, has realistic usefulness and is especially useful in the new areas where change is constant and the variables are multiple. Thus, the presumption is that there are multiple realities as experienced and interpreted by different people in their own unique fashion.

Qualitative research, thus, is presumed to go beyond the obvious of constructs and variables that are not visible or measurable; rather they have to be deduced by various methods. There are a variety of such methods which will be discussed in detail in this unit. However, common premise of all these are that they are relatively loosely structured and require a closer dialogue or interaction between the investigator and the respondent. The information collected is more in-depth and intensive and results in rich insights and perspectives than those delivered through a more formal and structured method. However, since the element of subjectivity is high, they require a lot of objectivity on the part of the investigator while collecting and interpreting the data. Conducting a qualitative research is an
Research Approaches

NOTES

extremely skillful task and requires both aptitude and adequate training in order to result in valuable and applicable data.

Fig. 3.1 Classification of qualitative data sources

Premise for Using Qualitative Research Methods

The rationale for using qualitative research methods is essentially to provide inputs that are helpful in uncovering the motives behind visible and measurable occurrences. The information extracted becomes critical when explaining and interpreting the findings obtained through quantitative methods. Qualitative methods might be used for exploratory studies, for formulating and structuring the research problem and hypotheses, as inputs for designing the structured questionnaires, as the primary sources of research enquiry for a clinical analysis, where the task is to unearth the reasons for certain occurrences and with segments like children.

Thus, there are multiple arguments for using these data-collection techniques:

- Developing an in-depth understanding of the individuals, beliefs, attitudes and behaviour. For example, why is it such a difficult task to sell old age homes to Indian families?
- Providing insights into verbal and non-verbal language and identifying the parameters that can be used for mapping a subject’s attitude and behaviour
- Understanding the dynamics of industry and key issues (expert interactions)
- Sometimes, direct and structured questions or information needed might not be obtainable, in which case one needs to obtain it through a more flexible and unstructured approach. Would you get into a live-in
relationship? Or even a relatively simple question like what aspects of your boss do you think need correction?

- Checking how individuals interpret the work-related policies or occurrences or product attributes/message/pricing
- Getting reactions to ideas and identifying likes/dislikes of human beings
- Sparking off new ideas and brainstorming. What does a consumer look for in probiotic curd, digestive enzymes or low fat? Tata’s Nano might mean something for a two-wheeler owner and something entirely different for a four-wheeler owner. Based upon the reaction to the car, the company can decide its positioning.
- Certain behaviour seems to be non-comprehensible by the respondent also, in which case the latent motives need to be unearthed through other methods. For example, why do you want to get a tattoo on your arm? Or why do you not take any initiative in a team discussion even when your senior asks you to? The classic example in this case is the half-filled glass, interpreted differently by optimists and pessimists.
- Each individual’s organization of reality is unique and his reaction would be uniquely dependent on that. Thus, it becomes critical to make sense of this through an unstructured and ambiguous stimulus (Kerlinger, 1986).

3.2.1 Distinguishing Qualitative from Quantitative Data Methods

To comprehend the distinction between the two approaches, one needs to appreciate the contribution of each to the research process.

**Research objective**

- **Qualitative research**: It can be used to explore, describe or understand the reasons for a certain phenomena. For example, to understand what a low-cost car means to an Indian consumer, this kind of investigation would be required.
- **Quantitative research**: When the data to be studied needs to be quantified and subjected to a suitable analysis in order to generalize the findings to the population at large or to be able to quantify and explain and predict the occurrence of a certain phenomena. For example, to measure the purchase intentions for Nano as a function of the demographic variables of income, family size and distance travelled, one would need to use quantitative methods.

**Research design**

- **Qualitative research**: The design is exploratory or descriptive, loosely structured and open to interpretation and presumptions.
- **Quantitative research**: The design is structured and has a measurable set of variables with a presumption about testing them.
Research Approaches

Sampling plan

**Qualitative research:** Only a small sample is manageable as the information required needs to be extracted by a flexible and sometimes lengthy procedure.

**Quantitative research:** Large representative samples can be measured and the data collected can be based upon a shorter time span with a larger number. Chances of error in extrapolating it to a larger population are less and measurable.

Data collection

**Qualitative research:** The data collection is in-depth and collected through a more interactive and unstructured approach. Data collected includes both the verbal and non-verbal responses. Methodology requires a well-trained investigator.

**Quantitative research:** The data collected is formatted and structured. The nature of interrogation is more of stimulus-response type. The data collected is usually verbal and well-articulated. Interrogation does not need extensive training on the part of the investigator.

Data analysis

**Qualitative research:** Interpretation of data is textual and usually non-statistical.

**Quantitative research:** Interpretation of data entails various levels of statistical testing.

Research deliverables

**Qualitative research:** The initial and ultimate objective is to explain the findings from more structured sources.

**Quantitative research:** The findings must be conclusive and demonstrate clear indications of the decisive action and generalizations.

Before we discuss the various methods of qualitative nature, it is essential to remember that even though the information obtained is rich and extensive, it is diagnostic and not evaluative in nature, thus, should not be used for generalizations on to larger respondent groups. Secondly, because of the nature of the conduction, they always cover smaller sample groups or individuals. Thus, they are indicative rather than predictive in nature. And lastly, they indicate the direction of respondent sentiments and should not be mistaken for the strength of the reactions. Thus, what is advocated is that the two approaches—qualitative and quantitative—are not to be treated as the extreme ends of a theoretical continuum. A business researcher should take them as complementary and supportive in order to get measurable as well as humanistic inputs for taking informed decisions.

3.2.2 Sampling and Design

Sampling is an extensive topic to be discussed in field of Statistics. When any type of data especially quantitative data is to be collected whether through the
observational method, through surveys or from secondary data, you need to decide which data to collect and from whom. This is called the sample.

There are numerous ways to select your sample, and to ensure that it gives you results that will be reliable and credible.

**Sampling design**

Let us try to understand this in simple words. For a finite population, a sampling design specifies for every possible sample its probability of being drawn. One of the simplest sample designs is simple random sampling, where each unit of a population has the same probability to be included in the sample.

You will study about this topic in detail in Unit 7.

**3.3 TYPES OF QUALITATIVE RESEARCH**

Quantitative techniques are not useful in studying the human behavior or intentions. This is where the application of qualitative techniques is required. Qualitative research helps to understand human behaviour and the reasons for their behaving as such. Thus, qualitative techniques need sufficient time to be carried out in order to be successful. Let us study the types of qualitative research methods.

**3.3.1 Focus group**

Focus group as a method developed in the 1940s in Columbia University by sociologist Robert Merton and his colleagues as part of a sociological technique. This was used as a method for measuring audience reaction to radio programmes (MacGregor and Morrison, 1995). In fact, the method was uniquely adapted and modified in different branches of social sciences namely anthropology (Wilson and Wilson 1945), sociology (Merton and Kendall, 1946), psychology (Bogardus, 1926), education (Edminton, 1944) and advertising (Smith, 1954). It essentially emerged as an alternative method which was more cost effective and less time consuming and could generate a large amount of information in a short time span.

Another argument given in its favour was that group dynamics play a positive role in generating data that the individual would be hesitant about sharing when he was spoken to individually (Morgan and Krueger, 1997).

A focus group is a highly versatile and dynamic method of collecting information from a representative group of respondents. The process generally involves a moderator who maneuvers the discussion on the topic under study. There are a group of carefully-selected respondents who are specifically invited and gathered at a neutral setting. The moderator initiates the discussion and then the group carries it forward by holding a focused and an interactive discussion. The technique is extensively used and at the same time also criticized. While one school of thought places group dynamics at an important position, another negates its contribution as detrimental. We will examine these as we go along.
Key elements of a focus group: There are certain typical requirements for a conducive discussion. These need to be ensured in order to get meaningful and usable outputs from the technique.

Size: The size of the group is extremely critical and should not be too large or too small. Fern (1983) stated that as every member is assumed to contribute meaningfully to the discussion, if the size of the group is too large then contribution by the members might not be premium. Ideal recommended size thus for a group discussion is 8 to 12 members. Less than eight would not generate all the possible perspectives on the topic and the group dynamics required for a meaningful session.

Nature: Individuals who are from a similar background—in terms of demographic and psychographic traits—must be included, otherwise the disagreement might emerge as a result of other factors rather than the one under study. For example, a group of homemakers and working women discussing packaged food might not have a similar perspective towards the product because they have different roles to manage and balance; thus what is perceived as convenience by one is viewed as indifferent and careless attitude towards one’s family by the other. The other requirement is that the respondents must be similar in terms of the subject/policy/product knowledge and experience with the product under study. Moreover, the participants should be carefully screened to meet a certain criteria.

Acquaintance: It has been found that knowing each other in a group discussion is disruptive and hampers the free flow of the discussion and it is believed that people reveal their perspectives more freely amongst strangers rather than friends (Feldwick and Winstanley, 1986). Bristol (1999) found that men revealed more about themselves amongst strangers, while females were more comfortable amongst acquaintances. Thus, it is recommended that the group should consist of strangers rather than subjects who know each other. There are exceptions however in certain cases; this would be further discussed in a subsequent section.

Setting: As far as possible, the external factors which might affect the nature of the discussion are to be minimized. One of these could be the space or setting in which the discussion takes place. Thus, it should be as neutral, informal and comfortable as possible. Even the ones that have one-way mirrors or cameras installed need to ensure that these gadgets are as unobtrusively placed as possible.

Time period: The conduction of the discussion should be held in a single setting unless there is a before and after design which requires group perceptions, initially before the study variable is introduced; and later in order to gauge the group’s reactions. The ideal duration of conduction should not exceed one and a half hour. This is usually preceded by a short rapport formation session between the moderator and the group members.

The recording: Earlier there were human recorders, either sitting behind one-way mirrors or in the discussion room. Today, these have been replaced by cameras that video-record the entire discussion. This can, then, be replayed for analysis and interpretation. The advantage over human recording is that one is able to observe the non-verbal cues and body language as well. This technology
has been further enhanced and one can evaluate the discussion happening at one location, being observed and transmitted at another.

The moderator: He is the key conductor of the whole session. The nature, content and validity of the data collected are dependent to a large extent on the skills of the moderator. His role might be that of a participant where he might be a part of the group discussion or he might be a non-participant and has the task of rapport formation, initiating the discussion and steering the discussion forward. Morgan and Thomas (1996) have stated that any group task has two clear agendas. One is the conscious agenda to complete the overt task and the second, more important, plan is related to the unconscious. This is concerned with the emotional needs of the group and has been described differently as ‘group mind’, ‘group as a whole’ and ‘group as a group’. The moderator is clearly responsible for this as he needs to work with the group as a group in order to maximize the group performance. Thus, he needs to possess some critical moderating skills like:

- Ability to listen attentively and have a positive demeanour that encourages others to discuss. At the same time, he must be detached and give no indication about his personal opinion in order to skew the discussion. He should be dressed in a manner that is informal and similar to the group.
- He needs to make others feel comfortable, thus the language used should be in the subjects’ lingo, with no use of technical words at all.
- He needs to be flexible in approach, so that the discussion flows naturally rather than becoming compartmentalized into a question and answer session. At the same time, he also needs to act as translator in case some one’s point is not understood or interpreted correctly.
- He must also discreetly handle the overbearing and dominating participants and encourage all the members to contribute by drawing out the hesitant ones as well. Thus, sensitivity to the respondents’ feelings must be present at all times.
- There is no external signal, so he needs to be sufficiently trained and acquainted with the topic to understand the specific interval when all the possible viewpoints get exhausted and the discussion needs to move on.

In conducting the discussions, he might use the summary and closure approach where he might pick up a similar point made by a participant to another and summarize it and ask for his opinion. Another tactic that can be used is to bring in the extreme opinions on the topic, in case no counter points are coming through; this, then, is able to generate more arguments into the discussion. Sometimes, rather than the moderator introducing another viewpoint, he might ask ‘is that all?’ This might sometimes trigger a fresh stance.

Steps in planning and conducting focus groups: The focus group conduction has to be handled in a structured and stepwise manner as stated below:

(i) Clearly define and enlist the research objectives of the research study that require qualitative research.
(ii) Then these objectives have to be split into information needs to be answered by the group. These may be bulleted as topics of interest or as broad questions to be answered by the group.

(iii) Next, a list of characteristics needs to be prepared, which would be used to select the respondent group. Based on this screening, a questionnaire is prepared to measure the demographic, psychographics, topic-related familiarity and knowledge. In case of a product or policy, one also needs to find out the experience and attitude towards it. Next, a comprehensive moderator’s outline for conducting the whole process needs to be charted out. Here, it is critical to involve the decision maker (if any), the business researcher as well as the moderator. This is done so that there is complete clarity for the moderator in terms of the intention and potential applicability of the discussion output. This involves extensive discussions among the researcher, client and the moderator. Another advantage of having a structured guideline is that in case of multiple moderators, who might need to conduct focus group discussions at different locales, collection of similar information and reliability of the method can be maintained.

(iv) After this, the actual focus group discussion is carried out. Different sociologists have enlisted various stages that take place in a focus group. The most famous and comprehensive is the linear model of group development formulated by Tuckman (1965). This has been adapted by Chrzanoswka (2002) to explain stages in the Focus group discussions (Table 3.1).

<table>
<thead>
<tr>
<th>Stage</th>
<th>Affective reactions</th>
<th>Behaviour patterns</th>
<th>Moderator role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forming</td>
<td>The group members are uncomfortable, insecure, a little lost and apprehensive.</td>
<td>Silence or general talk, greetings and introductions. Mundane activity.</td>
<td>Tries to bring clarity by explaining the purpose of gathering together, and the expected behaviour during the discussion.</td>
</tr>
<tr>
<td>Storming</td>
<td>There is chaos, as emotions start flying with members questioning others and voicing their own opinion.</td>
<td>Arguments directed at each other or trying to seek support from the moderator. Generally there is rigidity in terms of sticking to ones position. The leaders and the followers emerge.</td>
<td>Do not take side. Play poker face and say that all opinions are welcome. Steer the direction to the topic rather than arguments which might go off the tangent. Try to draw out the passive participants.</td>
</tr>
<tr>
<td>Norming</td>
<td>Cliques and sides start forming based on the stand that people have taken. More supportive and positive signals, especially non-verbal.</td>
<td>People have got the hang of the process and do not really need any steering by the moderator.</td>
<td>Takes it easy, is more bothered about sequencing of information and managing time now.</td>
</tr>
</tbody>
</table>

Table 3.1 Stages in a focus group discussion
Performing: Individuals are subservient to the group, roles are flexible and task-oriented.

Sense of concentration and flow, everything seems easy, high energy, group works without being asked.

Time to introduce difficult issues, stimulus material, projective techniques.

Re-adjustment:

There might be role reversals. People may have another perspective with which the loosely-defined cliques might not agree, so one of the earlier stages might emerge.

Mooring:

Group task nearing completion, so there might be a sense of loss as the energy generated with the discussion might be sapped.

If members do not feel that any clear stand is emerging, they might want to continue and not disband the group.

Signal conclusion. If you want to summarize, ask if any one has something to add. Thank everyone and disperse for refreshments or closure.

(v) The focus group reveals rich and varied data, thus the analysis cannot be quantitative or even in frequencies. The summary of the findings are clubbed under different heads as indicated in the focus group objectives and reported in a narrative form. This may include expressions like ‘majority of the participants were of the view’ or ‘there was a considerable disagreement on this issue’. A summary report on the focus group discussion held in the organic food study is presented below along with the moderator guide.

---

Moderator guide: Organic food products study

**Potential customers of organic food products**

**Rapport formation (5-8 minutes)**
- Greetings
- Purpose of the focus group: (Brief from covering note)
- Ground rules – nature of a focus group
- Video recording and moderator’s presence explained
- No right or wrong opinion
- Please speak as clearly as possible and listen to others’ opinion as well
- Kindly speak in Hindi or English, whatever is more comfortable for you
- Brief ‘get acquainted period’ Participants’ name, something about themselves that they would like to share with the group

**Orientation towards health and environmental concerns (10-12 minutes)**
- Everyday one hears of adulterated food and drinks, the alarming level of pesticides and fertilizers in food items. How much of this do you think is true? (opinion)
- Dose it bother you? PROBE
- What do you do at your own personal end to safeguard yourself/your family from these effects? Please share your strategies/methods with all of us. PROBE

---
Research Approaches

Organic food (30 minutes)
- Presentation of the concept with products (inform about both raw and the ready-to-use variety like preserves, biscuits, bread and snacks)
- How many of you have heard about this? EXPLORE
- Do you know that organic products have been available for almost a decade in the country but the level of awareness is very low?
- What should be done to improve the awareness about the products? EXPLORE

Marketing the product (30 minutes)
- Which products do you think would sell more? Why?
- What do you feel about the products (likes/dislikes)?
- How should these products be priced and packed?
- Where do you think these products should be sold?
- Do you think big brands, or government or the farmers themselves should sell it?

Closing the discussion (10 minutes)
- Finally, I would like you to be creative and give me ideas about possible brand names that can be used by a company selling organic food.
- Anybody who feels that we left out something or would like a clarification from me? Another member? If necessary EXPLORE, else refine and summarize.
- Thank the respondent members for their contribution and close the session.

Focus group summary: potential consumers

Two separate focus group discussions were conducted—one in Noida (UP) and the other in Hi-Tech City, Hyderabad. The group at Noida was predominantly of housewives and the one in Hi-Tech had professionals from different walks of life. Their opinion on a variety of subjects was sought. A summary of the discussions is presented below:

Adulteration in food

All the participants were unanimously concerned about adulterated food that they and their families were consuming. The discussion went from pesticides to chemicals and spurious food products. The ladies felt that they experienced a lot of health problems, specifically acidity, because of adulteration in the food. Some stated that they tried to grind all masalas at home as they felt that most of the problem was with masalas. However, some felt that this was meaningless as the whole masala was adulterated and contaminated by chemical residues. Thus, even though it was a matter of concern for them, they felt helpless to verbalize the possible solution.

There was one lady (Noida group), however, who felt that some of the problems were exaggerated and were basically created by the media and were plain hype. Another lady (HT group) felt that the problem of pollution was too
deep-rooted and just adulterated food or food grown with chemical fertilizers and pesticides was too elementary and small to comprehend the problem of health hazards of the general population.

**Changes in lifestyle**

The consumers observed major changes in the recent years. The groups were unanimously of the opinion that they were more health conscious and concerned than their mothers and grandmothers. The younger generation (post-teens especially) are extremely conscious about the nutritional content of their food. They actively avoid excess sugar and fats in their diet. As a regime, people said that they exercise in some form or the other. Some said they drink more water and include healthy supplements like sprouts and olive oil in their diets.

**Awareness of organic food products**

Almost all the consumers, with the exception of one, had read or heard of organic food. One respondent had tried the product and found it very tasty. Three of the group members, as stated earlier, were skeptical about the benefits of organic food.

**Willingness to try**

The product was formally introduced to the groups and their reactions were noted to the same. Most of them, with the exception of two, were extremely enthusiastic about the products and wanted to know more about them and had a number of queries about the availability, price, brands and benefits of the products.

**Suggestions for marketing the product**

- Divided opinion on who should sell the product. Some felt that a government-approved outlet like Mother Dairy/Trinetra should sell the products whereas others felt that there should be exclusive organic food outlets. There were two or three people who felt that there should be no distinction and the products should be available everywhere. Some were also of the opinion that the products could be sold at high-end grocery stores or departmental stores since this was an expensive product. One consumer suggested the vegetable mandi also as a possible outlet, however most of the others felt that the products would not be purchased by the masses.

- All the group members were unanimously of the opinion that they would buy a product only if it was certified as organic from an authentic and reputed body.

- The product should be vacuum packed, preferably in a brown paper packet with the label having the certification information and the source of the product clearly displayed.
• All felt that the price difference should not be too steep. At the same time, the Indian consumer who is buying a quality product accepts a price difference, so the product should be slightly expensive than the non-organic option.

• All the respondents felt that television was the best medium for promoting the product. All opined that there was a dire need for creating awareness. They felt that there was absolutely no visibility for the products and more availability and awareness would mean more sales and more organically converted consumers. Some suggested popular soap operas and others were in favour of educational programmes.

• Some respondents felt that product promotions should be effectively and widely-conducted by tying up with environment-related organizations that would be willing to promote a healthy cause.

• In terms of endorsement, they wanted sports personalities, film stars like Hema Malini, Simi Grewal, etc; and politicians like Menaka Gandhi and Sushma Swaraj endorsing the product, some even suggested common people who eat organic products and the farmer who produces.

• The groups were generally of the opinion that the campaigns should be targeted at housewives and school children who would be wonderful and effective change agents.

• Comparative advertising demonstrating the benefits of organic versus non-organic was another valuable suggestion discussed in the group. Some however argued for simply enlisting the benefits and resolving the myths about the products.

• Price and availability and the reputation of the organization or brand would be important issues in marketing the product effectively.

• Some punch lines suggested for the product were:
  – It is the future
  – The healthy alternative
  – Shudh and swachh
  – Shuddhahaar
  – Healthorganic
  – Organic is healthy
  – Go organic

Types of focus groups: As stated earlier, there could be several variations to the standard procedure. Some such innovations and alternative approaches are presented below:

Two-way focus group: Here one respondent group sits and listens to the other and after learning from them or understanding the needs of the group, carry out a discussion amongst themselves.
For example, in a management school the faculty group could listen to the opinions and needs of the student group. Subsequently, a focus group of the faculty could be held to study the solutions or changes that they perceive need to be carried out in the dissemination of the programme.

**Dual-moderator group:** Here, there are two different moderators; one responsible for the overt task of managing the group discussion and the other for the second objective of managing the ‘group mind’ in order to maximize the group performance.

**Fencing-moderator group:** The two moderators take opposite sides on the topic being discussed and thus, in the short time available, ensure that all possible perspectives are thoroughly explored.

**Friendship groups:** There are situations where the comfort level of the members needs to be high so that they elicit meaningful responses. This is especially the case when a supportive peer group encourages admission about the related organizations or people/issues. Stevens (2003) used the technique successfully when studying women groups for their experiential consumption of women magazines.

**Mini-groups:** These groups might be of a smaller size (usually four to six) and are usually expert groups/committees that on account of their composition are able to decisively contribute to the topic under study.

**Creativity group:** These are usually of longer than one and a half hour duration and might take the workshop mode. Here, the entire group is instructed which then brainstorms into smaller sub-groups and then reassembles to present their sub-groups opinion. They might also stretch across a day or two. A variation of the technique uses projective methods to extract alternative thinking (Desai, 2002).

**Brand-obsessive group:** These are special respondent sub-strata who are passionately involved with a brand or product category (say cars). They are selected as they can provide valuable insights that can be successfully incorporated into the brand’s marketing strategy.

**Online Focus Group:** This is a recent addition to the methodology and is extensively used today. Thus, it will be elaborated in detail. Like in the case of regular group process, the respondents are selected from an online list of people who have volunteered to participate in the discussion. They are then administered the screening questionnaire to measure their suitability. Once they qualify, they are given a time, a participating id and password and the venue where they need to be so that they can be connected with the others. The group size here varies from four to six, as otherwise there might be technical problems and lack of clarity in the voices received. To ensure a standardized way of responding, the respondents are mailed details of how to use specific symbols to express emotions, while typing the responses. Usual ways of denoting happiness and displeasure – ( or ) – are used. These could also be coloured differently; also to show a higher degree of the
emotion additional faces may be used. There are other symbols as well. Besides, a brief about the purpose of the discussion and clarity on specific or technical terms is provided before the conduction. At the designated time, the group assembles in a web-based chat room and enters their id and password to log on. Here the chatting between the moderator and the participant is real time. Once the discussion is initiated, the group is on its own and chats amongst themselves, with the moderator playing the typical role. The session lasts for one to one and a half hour and the process is much faster than a normal focus group.

The advantage of the method is that geographic locations are not a constraint and persons from varied locations can participate meaningfully in the discussion. Also, since it does not require a commitment to be physically assembled at a particular place and time, people who are busy and otherwise are not able to participate, can also be tapped. Since the addresses of the members are available to the moderators, it is also possible subsequently to probe deeper at a later date or seek clarifications. The interaction is faceless so the person interacting is completely assured of his/her anonymity and is thus less inhibited. The method also has a cost advantage as compared to a traditional focus group. People are generally less inhibited in their responses and are more likely to fully express their thoughts. A lot of online focus groups go well past their allotted time since so many responses are expressed. Finally, as there is no travel, videotaping or facilities to arrange, the cost is much lower than for traditional focus groups. Firms are able to keep costs between one-fifth and one-half the cost of traditional focus groups.

However, the method can be actively and constructively used only with those who are computer savvy. Another disadvantage is that since anonymity is assured, actual authentication of the respondent being a part of the population under study might be a little difficult to establish. Thus, to verify the details, one may use the traditional telephone method and cross check the information. Since the person is typing his/her response, other sensory cues of tone, body language and facial expressions are not available. Thus, while the apparent emotions or attitudes can be tapped, however, the unconscious or sub-conscious cannot be judged.

These techniques have extensive use for companies that are into e-commerce. Most companies today have started using this technique to get employee reactions to various organizational issues, in what is termed as a ‘virtual town hall meeting’. Thus, cyber dialogues can be carried out and meaningful feedback as well as population reaction can be measured with considerable ease and accuracy.

**Evaluating focus group as a method**

Focus groups are extensively criticized and yet have widespread usage in all areas of business research, to the extent that the technique is considered by some as synonymous with qualitative research. Before concluding the discussion on focus groups, let us examine the benefits and drawbacks of using the method.
Idea generation: As discussed earlier, the collective group mind creates an atmosphere where ideas and suggestions are churned out which are more holistic and significant than those that would be generated in an individual interview. The other advantage is that the group process works towards vetting each idea as it is presented. The dialogue between the members helps to refine and rephrase the perspective into a usable solution at the end of the discussion.

Group dynamics: Once the moderator has initiated the debate and some members have expressed their opinion, the atmosphere becomes charged and the respondents’ involvement with the topic increases with most members presenting reactions and counter reactions. The expressiveness becomes contagious and the contrived discussion slowly becomes a free-flowing discussion. As the comfort level of individuals with the other members increases, they start feeling at ease with the setting and expression becomes more open.

Process advantage: The discussion situation permits considerable flexibility in extracting the relevant information as the flow of topics and the extent to which the topic can be debated is dependent upon the group members and the emerging dynamics. Also, the situation permits a simultaneous conduction and collection of information from a number of individuals at a single point of time.

Reliability and validity: Since the objectives of the study have been listed out and the structure of the moderator outline is predetermined, the reliability of the information obtained is high. The mechanical recording of the data removes the element of human bias and error in the information collected.

However, the technique is not without shortcomings.

Group dynamics: What is the advantage could also be a disadvantage. On account of the group setting, the members might present a perspective not necessarily their own, but one that is along the lines of the group expression. This is the ‘nodding dog syndrome’, which is often a result of group conformity.

Scientific process: The group discussion must be treated as indicative and, thus, generalizing must be avoided. The answers obtained are varied and in a narrative form. Thus, coding and analysing this data is quite cumbersome.

Moderator/investigator bias: As discussed in earlier sections, the success or failure of the process depends, to a large extent, on the skills of the moderator. An unbiased and sensitive moderator who is able to generate meaningful and unbiased discussions is quite a rarity.

3.3.2 Content Analysis

This technique involves studying a previously recorded or reported communication and systematically and objectively breaking it up into more manageable units that are related to the topic under study. It is peculiar in its nature that it is classified as a primary data collection technique and yet makes use of previously produced or secondary data. However, since the analysis is original, first hand and problem
Research Approaches

NOTES

Self-Instructional Material

specific, it is categorized under primary methods. Some researchers classify it under observation methods, the reason being that in this, one is also analysing the communication in order to measure or infer about variables. The only difference being that one analyses communication that is ex-post facto rather than live. One can content-analyse letters, diaries, minutes of meetings, articles, audio and video recordings, etc. The method is structured and systematic and thus of considerable credibility.

The first step involves defining U, or the universe of content. For example, in the case of Ritu, who wants to know what makes the young Indian tick, she could make use of the blogs written by youngsters, essays and reality shows featuring the age group. She decides that she wants to assess value systems, attitudes towards others/elders, clarity of life goal and peer influences. This step is extremely critical as this indicates the assumptions or hypotheses the researcher might have formulated.

This universe can be reported in any of five different formats (Berelson, 1954). The smallest reported unit could be a word. This is especially useful as it can be easily subjected to a computer analysis. In Ritu’s case, the values that she wants to evaluate are individualistic or collectivistic, aggressive or compliant. Thus, she can sift the communication and place words such as ‘I’ or ‘we’ under the respective heads. Words like ‘hate’ ‘dislike’ go under aggression and ‘alright’ ‘fine’ ‘maybe not so good’ for complacency. Then counts and frequencies are calculated to arrive at certain conclusions.

The next level is a theme. This is very useful but, a little difficult to quantify as this involves reporting the propositions and sentences or events as representing a theme. For example, disrespect towards elders is the theme and one picks out the following as a representative: a young teen’s blog which says my old man (father) has gone senile and needs to be sent to the looney bin for expecting me to become a space scientist, just because he could not become one……

This categorization becomes more complex as the element of observer’s bias comes into play. Thus, this kind of analysis could be extremely useful when carried out by an expert. However, in the case of an untrained analyst, the reliability and validity of the findings would be questionable.

The other units are characters and space and time measures. The character refers to the person producing the communication, for example the young teenager writing the blog. Space and time are more related to the physical format, i.e., the number of pages used, the length of the communication and the duration of the communication.

The last unit is the item, which is more Gestaltian in nature and refers to categorizing the entire communication as say ‘responsible and respectful’ or ‘aggressive and amoral’. As in the case of theme, this categorization is equally complex as the observer’s bias is likely to be high. Thus, to ensure the reliability of the findings, one may ask another coder to evaluate the same data. Cohen (1960)
Research Approaches

states the measuring of the percentage of agreement between the two analyses by the following formula:

\[ K = \frac{Pr(a) - Pr(e)}{1 - Pr(e)} \]

Here, Pr(a) is the relative observed agreement between the two raters. Pr(e) is the probability that this is due to chance. If the two raters are in complete agreement, then Kappa is 1. If there is no agreement, then Kappa = 0. 0.21–0.40 is fair, 0.41–0.80 is good and 0.81–1.00 is considered excellent.

Content analysis of large volumes becomes tedious and prone to error if handled by humans. Thus, there are various computer programs available that can assist in the process. For computers running on Windows, one can use TEXTPACK, this is a dictionary word approach, where it can tag defined words for word frequency by sorting them alphabetically or by frequencies. Open-ended questions can be sorted by a program called Verbastat (generally used by corporate users) or Statpac, which has an automatic coding module and is of considerable use to individual researchers.

Content analysis is a very useful technique when one has a large quantity of text as data and it needs to be structured in order to arrive at some definite conclusions about the variables under study. Computer assistance has greatly aided in the active usage of the technique. However, it can appear too simplistic, when one reduces the whole data to counts or frequencies.

The next two methods that are being discussed now are the most frequently-used methods of qualitative research and are also strong in terms of reliability and validity of the findings.

3.3.3 Ethnography and Life History

Let us study the ethnographic and life history approaches.

Ethnography

The ethnographic approach to qualitative research has been largely derived from the field of anthropology. The main focus of ethnography lies on studying an entire culture. Initially, the idea of a culture was intricately linked to the notion of ethnicity and geographic location (for example, the culture of the Trobriand Islands), but it has been expanded to include almost any group or organization. This implies that we can study the ‘culture’ of a business or defined group.

Ethnography is an enormously broad area with numerous practitioners and methods. However, the most practiced ethnographic approach is participant observation as a part of field research. The ethnographer becomes immersed in the culture as an active participant and records extensive field notes. As in grounded theory, there is no preset limiting of what will be observed and no real ending point in an ethnographic study.
Life history

The life history method of qualitative research is an alternative method to empirical methods for recognizing and authenticating health patterns of individuals and groups. It allows the researcher to explore a person’s micro-historical (individual) experiences within a macro-historical (history of the time) structure. Life history information challenges the researcher to comprehend an individual’s current attitudes and behaviour and how they may have been impacted by initial decisions made at another time and in another place.

3.3.4 Limitations and Obstacles in Qualitative Research

Qualitative data is generally gathered through the means of observation, interviews or focus groups; however, they may also be gathered from written documents and through case studies. In qualitative research, there is less emphasis on counting numbers of people who think or behave in certain ways and more emphasis on explaining why people think and behave in certain ways. Participants in qualitative studies often make use of smaller number of tools and utilize open-ended questionnaires interview guides. This type of research is largely used to answer ‘how’ and ‘why’ questions.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. It complements and refine</td>
<td>1. The findings usually cannot be</td>
</tr>
<tr>
<td>quantitative data.</td>
<td>generalized to the study population or community.</td>
</tr>
<tr>
<td>2. It provides more detailed</td>
<td>2. It is more difficult to analyse. It</td>
</tr>
<tr>
<td>information to explain complex</td>
<td>does not fit neatly in standard categories.</td>
</tr>
<tr>
<td>issues.</td>
<td></td>
</tr>
<tr>
<td>3. It has multiple methods for</td>
<td>3. Data collection is usually time consuming.</td>
</tr>
<tr>
<td>gathering data on sensitive</td>
<td></td>
</tr>
<tr>
<td>subjects.</td>
<td></td>
</tr>
</tbody>
</table>

Quantitative research

Quantitative data includes information which is countable and is largely gathered through surveys from large numbers of respondents randomly selected for inclusion. Secondary data sources such as census data, government statistics, health system metrics and other methods are often included in quantitative research. Quantitative data is analysed using statistical methods. Quantitative approaches are best used to answer ‘what’, ‘when’ and ‘who’ questions.
Research Approaches

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The findings can be generalized if selection process is well-designed and sample is representative of study population.</td>
<td>1. Related secondary data is sometimes not available or accessing available data is difficult/impossible.</td>
</tr>
<tr>
<td>2. It is relatively easy to analyse.</td>
<td>2. It is difficult to understand context of a phenomenon.</td>
</tr>
<tr>
<td>3. Data can be very consistent, precise and reliable.</td>
<td>3. Data may not be robust enough to explain complex issues.</td>
</tr>
</tbody>
</table>

Check Your Progress
1. In which year was the focus group method developed and by whom?
2. State one benefit of using content analysis method.

3.4 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Focus group as a method developed in the 1940s in Columbia University by sociologist Robert Merton and his colleagues as part of a sociological technique.

2. Content analysis is a very useful technique when one has a large quantity of text as data and it needs to be structured in order to arrive at some definite conclusions about the variables under study.

3.5 SUMMARY

- Primary data source available to the researcher is original, first-hand data.
- Conducting a qualitative research is an extremely skillful task and requires both aptitude and adequate training in order to result in valuable and applicable data.
- The rationale for using qualitative research methods is essentially to provide inputs that are helpful in uncovering the motives behind visible and measurable occurrences.
- Focus group as a method developed in the 1940s in Columbia University by sociologist Robert Merton and his colleagues as part of a sociological technique.
- A focus group is a highly versatile and dynamic method of collecting information from a representative group of respondents. The process generally involves a moderator who maneuvers the discussion on the topic under study.
Research Approaches

NOTES

• This technique involves studying a previously recorded or reported communication and systematically and objectively breaking it up into more manageable units that are related to the topic under study.

• The ethnographic approach to qualitative research comes largely from the field of anthropology.

• The life-history method of qualitative research is an alternative to empirical methods for identifying and documenting health patterns of individuals and groups.

• Qualitative data are usually gathered by observation, interviews or focus groups, but may also be gathered from written documents and through case studies.

• Quantitative data are pieces of information that can be counted and which are usually gathered by surveys from large numbers of respondents randomly selected for inclusion. Secondary data such as census data, government statistics, health system metrics, etc. are often included in quantitative research.

3.6 KEY WORDS

• Ethnography: It is defined as the study and the systematic recording of human cultures.

• Primary data: This denotes data that is collected by a researcher from first-hand sources such as surveys, interviews or experiments.

• Anthropology: It is study of human beings and their ancestors through time and space and in relation to physical character, environmental and social relations and culture.

3.7 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short Answer Questions

1. What are the differences between qualitative and quantitative data methods?

2. Briefly mention the types of focus groups.

3. Write short notes on the following:
   (a) Content analysis
   (b) Ethnography
Long Answer Questions

1. Examine the scope of qualitative research.
2. Discuss the types of qualitative research.
3. Discuss the strengths and limitations of the qualitative method.

3.8 FURTHER READINGS


4.0 INTRODUCTION

Irrespective of the nature of research like pure science, social science or any other, the process of undertaking research essentially remains the same. In all kinds of research the researcher must ascertain the extent of existing knowledge, define their own area of inquiry, collect data and analyse it and draw conclusions. In the social work research there exists no single, universally accepted way of conducting. In fact, there exists variety of ways in which research in the social world, is carried out using different designs and methodologies ranging from phenomenology to randomized controlled trials from epidemiology to action research.
In order to undertake research a universally accepted process is to be followed. The steps of the process include the following:

- Selection of the topic or problem
- Reviewing the literature
- Development of conceptual and theoretical framework
- Clarification of research questions and hypothesis
- Research design
- Data collection
- Data analysis
- Drawing conclusions

Any research commences with the identification and selection of the problem. Correct identification and selection of the problem at hand is the first step that if undertaken correctly eases the subsequent processes ahead. It is also very important to understand that the steps of research are tightly linked with each other and do not stand alone. The decisions taken in one step affect the other and, therefore, meticulous planning is the key to success in any research. The other steps including literature review, developing the conceptual framework and research questions or hypothesis, surveying and collecting data in the field, developing bibliography and other steps are linked to each other and are prominently important.

4.1 OBJECTIVES

After going through this unit, you will be able to:

- Identify steps of the research process
- Explain the sources and criterion of problem identification in research
- Discuss the process of literature review
- Analyse the importance of research objectives

4.2 SELECTION OF PROBLEM: SOURCES AND CRITERIA

The first and the most important stage in the entire research process is that of the selection of the problem. This stage is very time consuming stage in the beginning of the research process and shall take up the most if not all the time of the researcher. This is the stage that assists the researcher in outlining and developing a preliminary research question and set of objectives.
4.2.1 Sources of Research Problems

Most of the research problem or topics begin with a ‘hunch’ or initial idea that is not precisely defined. Several sources assist a researcher in identification and selection of the problem. The few important ones are outlined below:

- **Intuition**: One of the sources of identifying and selecting the research problem is our own intuition. At times, research ideas or problem might come up all of a sudden in our minds and can further be elaborated.

- **Reading**: Another important source of problem identification and selection is that of reading. Reading newspapers or reports might help the researcher in narrowing down probable research problems.

- **Daily Experiences**: Our daily experiences or happenings around us might provide a great resource of research problem identification and selection. One of the best examples of the same is Newton’s discovery of law of gravitation where he identified the possibility of a research problem on seeing a fruit falling from the tree.

- **Exposure to field situations**: Many times, an opportunity to be in field or on internship or on undergoing training provides us with significant ideas to identify and select research problems.

- **Consultation**: Discussions with fellow researchers, experts, practitioners, stakeholders and several others also triggers problem identification and selection for the research.

- **Brainstorming**: Often brainstorming exercises i.e., an intense discussion with the interested group leads to problem identification and selection.

- **Academic experiences**: Academic experiences including classroom lectures, class discussions, seminars, conferences, out of class exchanges and ideas and several other similar opportunities facilitate identification and selection of the research topic and problem.
4.2.2 Criteria of Research Problem Selection

Research topic is undertaken after taking into consideration a number of factors or criteria. The criteria of research problem selection can be categorized into two types namely, internal and external.

The internal criteria include researcher’s interest, competencies and resources including time and finance. The external criteria include researchability of the problem, importance and urgency, novelty of the problem, feasibility, facilities, usefulness and social relevance and research team.

1. Internal Criteria

- **Researchers Interest:** It is very important that the research must stir interest in the researcher himself. It is very obvious that research is a long-term tedious process and the active interest of the researcher himself can make the entire process work.

- **Researchers Competence:** Competence of the researcher is also very significant in the research process and is, therefore, an important criterion of research. Researcher must possess necessary skills sets for designing, planning and conducting the research in the field.

- **Researchers Resources:** Conducting research requires resources. Printing of the questionnaire, field visits, photographs, printing of the report and so forth all require finances. The entire process of the research is also time consuming and researcher must have sufficient time for this purpose.

2. External Criteria

- **Research ability of the Problem:** One of the very important criteria for selecting the research problem is the potentiality of the problem itself. The problem must be such that it can be exposed to research process. Data availability about the research problem is also significantly required.

- **Importance and Urgency:** Importance of the problem and its urgency is yet another significant external criterion in the selection of research problem. Important and urgent problems must be given priority because the immediate solution can benefit the people.

- **Novelty of the Problem:** Newness of the research problem is an important selection criterion. New research topics are always sought by the researchers.

- **Feasibility:** Feasibility is also an important factor for the selection of the research problem. The researcher’s qualification, training and experience should match the problem. The researcher must ask certain questions to examine the feasibility of the research problem:
  - Are suitable research techniques available to conduct the research on the proposed issue?
Selection of the Problem for Research

NOTES

- Are resources including time and finance available?
- Is accurate and reliable data available?
- Will the concerned stakeholders support the research initiative?
- Will respondents be readily available for the interview?
- Can the study be performed within the timeline proposed?

- **Facilities**: In order to design, plan and conduct research certain basic facilities are required. The researcher needs library resources, computer and IT infrastructure, mentors, data analysis software and other tools. In the absence of these basic facilities, it is difficult to undertake research. Facilities, therefore, are an important criterion for selecting the problem.

- **Usefulness and Social Relevance**: It is highly recommended that any research contributes towards improvement of the problem discussed. Without any relevance and usefulness the research document ends up filling the shelf space in offices and library.

- **Research Team**: Research team plays a very vital role in research and is a valid criterion for problem selection. The mentor, the research team and the researcher himself form a team that work together to complete the research work.

4.3 LITERATURE REVIEW IN RESEARCH

Research process includes literature review which aims at highlighting what has already been done so far in the field of interest and how your findings relate to earlier research. In general, the literature review provides in-depth understanding and explanation on how your findings are similar to or novel from previous research work. The review of literature also indicates the following:

- Approaches;
- Methods;
- Variables used; and
- Statistical procedure

The literature review is important due to the following reasons:

- It describes how the proposed research is related to prior research in statistics.
- It shows the originality and relevance of your research problem. Specifically, your research is different from other statisticians.
- It justifies and improves your proposed methodology.
- It demonstrates your preparedness to complete the research.
Reviewing literature is not an easy task and is very time-consuming and daunting. However, it is always rewarding and has a number of functions in research methodology. The three important functions of research methodology are the following:

- Provides theoretical background to your study or field.
- Helps justify how your findings are related to the body of knowledge in your field of research.
- Establish the links between what you propose to examine and what has already been found. It helps you to refine your research methodology.

4.3.1 Procedure of Literature Review

Earlier the process of literature review used to be very time-consuming and daunting. Researchers used to sift through varied printed resources in the library including journals, newspapers, textbooks and many others. With the advent of Information Technology (IT) including Internet the literature review has become less cumbersome. However, the process of literature review must follow a systematic approach while doing so. The section below presents in brief the literature review process.

- Search the existing literature in your research area of interest
- Review the obtained literature
- Develop a theoretical framework
- Writing the literature review

We shall discuss the steps briefly below:

**Step 1: Search the Existing Literature in your Research Area of Interest**

The first step of literature review is that of searching the existing literature in your area of interest. The topic of research once selected must be very well researched to bring in two important components around the issue. The first is that of comprehensiveness and the second narrowness. Both of these must go hand in hand to develop a robust literature review. Researcher has many sources that assist in doing so including articles, journals, newspapers, magazines and so forth.

**Step 2: Review the Literature Obtained**

Once the researcher has identified several journals and books, the next most logical thing to do is to start reading them critically to pull together themes and issues that are associated with the research topic. The bottom line of this step is to read the obtained information as much as possible and develop a rough framework of the research. It is important for the researcher here to critically review the information with particular focus on the following aspects:

- Note the theories put forward, critics, methods used (sample size, data used, measurement procedure)
• Note whether the knowledge relevant to your designed framework has been confirmed beyond doubt
• Find differences of opinions among researchers and note down your opinions about their validity
• Examine the gaps that exist in the body of knowledge

Step 3: Develop a Theoretical Framework

Literature review can be a never-ending process. However, the research has to be conducted within a timeframe and, therefore, it is highly suggestive that a researcher does create a boundary and develop a theoretical framework as soon as possible. Every information that is obtained from literature sources must be sorted out accordingly with the themes and issues that relate to the research. Unless you review the literature with regard to the framework you developed, you will not be able to develop focus in your literature search.

Step 4: Writing Up the Literature Review

The final step in the literature review process is that of writing the literature review. While writing, identify and describe various theories relevant to your field and specify gaps in the body of knowledge in that area. Proceed to explain recent advances in the area of study as well as current trends. An ideal format of the literature review write-up might include the following aspects:

• Assumptions of research
• Theories related to the area of study
• Hypotheses
• Research designs applied
• Variables selected
• Potential future work speculated by researchers

Also with writing the literature review due attention must be paid to avoid plagiarism. Also due recognition to the authors must be given whose work is been cited.

4.3.2 Using Library and Internet for Literature Review

We have already mention in the earlier section that the purpose of a literature review is to gain an understanding of the existing research and debates relevant to a particular topic or area of study, and to present that knowledge in the form of a written report. Literature review is the first step towards building one’s knowledge in the field of interest. Through literature review, the researcher develops an understanding about important concepts, research methods and experimental techniques that are used in the field. We have also seen that through literature review the researcher gain insight into the works of other researchers and how it can be applied to his work.
In order to conduct literature review various sources are required that have been discussed briefly in the beginning of this section. The sources of literature review can be found in library and on Internet at large.

Over the years and before the Information Technology revolution especially the launch and commercialization of search engines; it was only the library which used to assist researchers in getting the literature review done. With a single place where newspapers, journals, magazines, text and reference books, monographs, and several other documents were available, library was the first and only resort to accessing them for research work. However, the process of gathering information, accessing it, noting it and storing it was very cumbersome. The researcher literally had to pen down everything in black and white for literature review writing and other purposes. Often it was very painful to draw models or note lengthy content. Much later the possibility of photocopying the documents gave much relief to the researcher. However, the photocopying had its own limitations and was a costly way of gathering and storing information.

It was much later that computer arrived and even later the Internet changed the way research was undertaken. With Internet accessing different sources of information including the journals, magazines, news archives and even textbooks became easy. It also became easy to store the information at much ease and at a lesser cost. Later, when search engines became operational accessing knowledge became extremely easy.

Today, even libraries are digitalized and one can actually find access any article from a research journal, any textbook, any white paper or any news archive about a topic of any interest.

Developing Bibliography

Developing a working bibliography—a detailed list of books, articles and other sources relevant to a project keeps everything organized while gathering and sorting through potentially useful sources. Most importantly, a working bibliography is a tool, one that will change and grow as the focus of your research shifts and narrows. It has two purposes:

  i. To keep a record of the sources you have already examined and those that you are going to examine.
  ii. To record the publishing details of each source you use or cite so that they can be properly referenced in a Works Cited or References List at the end of your document.

For any research purpose, the researcher might have to include following bibliographical content.

- Creating Book Source Notes
- Creating Periodical Source Notes
Selection of the Problem for Research

• Creating Field Source Notes
• Creating Electronic Source Notes

1. Creating Book Source

If during literature review, the work is cited from a book it must acknowledge the author by documenting the following information.

• The author’s full name, last name first
• The book’s title, including its subtitle if it has one, underlined, or in italics if you are using a computer
• The publication information: place, publisher and year of publication

2. Creating Periodical Source

While citing the periodical sources the information must have.

• The author’s full name.
• The title of the article, in quotation marks, followed by the name of the publication, underlined or in italics.
• For a scholarly journal, the volume number and for certain journals, the issue number.
• The date of the issue. (Form varies with the type of journal or magazine.)
• The page numbers of the article. Including a + sign will indicate an article that appears on more than one page, but not on consecutive pages

3. Creating Field Source

For citing and acknowledging the field source notes the following information must be included.

• The name of the person you interviewed or the setting you observed.
• A descriptive title
• The date on which you conducted the interview or observation.

4. Creating Electronic Source Notes

While citing the electronic source the following information must be documented to acknowledge the author.

• The author’s full name, if one is available (many Web pages do not list authors).
• The editor’s full name, if indicated.
• The title of the database entry, Web page, Gopher page, or message.
• The name of the database, Website, newsgroup or mailing list, or Gopher site in which you found the source.
The Internet address - or URL - of sources you found on the Internet. URL stands for Uniform Resource Locator. The date the source was created or last updated.

The date you accessed the source.

Check Your Progress
1. What is internal and external criteria of research problem selection?
2. What does literature review in research denote?
3. What is the main purpose of developing a bibliography?

4.4 DEFINING THE RESEARCH PROBLEM

Once the research problem has been identified and literature review undertaken, the research problem needs to be defined in a way that it becomes comprehensible to people other than the researcher. Defining the research problem requires the researcher to be aware of the paradigms and underlying philosophical assumptions. The paradigms include ontological, epistemological, axiological, rhetorical and methodological approaches. The same are associated with their respective assumptions at each level that guides a researcher to define a problem further.

The basic steps involved in defining the research problem are:

Step 1: Decide on the general area of study: Influenced by his own experiences, the researcher formulates the general area of study. While doing so, Madsen’s criteria for defining research problem become handy. These include the following:

- Sustain your interest and stimulate your imagination
- Within your range of competencies
- Manageable in size
- Potential to make a contribution to body of knowledge
- Based on obtainable data
- Demonstrate your independent mastery of both the subject and method

Step 2: Narrowing the General Topic Down to a Specific Statement of the Research Problem: Once the general area of study been identified the researcher must narrow down the topic to a specific statement of the research problem.

Step 3: Understand the Sources of Problem Definition: The researcher must also list and understand the sources from which the problem can be defined. These sources include experience, experts, deductions from theory, literature review and the problem at hand.
Step 4: Evaluation of the Research Problem: The researcher must evaluate the potential of the problem and must ensure that if at all it is important enough to be investigated. The various criteria for the same are the following:

- It is to be identified whether the findings will make a contribution to body of knowledge?
- It is to be recognized whether this will lead to definition of new problems or other research?
- It is to be evaluated whether the research problem is really worthy of research?
- It is to be identified whether information or data is available to you?
- Is the research problem ready to be completed in the allotted time frame?

Step 5: Writing a Good Problem Statement: Finally, the researcher must write a good problem statement that clarifies exactly what needs to be solved as a research problem. A good problem statement defines the variables operationally and defines a concept in terms of the operations or processes that will be used to measure or manipulate the concept.

4.5 RESEARCH QUESTIONS

Defining the research problem is not an end in itself. The researcher must develop and write a research question that guides and centres the research. The research questions must be clear and focussed, and also synthesize multiple sources to present researcher’s unique argument.

The section below outlines the journey of a researcher from topic to research questions including hypothesis. Post topic identification and literature review the formulation of research questions is undertaken to add focus to the research. Ideally the researcher undertakes the following steps to reach the stage of focused yet understandable research questions.

Explore questions

- Ask open-ended ‘how’ and ‘why’ questions about your general topic.
- Consider the ‘so what’ of your topic. Why does this topic matter to you? Why should it matter to others?
- Reflect on the questions you have considered. Identify one or two questions you find engaging and which could be explored further through research.

Determine and evaluate your research question.

- What aspect of the more general topic you will explore?
- Is your research question clear?
Selection of the Problem for Research

- Is your research question focussed? (Research questions must be specific enough to be well covered in the space available.)
- Is your research question complex? (Questions should not have a simple yes/no answer and should require research and analysis.)

Hypothesize: After you have come up with a question, consider the path your answer might take.

- If you are making an argument, what will you say?
- Why does your argument matter?
- How might others challenge your argument?
- What kind of sources will you need to support your argument?

4.6 SURVEYING THE FIELD

Significant breakthroughs and improvements in the methods of scientific inquiry have been redefining and refining the social work inquiry as well. Surveying in the field to gather information from various stakeholders was never as interesting as it was earlier. Today, a wide range of surveying techniques allow social work researchers to design, plan and gather data from their respondents in novel ways. Today, the social work surveying methods have moved beyond the descriptive surveys and analysis to include newer techniques of participatory research and appraisals.

A survey is any activity that collects information in an organized and methodical manner about characteristics of interest from some or all units of a population using well-defined concepts, methods and procedures and compiles such information into a useful summary form.

A survey can be thought to consist of several interconnected steps which include defining the objectives, selecting a survey frame, determining the sample design, designing the questionnaire, collecting and processing the data, analysing and disseminating the data and documenting the survey.

Irrespective of the nature of the survey i.e., whether it is qualitative or quantitative, it can be broken down into several parts. The first part of the survey is the planning phase, followed by the design and development phase, and then the implementation phase. Finally, the entire survey process is reviewed and evaluated.

4.6.1 The Planning Phase

The planning phase is the first phase of the survey process. The planning phase begins with the composition of the research team. Depending on the nature of the research the entire survey team is constituted with appropriate tasks assigned to each of the members. While composing the team the members possessing different skill sets in research must be sought and briefed about the research. A good mix
might consist of an interdisciplinary team including a statistician, a computer programmer, an expert in the field of study, a data collection expert and so forth. Survey planning should be conducted in stages. Once the objectives of the survey are clear, each team member prepares the component plans associated with his or her responsibility within the team. During this stage, planning becomes a more complex matter. The advantages and disadvantages of alternative methodologies should be examined and compared in terms of: coverage, mode of data collection, frequency, geographical detail, response burden, quality, cost, resources required and timeliness.

In the later stages of the survey process, plans are revised, elaborated and refined, and more detailed aspects are examined. Each and every activity and operation needs some form of plan for design, development and implementation. Planning continues throughout the entire survey process with modifications being made as required.

4.6.2 Design and Development

In the earlier steps of the research process the researcher aims at designing and developing a framework. Once the framework is established, it is possible to carry out detailed work on the various steps of a survey. It is during this phase that any required pre-tests or pilot surveys are carried out to assess, for example, the adequacy of the questionnaire, suitability of the survey frame, operational procedures and other aspects. All field materials (for example, interviewer training and instruction manuals, sample control documents) are prepared for the data collection stage. Software programmes for computer administered questionnaires are developed, or adapted and tested. Sample selection and estimation procedures are finalised in the form of specifications. Specifications for coding, data capture, editing and imputation are all prepared to set the stage for data processing.

4.6.3 Implementation

In the implementation phase the actual survey is launched. This is where the entire action takes place in the form of printing of necessary documents including questionnaires, training of the research team, sampling is undertaken and the sample is selected and information is collected, all in a manner established during the development phase. Following these activities, data processing begins. Processing activities include data capture, coding, editing and imputation. The result is a well-structured and complete data set from which it is possible to produce required tabulations and to analyse survey results. These results are then checked for confidentiality and disseminated. At every step, data quality should be measured and monitored using methods designed and developed in the previous phase.

4.6.4 Survey Evaluation

Survey evaluation is an ongoing process throughout the survey. Every step of the survey is evaluated in terms of its efficiency, effectiveness and cost. The evaluation
Selection of the Problem for Research

NOTES

of the survey serves as a test of the suitability of the technical practices. They also assist to improve and guide implementation of specific concepts or components of methodology and operations, within and across surveys. They support the activities and provide measures and assessments of the quality limitations of the programme data. As well, each survey step is evaluated to provide insight into the shortcomings or problems in other steps of the survey. For example, editing and imputation can provide information on problems with the questionnaire.

Check Your Progress
4. What are the basic steps involved in defining the research problem?
5. Mention the steps involved in surveying the field.

4.7 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. The criteria of research problem selection can be categorized into two types namely, internal and external. The internal criteria include researcher’s interest, competencies and resources including time and finance. The external criteria include researchability of the problem, importance and urgency, novelty of the problem, feasibility, facilities, usefulness and social relevance and research team.

2. Research process includes literature review which aims at highlighting what has already been done so far in the field of interest and how your findings relate to earlier research. In general, the literature review provides in-depth understanding and explanation on how your findings are similar to or novel from previous research work.

3. Developing a bibliography serves the following two purposes:
   i. To keep a record of the sources you have already examined and those that you are going to examine.
   ii. To record the publishing details of each source you use or cite so that they can be properly referenced in a Works Cited or References List at the end of your document.

4. The basic steps involved in defining the research problem are the following:
   i. Decide on the general area of study
   ii. Narrowing the General Topic Down to a Specific Statement of the Research Problem
   iii. Understand the Sources of Problem Definition
   iv. Evaluation of the Research Problem
   v. Writing a Good Problem Statement
5. A survey can be thought to consist of several interconnected steps which include defining the objectives, selecting a survey frame, determining the sample design, designing the questionnaire, collecting and processing the data, analysing and disseminating the data and documenting the survey.

4.8 SUMMARY

- Irrespective of the nature of research like pure science, social science or any other, the process of undertaking research essentially remains the same. In all kinds of research the researcher must ascertain the extent of existing knowledge, define their own area of inquiry, collect data and analyse it and draw conclusions.

- The first and the most important stage in the entire research process is that of the selection of the problem. This stage is very time consuming stage in the beginning of the research process and shall take up the most if not all the time of the researcher.

- Research topic is undertaken after taking into consideration a number of factors or criteria. The criteria of research problem selection can be categorized into two types namely, internal and external.

- Research process includes literature review which aims at highlighting what has already been done so far in the field of interest and how your findings relate to earlier research.

- Earlier the process of literature review used to be very time consuming and daunting. Researchers used to sift through varied printed resources in the library including journals, newspapers, textbooks and many others.

- The first step of literature review is that of searching the existing literature in your area of interest. The topic of research once selected must be very well researched to bring in two important components around the issue.

- Developing a working bibliography—a detailed list of books, articles and other sources relevant to a project keeps everything organized while gathering and sorting through potentially useful sources.

- Once the research problem has been identified and literature review undertaken, the research problem needs to be defined in a way that it becomes comprehensible to people other than the researcher.

- Defining the research problem is not an end in itself. The researcher must develop and write a research question that guides and centres the research. The research questions must be clear and focussed, and also synthesize multiple sources to present researcher’s unique argument.
• A survey can be thought to consist of several interconnected steps which include defining the objectives, selecting a survey frame, determining the sample design, designing the questionnaire, collecting and processing the data, analysing and disseminating the data and documenting the survey.
• The planning phase is the first phase of the survey process. The planning phase begins with the composition of the research team. Depending on the nature of the research the entire survey team is constituted with appropriate tasks assigned to each of the members.
• Survey evaluation is an ongoing process throughout the survey. Every step of the survey is evaluated in terms of its efficiency, effectiveness and cost. The evaluation of the survey serves as a test of the suitability of the technical practices.

4.9 KEY WORDS

• **Brainstorming:** It is a group problem-solving technique that involves the spontaneous contribution of ideas from all members of the group.
• **Consultation:** It involves seeking and giving of advice, information, opinion, usually involving a consideration.
• **Pilot survey:** It is a strategy used to test the questionnaire using a smaller sample compared to the planned sample size.

4.10 SELF ASSESSMENT QUESTIONS AND EXERCISES

**Short Answer Questions**
1. Briefly mention the sources of research problem.
2. What is the significance of literature review in research?
3. State the use of library and Internet for literature review.

**Long Answer Questions**
1. Discuss the procedure of literature review.
2. Explain the steps involved in surveying the field.
3. ‘The research questions must be clear and focussed, and also synthesize multiple sources to present researcher’s unique argument.’ Justify the statement.
4.11 FURTHER READINGS


UNIT 5 ROLE OF THEORY IN RESEARCH

5.0 INTRODUCTION

The word theory is one of the most important words in the glossary of social scientists. The words ‘theory,’ ‘theoretical,’ and ‘theorize’ are constantly and consequentially used by all social scientists around the world. Theory plays a vital role in research. Its importance in research cannot be underestimated as any research requires a strong theoretical basis and methodology.

In this unit, you will study about the meaning and use of theory in research inductive and deductive approaches to theory construction, concepts, indicators and variables and finally, measurements in research.

5.1 OBJECTIVES

After going through this unit, you will be able to:
- Interpret theory and its application in research
- Explain the inductive and deductive approaches to theory building
- Define the terms concepts, indicators and variables
- Examine the notion of measurement in research
- List the types of measurement scales


We have seen that theory is very important in research. In the absence of theory, it is not possible to develop frameworks and methodology for conducting any research.

Wacker provided three reasons why theory is important for research:

- It provides a framework for analysis,
- It provides an efficient method for field development, and
- It provides a clear explanation for the pragmatic world.

Several authors have attempted to define theory and most of them have arrived at the competing views. Researchers have not been able to decide the constituents of theory and made attempts to describe the types of theory, in the context of purpose, functions, boundaries and goals.

Amidst varying opinions and conflicting points of view, Gelso defined theory using nine constructs. These include the following:

i. descriptive ability
ii. explanatory power
iii. heuristic value
iv. testability
v. integration
vi. parsimony
vii. clarity
viii. comprehensiveness and
ix. delimitation

These constructs are based on the fact that theory generates research and research generates and refines theory.

Harlow argued that theory does not have a fixed and universal meaning, but considering the competing research paradigms, theory might suggest a determining law, or system of laws, as in the natural sciences, or a construct or set of constructs for ordering and understanding phenomena.

Wacker stated, ‘Operationalization of the definition of theory should directly be tied to the necessary components of theory’. According to him, theory is composed of four components including definitions, a domain of applicability, a set of relationships of variables, and specific predictions or factual claims.

Rychlak argued that a good theory must be stated explicitly with the aim of formulating a logically consistent and mutually interdependent body of knowledge. He suggested the four functions of a theory are descriptive, delimiting, generative and integrative.
Theory has a central role in research. Both theory and research are interrelated and are dependent on each other. Research contributes to further development of theory and theory on the other hand assists research through methodological frameworks. The connectedness between theory and research begins with a problem definition, and indeed, when a research idea is generated. Research projects usually begin with a review of the relevant literature in which the researcher engages with existing theoretical explanation of the topic in question.

Ellis and Levy discussed seven ways in which original research contributions can be made to the body of knowledge. Such contributions can be summarized using the following constructs:

- Establishment of causal relationship,
- Examination of element,
- Method of creating product through developmental study,
- Constructs development,
- Predictive model development,
- Efficacy evaluation, and
- Examination of the impact of time on the nature of the documented problem in a longitudinal study.

In the context of research, theories assist researchers in the following ways:

- Classifying things including entities, processes and causal relationships
- Assisting us understand how and why already observed regularities occur
- Predicting us predict as yet unobserved relationships
- Guiding research in useful directions
- Serving as a basis for action

### 5.3 INDUCTIVE AND DEDUCTIVE APPROACHES TO THEORY CONSTRUCTION

Researchers have invested in understanding the two important approaches to theory building. These are termed as the inductive and deductive approaches to building theories.

Trochim identified two "broad methods of reasoning as the inductive and deductive approaches and defines induction as moving from the specific to the general, while deduction begins with the general and ends with the specific; arguments based on experience or observation are best expressed inductively, while arguments based on laws, rules, or other widely accepted principles are best expressed deductively."
According to Creswell and Plano Clark, the deductive researcher “works from the “top down”, from a theory to hypotheses to data to add to or contradict the theory”. In contrast, they define the inductive researcher as someone who works from the “bottom-up, using the participants’ views to build broader themes and generate a theory interconnecting the themes”.

In research, the deductive analysis is also referred to as quantitative and inductive analysis is referred to as qualitative.

The qualitative research method emerged in the beginning of the 20th century and the researchers who followed this method believed that “social reality was constructed and thus was subjective”. It was at this point that the polarization of quantitative and qualitative research methods began. In the later part of the 20th century, the researchers argued that the quantitative and qualitative approaches could not coexist. Several authors and researchers have suggested that promoters of both deductive and inductive approaches are engaged in competition with each other. Onwuegbuzie and Leech suggest that “instructors of quantitative and qualitative research often view themselves as being in competition with each other”.

The authors go on to argue that “this polarization has promoted . . . “uni-researchers” [who are] namely researchers who restrict themselves either exclusively to quantitative or to qualitative research methods”.

The section below distinguishes both the approaches.

An inductive approach to research is characterized by data collection relevant to the topic of interest. Post data collection attempts are made to analyse the data to develop a theory that can explain patterns showcased in the data. In an inductive approach, therefore, the researchers start with a set of observations and then move from those particular experiences to a more general set of propositions about those experiences. In other words, they move from data to theory or from the specific to the general. The approach is also known as theory building approach of research.

The figure below depicts the process of inductive approach.

---

**Fig 5.1 The Inductive Approach**

The deductive approach on the other hand is the reverse of an inductive approach. Researchers in this approach are testing the theory unlike the inductive approach where theory building is the focus. Researchers undertake a social theory and then test its implications with data. In deductive approach the researcher moves from a more general level to a more specific one. Often the approach is
associated with scientific investigation where the researcher studies what others have done, reads existing theories of whatever phenomenon he or she is studying, and then tests hypotheses that emerge from those theories.

The figure below depicts the process of deductive approach.

![Fig 5.1 The Deductive Approach](image)

A deductive approach usually begins with a hypothesis, whilst an inductive approach will usually use research questions to narrow the scope of the study.

For deductive approaches the emphasis is generally on causality, whilst for inductive approaches the aim is usually focused on exploring new phenomena or looking at previously researched phenomena from a different perspective.

Inductive approaches are generally associated with qualitative research, whilst deductive approaches are more commonly associated with quantitative research.

### Check Your Progress

1. Name the nine constructs through which Gelso has defined theory.
2. Mention the main approaches of theory construction.

### 5.4 CONCEPTS, INDICATORS AND VARIABLES

In research concepts, constructs, indicators and variables play a significant role. We have seen earlier that the two approaches i.e., inductive and deductive make researchers operate at two different levels. The former is a theory building while the latter is the theory testing approach. However, both the approaches rest on concepts, constructs, indicators and variables for their further development.

Kumar (2000) says that concepts are mental images and therefore their meanings vary markedly from individual to individual.

According to Blumer, to speak of a science without concepts suggests all sort of analogies – a carpenter without tools, a railroad without tracks, a man without bones, a love story without love.

Concepts play a pivotal role in the formulation of a research problem. Concept is a word which is so constructed and defined that observations become possible.
It is an idea that is expressed in words and consists of both a word and a definition. Concepts name possible or imagined properties of things, people or events and are both obvious and non-obvious.

Concepts are explained through definitions and are often subjected to a range of definitions with varied contexts. In research concepts are required to be operationalizing before putting them to any use. The role of concepts in research is very important as they establish a link with the social world. They are significant in the theoretical framework in setting context of the research, stating the research problem, determining the data collection methods and also in describing the findings.

According to Norman Blaikie concepts have four sources. These include the following:

- A theoretical perspective that is dominant with a discipline or social scientific community
- A specific research problem
- Commonly used theoretical concepts that are given a new definition
- Everyday concepts that give precise meanings

Related to concept is the notion of construct in research. A ‘construct’ is a concept devised to aid in scientific analysis and generalization. A construct is generally inferred from an observable phenomenon. It is an abstraction from reality, selecting and focusing on certain aspects of reality and ignoring others. Thus, a ‘construct’ is also a concept with the added meaning of having been deliberately and consciously invented or adopted.

According to Jonathan Turner two types of concepts exist, abstract and concrete. The abstract concept refers to very general properties of phenomenon. Such concepts are not specific to a particular place, time or event. The abstract concepts therefore apply to a much wider range of occurrences and are of great significance in the research. The concrete concept on the other hand refers to particular individuals and interactions. Concrete concepts as they are fixed do not have wider applications are not as useful as the abstract concepts.

Associated with concepts is the aspect of variable. We have seen that a concept cannot be measured. For measurement the concept needs to be converted into variables.

A variable is a characteristic that takes on two or more values. Variables are something that takes varying values.

Variables can be classified into different types. The major types are:

- Independent and Dependent Variables
- Experimental and measured Variables
- Discrete and continuous Variables
- Quantitative and Qualitative Variables
1. **Independent and Dependent Variable**: Independent variable is the major variable the researcher wishes to investigate. It is the variable which is selected, manipulated and measured by the researcher. An independent variable (also called X variable in statistics) is one whose change results in the change of another variable.

The dependent variable (also called Y variable in statistics) on the other hand is the condition researcher is trying to explain. It is one which changes in relationship to changes in another variable(s).

2. **Experimental and Measured Variable**: The experimental variables spell out the details of the investigator’s manipulations while the measured variables refer to measurement.

3. **Discrete and Continuous Variable**: A discrete variable is a variable having only integer value. Any variable that is not restricted to particular values (other than limited by the accuracy of the measuring instrument) is known as continuous variable.

4. **Quantitative and Qualitative Variables**: The quantitative variable is one whose values or categories consist of numbers and if differences between its categories can be expressed numerically. Examples of quantitative variables include age, income, size and so forth.

The qualitative variable is one which consists of discreet categories rather than numerical units. This variable has two or more categories that are different from each other. For examples sex (male of female), religion (Hindu, Jain, Muslim, Sikh), caste (General, OBC, SC, ST).

Therese Baker has used the terms categorical and numerical variables for qualitative and quantitative variables respectively. Occupation, religion, caste, gender, education and other aspects are all examples of categorical variables and are made up of sets of categories (or attributes) which must follow two rules. One, the categories must be distinct from each other also known as mutually exclusive and two, the categories must be exhaustive, i.e., they should cover all the potential range of variation in a variable.

Related to concept and variable is the notion of an indicator. It is clear that a concept in research cannot be measured unless it is converted into a variable that takes a value and thus becomes measurable. In doing so an indicator comes into picture. Indicator is a set of criteria reflected from the concepts and are used to show whether or not the objectives have been achieved.

Another important aspect in concept is that of operationalization. For any study a working or operation definition of concepts and variables is very necessary. The researcher develops indicators from the concept. This is known as operationalization. Operationalization is the process of converting concepts in their empirical measurements, or quantifying variables for the purpose of measuring their occurrence and frequency.
According to Sarantakos, operationalization contains three elements. These are:

i. Selection of indicators which reflect the presence or absence of the element,

ii. Quantification of the indicators, and assignment of scores that represent the degree of presence or absence of the concept or variable, and

iii. Quantification of the variable i.e., identification of the continuum of values the variables can assume.

5.5 MEASUREMENTS IN RESEARCH

Measurement is one of the most important foundations of any research activity. The term measurement refers to assigning numbers or some other symbols to the characteristics of certain objects.

5.5.1 Levels of Measurement

In research, measurement of variables can be undertaken at four different levels. These levels of measurement are:

- Nominal,
- Ordinal,
- Interval, and
- Ratio

Let us now study them briefly here.

1. Nominal Level

Nominal level is the simplest measurement. It involves classification of events into categories that are distinct, uni-dimensional and mutually exclusive. The examples of nominal variables include classifying respondents in categories like male-female, single-married-divorced-separated, widow-widower, Hindu-Muslim-Christian-Sikh and so forth. Measurement of the nominal scale has the following characteristics:

- It is essentially qualitative.
- It cannot be arranged in a continuum of low-high.
- It is based on the principle of equivalence.

The numbers in the nominal scale do not provide possibility for any kind of arithmetic operations. It is only possible to add the count of each category assigned to the variable. In such a case, it is only possible to develop frequency distribution table for nominal level of measurement. Chi-square and contingency coefficient along with mode calculations is possible with this level.

2. Ordinal Level

Ordinal scale or level is the next higher level of measurement than the nominal level. Unlike nominal level, the ordinal level of measurement involves not only categorization but also ranking of variables in a continuum of low-high. The limitation...
of nominal level is its inability to measure the low and high of the variable. The ordinal scale takes care of this limitation and can assign numbers to the variables and categorize them on a low – high level. An ordinal scale tells us the relative positions of the objects and not the difference between the magnitudes of the objects. The examples of this scale include first, second, and third division students; lower, middle and upper classes of people; low and high castes and so forth.

Statistically in the ordinal scale, the ranks cannot be put into any mathematical operations. No possibility of addition, subtraction, multiplication or division operations are possible using the ordinal scale. It is possible to calculate median, percentiles and quartile deviations. Rank order correlation and sign test is also possible.

3. Interval Level

Interval level is the next higher level of measurement and takes care of the limitation of the ordinal scale where the difference between the score on the ordinal scale does not have any meaningful interpretation. In the interval level the difference of the score on the scale has meaningful interpretation. The interval scale data has an arbitrary origin (non-zero origin). The most common example of the interval scale data is the relationship between Celsius and Fahrenheit temperature.

The number of interval scale can be added, subtracted, multiplied or divided. The scale offers possibilities of conducting arithmetic mean, standard deviation, correlation coefficient and conduct a t-test, Z-test, regression analysis and factor analysis.

4. Ratio Level

The ration level is the highest level of measurement and takes care of the limitations of the interval scale. Ratio scale measures proportions and ratios and relates one value to another. For examples the weight of one person is 40 kgs and that of the other person is 80 kgs. This means that the second person is twice as heavy as the first one. The ratio scale measurement can be converted into interval, ordinal and nominal but this is not possible vice-versa.

Ratio scales provide immense possibilities when it comes to statistical analysis. These variables can be meaningfully added, subtracted, multiplied and divided (ratios). Central tendency can be measured by mode, median, or mean; measures of dispersion, such as standard deviation and coefficient of variation can also be calculated from ratio scales.

In summary, nominal variables are used to ‘name’, or label a series of values. Ordinal scales provide good information about the order of choices, such as in a customer satisfaction survey. Interval scales give us the order of values + the ability to quantify the difference between each one. Finally, ratio scales give us the ultimate order, interval values, plus the ability to calculate ratios since a ‘true zero’ can be defined. Table 5.1 provides a summary of all the three scales.
Table 5.1 Summary of Nominal, Ordinal, Interval and Ratio Scales

<table>
<thead>
<tr>
<th>Provides:</th>
<th>Nominal</th>
<th>Ordinal</th>
<th>Interval</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>The &quot;order&quot; of values is known</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>&quot;Counts,&quot; also &quot;Frequency of Distribution&quot;</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Mean</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Median</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Can quantify the difference between cash value</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Can add or subtract values</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Can multiply and divide values</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Has &quot;true zero&quot;</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Check Your Progress

3. What are the types of concepts as per Jonathan Turner?
4. Define a discrete variable.

5.6 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. The nine constructs through which Gelso has defined theory are the following:
   i. descriptive ability
   ii. explanatory power
   iii. heuristic value
   iv. testability
   v. integration
   vi. parsimony
   vii. clarity
   viii. comprehensiveness and
   ix. delimitation

2. The two main approaches of theory construction are inductive and deductive approaches.

3. According to Jonathan Turner two types of concepts exist, abstract and concrete.

4. A discrete variable is a variable having only integer value.
5.7 SUMMARY

- The word theory is one of the most important words in the glossary of social scientists. The words ‘theory,’ ‘theoretical,’ and ‘theorize’ are constantly and consequentially used by all social scientists around the world.
- We have seen that theory is very important in research. In the absence of theory, it is not possible to develop frameworks and methodology for conducting any research.
- Theory has a central role in research. Both theory and research are interrelated and are dependent on each other. Research contributes to further development of theory and theory on the other hand assists research through methodological frameworks.
- Researchers have invested in understanding the two important approaches to theory building. These are termed as the inductive and deductive approaches to building theories.
- In research concepts, constructs, indicators and variables play a significant role. We have seen earlier that the two approaches i.e., inductive and deductive make researchers operate at two different levels.
- Variables can be classified into different types. The major types are:
  - Independent and Dependent Variables
  - Experimental and measured Variables
  - Discrete and continuous Variables
  - Quantitative and Qualitative Variables
- Measurement is one of the most important foundations of any research activity. The term measurement refers to assigning numbers or some other symbols to the characteristics of certain objects.
- Interval level is the next higher level of measurement and takes care of the limitation of the ordinal scale where the difference between the score on the ordinal scale does not have any meaningful interpretation.

5.8 KEY WORDS

- **Operationalization:** It is the process of converting concepts in their empirical measurements, or quantifying variables for the purpose of measuring their occurrence and frequency.
- **Variable:** It is a characteristic that takes on two or more values. Variables are something that takes varying values.
- **Concept:** It is a word which is so constructed and defined that observations become possible.
5.9 SELF ASSESSMENT QUESTIONS AND EXERCISES

**Short Answer Questions**

1. State the meaning and use of theory in research.
2. What is the significance of measurement in research?

**Long Answer Questions**

1. Discuss the inductive and deductive approaches to theory construction with the help of diagrams.
2. Explain the types of variables.
3. Examine the types of measurement scales.

5.10 FURTHER READINGS


Footnotes

UNIT 6  HYPOTHESIS

6.0  INTRODUCTION

A hypothesis is an assumption or a statement that may or may not be true. The hypothesis is tested on the basis of information obtained from a sample. A well formulated or good hypothesis helps the researchers to focus/concentrate on the key points of investigation.

A hypothesis is significant because it guides the research. The researchers or investigators refer to the hypothesis in order to direct their thought processes toward the result of the research problem or sub-problems. There are several reasons why hypothesis is significant and these will be dealt in the unit.

It is important that the hypothesis formulated guides the researcher in the right direction. For this, it is important that one knows the characteristics of valid research. It is only after this that the steps in the formulation of a hypothesis can be understood well. Further, knowing the source of hypothesis is also crucial for the researcher. You will also learn about the hypothesis testing. First step is to establish the hypothesis to be tested. The next step in the testing of hypotheses exercise is to choose a suitable level of significance.

6.1  OBJECTIVES

After going through this unit, you will be able to:

- Define hypothesis
- Discuss the characteristics of a valid hypothesis
- Describe the procedure of hypothesis testing
- List the attributes of a sound hypothesis
6.2 MEANING, CHARACTERISTICS AND ATTRIBUTES OF A SOUND HYPOTHESIS

A hypothesis is an approximate assumption that a researcher wants to test for its logical or empirical consequences. It can contain either a suggested explanation for a phenomenon or a proposal having deductive reasoning to suggest a possible interrelation between multiple phenomena. A deductive reasoning can be defined as a type of reasoning that can be derived from previously known facts.

Some definitions of hypothesis are:
- According to Townsend, 'Hypothesis is defined as suggested answer to a problem.'
- According to McGuigan, 'A hypothesis is a testable statement of a potential relationship between two or more variables.'
- According to Uma Sekaran, 'A hypothesis is defined as a logically conjectured relationship between two or more variables in the form of testable statement. These relationships are based on theoretical framework formulated for the research problem. The hypotheses are often statements about population parameters like expected value and variance, for example a hypothesis might be that the expected value of the height of 10-year-old boys in the Scottish population is not different from that of 10-year-old girls.'
- According to Kerlinger, 'A good hypothesis is one which satisfies the following criteria:
  (i) Hypothesis should state the relationship between variables.
  (ii) They must carry clear implications for testing the stated relations.'

This means that: (a) statements contain two or more variables which can be measured, (b) they must state clearly how the two or more variables are related, and (c) it is important to note that facts and variables are not tested but relations between variables exist.

Characteristics of Valid Hypothesis

There are several characteristics of hypothesis, which are as follows:
- **Conceptually clear and accurate:** The hypothesis must be conceptually clear. The concepts and variables should be clearly defined operationally. The definition should use terms which are commonly accepted and it should ensure that communication is not hindered. Hypothesis should be clear and accurate so as to draw a consistent conclusion.
- **Statement of relationship between variables:** If a hypothesis is relational, it should state the relationship between the different variables.
Hypothesis

- **Testability**: A hypothesis should have empirical referents which means that it should be testable through the empirical data. Hypothesis involving mystical or supernatural arenas are impossible to test. For example, the hypothesis “education brings all-round development” is difficult to test because it is not easy to operationally isolate the other factors that might contribute towards all-round development. Since a hypothesis predicts the outcome of a study and it must relate variables that are capable of being measured. The hypothesis such as ‘there is a positive relationship between the learning style and academic achievement of 8th grade students’ can be tested since the variables in the hypothesis are operationally defined, and therefore can be measured.

- **Specific with limited scope**: A hypothesis, which is specific with limited scope, is easily testable than a hypothesis with limitless scope. Therefore, a researcher should give more time to conduct research on such a kind of hypothesis.

- **Simplicity**: A hypothesis should be stated in simple and clear terms to make it understandable.

- **Consistency**: A hypothesis should be reliable and consistent with established and known facts.

- **Time limit**: A hypothesis should be capable of being tested within a reasonable amount of time. In other words, the excellence of a hypothesis is judged by the time taken to collect the data needed for the test.

- **Empirical reference**: A hypothesis should explain or support all the sufficient facts needed to understand what the problem is all about.

A few more characteristics of a good hypothesis are as follows:

- It ensures that the sample is readily approachable.
- It maintains a very apparent distinction with what is called theory, law, facts, assumptions and postulates.
- It ideally has logical simplicity, large number of consequences and is expressed in quantified form.
- It displays equal chances of confirmation and rejection.
- It permits the application of deduction reasoning.
- Its tools and data are easily available and effectively used.
- It is based on the study of previous literature and an existing theory, and verifiable.

As soon as a research question is formulated, it makes the hypothesis formulation imperative since a hypothesis is a tentative solution or an intelligent guess about a research question under study. It is an assumption or proposition whose tenability is to be tested on the basis of its implications with empirical evidence and previous knowledge. Modern investigators agree that, whenever possible, research should
proceed from a hypothesis. In the words of Van Dalen (1973), ‘a hypothesis serves as a powerful beacon that lights the way for the research worker’.

6.2.1 Formulating a Hypothesis

As per the Concise Oxford Dictionary (1990) hypothesis is ‘A proposition made as a basis for reasoning, without the assumption of its truth, a supposition made as a starting point for further investigation from known facts’.

Leedy and Ormrod (2001) have defined the term hypothesis as ‘A hypothesis is a logical supposition, a reasonable guess, an educated conjecture. It provides a tentative explanation for a phenomenon under investigation’.

There is no certainty that the hypothesis formulated for a problem is true or correct. Formulated hypothesis is the initial point, a statement that the researcher has to prove true after further research and investigations. It is also possible that after further research the researcher might find that this hypothesis is not valid for the problem and that it needs modifications.

Why is a Hypothesis Required?

A well formulated or good hypothesis helps the researchers to focus/concentrate on the key points of investigation. Also a hypothesis is significant because it guides the research. The researchers or investigators refer to the hypothesis in order to direct their thought processes toward the result of the research problem or sub-problems. The hypothesis also helps the researcher or investigator to collect the right, precise and accurate data required for the research or investigation. As per Leedy and Ormrod (2001), ‘Hypotheses are exceptionally essential and significant because they help an investigator or researcher to locate information needed to resolve the research problem or sub-problems’.

Accepting or Rejecting Hypothesis

‘A hypothesis is never proved or disproved. In fact, an investigator or researcher who sets out to prove a hypothesis would lose the impartiality of the research investigation’ (Leedy and Ormrod, 2001).

In research, an investigator or researcher is proficient to either accept (support) or reject a hypothesis. If a hypothesis is rejected, it will lead an investigator or researcher to develop new hypothesis to explain the phenomenon in question. If a hypothesis is continually supported or accepted, then it may evolve into a ‘Theory’ (Leedy and Ormrod, 2001).

Therefore, when a hypothesis is continually accepted or supported over time by a growing body of data, then it becomes a theory. As per Leedy and Ormrod (2001), ‘A theory is an organized body of concepts and principles intended to explain a particular phenomenon’. A theory is similar to a hypothesis in that it presents a tentative explanation for a phenomenon that new data will either support or not support. Both are supported or rejected based on the testing performed by
Hypothesis

Various investigators or researchers under different conditions. An example of a well known theory is ‘Einstein’s Theory of Relativity’ (Leedy and Ormrod, 2001).

Further, a theory that is continually validated over time by a growing body of data becomes a ‘Law’. An example of a well known law is the ‘Law of Gravity’ (Leedy and Ormrod, 2001).

Steps in Hypothesis Generation

Often times, an investigator will formulate a hypothesis based on the problem or sub-problems of the research. Typically, the hypothesis is driven by the research question (Leedy and Ormrod, 2001). The following steps helps in generating or writing an effective hypothesis:

- **Step One: Preliminary Research**: The researcher or investigator must review the information collected up to now and then decide which information is significant for the research and how it will help to develop the hypothesis.

- **Step Two: Write Your Hypothesis**: The hypothesis is a statement that the researcher or investigator intend to prove through the research. It should state or affirm the focus of research. When the final hypothesis is written, verify it to be certain that it has the following criteria:
  1. It is written in the form of a concise statement.
  2. It reflects a situation specified by the researcher or investigator.
  3. It is arguable and a contrary situation can be taken.
  4. It requires research to determine whether or not it is true.
  5. It is a significant theme to social scientists.
  6. It is a complex notion, dealing with a number of variables.
  7. It is not written in the first person.
  8. It can be tested.

- **Step Three: Test It Against the Criteria in Step Two**: Take the hypothesis and verify to perceive if it has the criteria listed in Step Two. If it is not so, then the researcher or investigator has to again check the formulated hypothesis for the research problem. It should be reworked such that it fits well with the research assumptions. Also the researcher or investigator has to be certain that they are diverting from the focus of research.

Formulating the Hypothesis and Research Question

Formulating a hypothesis helps by defining an initial explanation to be tested in the research process. The following are the essential key points that must be defined at the time of hypothesis formulation:

- Hypotheses are testable explanations of a problem, phenomenon or observation.
Both quantitative and qualitative research involves formulating a hypothesis to address the research problem.

Hypotheses that suggest a causal relationship involve at least one independent variable and at least one dependent variable; in other words, one variable which is presumed to affect the other.

An independent variable is one whose value is manipulated by the researcher or investigator.

A dependent variable is a variable whose values are presumed to change as a result of changes in the independent variable.

In an equation, a dependent variable is the variable whose value depends on one or more variables in the equation. An independent variable in an equation is any variable whose value is not dependent on any other variable in the equation.

Hypothesis is a tentative assumption explaining an observation, phenomenon or scientific problem that can be tested by further observation, investigation or experimentation. Characteristically, the research is a process of investigation of a particular/specific topic of study with the aim of studying a problem or question. The research topic for study is established by the researcher or investigator according to the specific assignment that needs to be explored.

After the final section of topic, the researcher or investigator has to develop a question for research and hypothesis that relates to the research being conducted. The formulation of a research question must be made before the researcher initiates conducting research on specified topic. This will be a question developed from the purpose statement and will be the specification that the researcher intents to find out by conducting the research. The question selected will guide the researcher or investigator through their research process and will also concentrate on the objective of the research. As already discussed, the hypothesis is a prediction regarding the outcome of the research being conducted. The key objective for the researcher or investigator in developing a hypothesis statement is to test and ultimately accept or reject it when the assessment of the research is performed.

A well researched and planned research question will help and ensure the researcher or investigator that they are collecting the appropriate data. This is a critical and most significant step in the research process. The research question determines what, where, when and how the data are collected as it is an important association between the abstract, theoretical, conceptual and logistic aspects of the research plan.

### 6.3 SOURCES OF HYPOTHESIS

Since the mind is fed by innumerable streams and sources, it is difficult to pinpoint how a particular good idea comes to a researcher. The following are some of the popularly known sources of research hypothesis:
Hypothesis

- **Scientific theories:** A systematic review and analysis of theories developed in the field of psychology, sociology, economics, political science and biological science may provide the researcher with potential clues for constructing a good and testable hypothesis.

- **Expert opinions:** Discussion with the experts in the field of research may further help the researcher obtain necessary insight and skill into the problem and in the formulation of a hypothesis.

- **Method of related difference:** When we find that two phenomena differ constantly and the other circumstances remain the same, we suspect a causal connection. For example, when we find uncontrolled traffic in a locality, resulting in a greater number of road accidents, we suspect a causal connection between uncontrolled traffic and road accidents. This method also suggests hypothesis.

- **Intellectual equipment of researcher:** Intellectual abilities of a researcher like creative thinking and problem solving techniques are very helpful in the formulation of a good hypothesis.

- **Related literature:** Related literature is the most important source of hypothesis formulation. A review of this literature may reveal to the researcher the variables that have been considered important in relation to his/her problem, which aspects have already been studied and which are left to be studied, which theories have supported the relationships and which theories present a contradictory relationship. Familiarity with related literature may give the researcher a tremendous advantage in the construction of hypothesis.

- **Experience:** One’s own experience may be a rich source of hypothesis generation. Personal experiences of an individual which has been gained through reading biographies, autobiographies, newspaper readings or through informal talks among friends, etc., can be a potential source of generation of a hypothesis. For example, a researcher who is working on the effectiveness of guidance in teaching, can think of factors such as the teacher’s polite behaviour, techniques of counselling, mastery over the subject, effective use of teaching skills, decision-making capability, perception of his/her competence, perception of student’s capacity for better interaction, use of communication skills, etc.

- **Analogies:** Several hypotheses in a branch of knowledge may be made by using analogies from other sciences. Models and theories developed in a discipline may help, through extrapolation, in the formulation of hypothesis in another discipline. By comparing the two situations, analysing their similarities and differences, some rationale may emerge in the mind of the researcher which may take the form of a hypothesis for testing. For example, in a research problem like studying the factors of unrest among college level students, the researcher insightfully thinks: ‘Why was unrest found among school students?’ and ‘What has changed them: quality of teaching or quality of leadership?’
Arguing analogically in this way may lead the investigator to some conclusions which may be used for identifying variables and relationships, which form the basis of hypothesis construction. If a researcher knows from previous experience that the old situation is related to other factors Y and Z as well as to X, he/she may reason out that the new situation may also be related to Y and Z.

- **Methods of residues**: When the greater part of a complex phenomenon is explained by some causes already known, we try to explain the residual part of phenomenon according to the known law of operation. It also provides possible hypothesis.

- **Induction by simple enumeration**: Sometimes scientists take common experience as a starting point of their investigation. For example, after observing a large number of scarlet flowers that are devoid of fragrance, we frame a hypothesis that all scarlet flowers are devoid of fragrance. Thus, induction by simple enumeration is a source of discovery.

- **Formulation of hypothesis**: It may also originate from the need and practice of present times.

- **Existing empirical uniformities**: In terms of common sense proposition, the existing empirical uniformities may form the basis for scientific examination.

- **A study of general culture**: It is also a good source of hypothesis.

- **Suggestions**: When given by other researchers in their reports, suggestions are quite helpful in the establishment of hypothesis for future studies.

---

### Check Your Progress

1. List few characteristics of a good hypothesis.
2. What is the significance of a hypothesis?

---

### 6.4 Hypothesis Testing/Functions and Types: Level of Significance and Errors

Till now, we have learnt about the formulation and sources of hypothesis, let us now move towards the testing of hypothesis. The testing of hypothesis requires an understanding of some important concepts.

Below are discussed some concepts on testing of hypotheses:

- **Null hypothesis**: The hypotheses that are proposed with the intent of receiving a rejection for them are called null hypotheses. This requires that we hypothesize the opposite of what is desired to be proved. For example, if we want to show that sales and advertisement expenditure are related,
we formulate the null hypothesis that they are not related. If we want to prove that the average wages of skilled workers in town 1 is greater than that of town 2, we formulate the null hypotheses that there is no difference in the average wages of the skilled workers in both the towns. A null hypothesis is denoted by $H_0$.

- **Alternative hypotheses:** Rejection of null hypotheses leads to the acceptance of alternative hypotheses. The rejection of null hypothesis indicates that the relationship between variables (e.g., sales and advertisement expenditure) or the difference between means (e.g., wages of skilled workers in town 1 and town 2) or the difference between proportions have statistical significance and the acceptance of the null hypotheses indicates that these differences are due to chance. The alternative hypotheses are denoted by $H_1$.

- **One-tailed and two-tailed tests:** A test is called one-sided (or one-tailed) only if the null hypothesis gets rejected when a value of the test statistic falls in one specified tail of the distribution. Further, the test is called two-sided (or two-tailed) if null hypothesis gets rejected when a value of the test statistic falls in either one or the other of the two tails of its sampling distribution. For example, consider a soft drink bottling plant which dispenses soft drinks in bottles of 300 ml capacity. The bottling is done through an automatic plant. An overfilling of bottle (liquid content more than 300 ml) means a huge loss to the company given the large volume of sales. An underfilling means the customers are getting less than 300 ml of the drink when they are paying for 300 ml. This could bring bad reputation to the company. The company wants to avoid both overfilling and underfilling. Therefore, it would prefer to test the hypothesis whether the mean content of the bottles is different from 300 ml. This hypothesis could be written as:

$$H_0 : \mu = 300 \text{ ml}.$$  
$$H_1 : \mu \neq 300 \text{ ml}$$

The hypotheses stated above are called two-tailed or two-sided hypotheses. However, if the concern is the overfilling of bottles, it could be stated as:

$$H_0 : \mu = 300 \text{ ml}.$$  
$$H_1 : \mu > 300 \text{ ml}.$$ 

Such hypotheses are called one-tailed or one-sided hypotheses and the researcher would be interested in the upper tail (right hand tail) of the distribution. If however, the concern is loss of reputation of the company (underfilling of the bottles), the hypothesis may be stated as:

$$H_0 : \mu = 300 \text{ ml}.$$  
$$H_1 : \mu < 300 \text{ ml}.$$
The hypothesis stated above is also called one-tailed test and the researcher would be interested in the lower tail (left hand tail) of the distribution.

**Type I and Type II error:** The acceptance or rejection of a hypothesis is based upon sample results and there is always a possibility of sample not being representative of the population. This could result in errors, as a consequence of which inferences drawn could be wrong. The situation could be depicted as given in Figure 6.1.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Accept H₀</th>
<th>Reject H₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₀ True</td>
<td>Correct decision</td>
<td>Type I Error</td>
</tr>
<tr>
<td>H₀ False</td>
<td>Type II Error</td>
<td>Correct decision</td>
</tr>
</tbody>
</table>

*Fig. 6.1 Type I and Type II Errors*

If null hypothesis H₀ is true and is accepted or H₀ when false is rejected, the decision is correct in either case. However, if the hypothesis H₀ is rejected when it is actually true, the researcher is committing what is called a Type I error. The probability of committing a Type I error is denoted by alpha (α). This is termed as the level of significance. Similarly, if the null hypothesis H₀ when false is accepted, the researcher is committing an error called Type II error. The probability of committing a Type II error is denoted by beta (β). The expression 1 – β is called power of test. To decrease the risk of committing both types of errors, you may increase the sample size.

**Steps in Testing of Hypothesis Exercise**

The following steps are followed in the testing of a hypothesis:

**Setting up of a hypothesis:** The first step is to establish the hypothesis to be tested. As it is known, these statistical hypotheses are generally assumptions about the value of the population parameter; the hypothesis specifies a single value or a range of values for two different hypotheses rather than constructing a single hypothesis. These two hypotheses are generally referred to as (1) the null hypotheses denoted by H₀ and (2) alternative hypothesis denoted by H₁.

The null hypothesis is the hypothesis of the population parameter taking a specified value. In case of two populations, the null hypothesis is of no difference or the difference taking a specified value. The hypothesis that is different from the null hypothesis is the alternative hypothesis. If the null hypothesis H₀ is rejected based upon the sample information, the alternative hypothesis H₁ is accepted. Therefore, the two hypotheses are constructed in such a way that if one is true, the other one is false and vice versa.

**Setting up of a suitable significance level:** The next step is to choose a suitable level of significance. The level of significance denoted by α is chosen
before drawing any sample. The level of significance denotes the probability of rejecting the null hypothesis when it is true. The value of \( \alpha \) varies from problem to problem, but usually it is taken as either 5 per cent or 1 per cent. A 5 per cent level of significance means that there are 5 chances out of hundred that a null hypothesis will get rejected when it should be accepted. When the null hypothesis is rejected at any level of significance, the test result is said to be significant. Further, if a hypothesis is rejected at 1 per cent level, it must also be rejected at 5 per cent significance level.

**Determination of a test statistic:** The next step is to determine a suitable test statistic and its distribution. As would be seen later, the test statistic could be \( t, Z, \chi^2 \) or \( F \), depending upon various assumptions to be discussed later in the book.

**Determination of critical region:** Before a sample is drawn from the population, it is very important to specify the values of test statistic that will lead to rejection or acceptance of the null hypothesis. The one that leads to the rejection of null hypothesis is called the critical region. Given a level of significance, \( \alpha \), the optimal critical region for a two-tailed test consists of that 2 per cent area in the right hand tail of the distribution plus that \( \alpha/2 \) per cent in the left hand tail of the distribution where that null hypothesis is rejected.

**Computing the value of test-statistic:** The next step is to compute the value of the test statistic based upon a random sample of size \( n \). Once the value of test statistic is computed, one needs to examine whether the sample results fall in the critical region or in the acceptance region.

**Making decision:** The hypothesis may be rejected or accepted depending upon whether the value of the test statistic falls in the rejection or the acceptance region. Management decisions are based upon the statistical decision of either rejecting or accepting the null hypothesis.

In case a hypothesis is rejected, the difference between the sample statistic and the hypothesized population parameter is considered to be significant. On the other hand, if the hypothesis is accepted, the difference between the sample statistic and the hypothesized population parameter is not regarded as significant and can be attributed to chance.

**Test Statistic for Testing Hypothesis about Population Mean**

In this section, we will take up the test of hypothesis about population mean in a case of single population.

One of the important things that have to be kept in mind is the use of an appropriate test statistic. In case the sample size is large (\( n > 30 \)), \( Z \) statistic would be used. For a small sample size (\( n \leq 30 \)), a further question regarding the knowledge of population standard deviation (\( \sigma \)) is asked. If the population standard deviation \( \sigma \) is known, a \( Z \) statistic can be used. However, if \( \sigma \) is unknown and is estimated using sample data, at test with appropriate degrees of freedom is used.
under the assumption that the sample is drawn from a normal population. It is assumed that you have the knowledge of \( Z \) and \( t \) distribution from the course on statistics. However, these would be briefly reviewed at the appropriate place. Table 6.1 summarizes the appropriateness of the test statistic for conducting a test of hypothesis regarding the population mean.

**Table 6.1 Appropriateness of Test Statistic in Testing Hypotheses about Means**

<table>
<thead>
<tr>
<th>Sample Size</th>
<th>Knowledge of Population Standard Deviation (( \sigma ))</th>
<th>Known</th>
<th>Not Known</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large ((n &gt; 30))</td>
<td>( Z )</td>
<td>( Z )</td>
<td></td>
</tr>
<tr>
<td>Small ((n \leq 30))</td>
<td>( Z )</td>
<td>( t )</td>
<td></td>
</tr>
</tbody>
</table>

**Tests Concerning Means—the Case of Single Population**

In this section, a number of illustrations will be taken up to explain the test of hypothesis concerning mean. Two cases of large sample and small samples will be taken up.

**Case of large sample**

As mentioned earlier, in case the sample size \( n \) is large or small but the value of the population standard deviation is known, a \( Z \) test is appropriate. There can be alternate cases of two-tailed and one-tailed tests of hypotheses.

Corresponding to the null hypothesis \( H_0: \mu = \mu_0 \), the following criteria could be used as shown in Table 6.2.

The test statistic is given by,

\[
Z = \frac{\bar{X} - \mu_0}{\sigma/\sqrt{n}}
\]

Where,

- \( \bar{X} = \) Sample mean
- \( \sigma = \) Population standard deviation
- \( \mu_0 = \) The value of \( \mu \) under the assumption that the null hypothesis is true.
- \( n = \) Size of sample.

**Table 6.2 Criteria for Accepting or Rejecting Null Hypothesis under Different Cases of Alternative Hypotheses**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Alternative Hypothesis</th>
<th>Reject the Null Hypothesis if</th>
<th>Accept the Null Hypothesis if</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>( \mu &lt; \mu_0 )</td>
<td>( Z &lt; -Z_\alpha )</td>
<td>( Z \geq -Z_\alpha )</td>
</tr>
<tr>
<td>2.</td>
<td>( \mu &gt; \mu_0 )</td>
<td>( Z &gt; Z_\alpha )</td>
<td>( Z \leq Z_\alpha )</td>
</tr>
<tr>
<td>3.</td>
<td>( \mu \neq \mu_0 )</td>
<td>( Z &lt; -Z_{\alpha/2} ) or ( Z &gt; Z_{\alpha/2} )</td>
<td>( -Z_{\alpha/2} \leq Z \leq Z_{\alpha/2} )</td>
</tr>
</tbody>
</table>
If the population standard deviation \( \sigma \) is unknown, the sample standard deviation \( s = \frac{1}{\sqrt{n-1}} \sum (X - \bar{X})^2 \) is used as an estimate of \( \sigma \). It may be noted that \( Z_{\alpha} \) and \( Z_{\alpha/2} \) are \( Z \) values such that the area to the right under the standard normal distribution is \( \alpha \) and \( \alpha/2 \) respectively.

Below are solved examples using the above concepts.

**Example 6.1:** A sample of 200 bulbs made by a company give a lifetime mean of 1540 hours with a standard deviation of 42 hours. Is it likely that the sample has been drawn from a population with a mean lifetime of 1500 hours? You may use 5 per cent level of significance.

**Solution:**
In the above example, the sample size is large \((n = 200)\), sample mean \((\bar{X})\) equals 1540 hours and the sample standard deviation \((s)\) is equal to 42 hours. The null and alternative hypotheses can be written as:

- \( H_0 : \mu = 1500 \text{ hrs} \)
- \( H_1 : \mu \neq 1500 \text{ hrs} \)

It is a two-tailed test with level of significance \((\alpha)\) to be equal to 0.05. Since \( n \) is large \((n > 30)\), though population standard deviation \( \sigma \) is unknown, one can use \( Z \) test. The test statistics are given by:

\[
Z = \frac{\bar{X} - \mu_0}{\sigma/\sqrt{n}}
\]

Where, \( \mu_0 = \) Value of \( \mu \) under the assumption that the null hypothesis is true

\[ \sigma/\sqrt{n} = \text{Estimated standard error of mean} \]

Here \( \mu_0 = 1.500, \bar{X} = \frac{\sum X}{n} = \frac{42}{\sqrt{200}} = 2.97 \)

(Note that \( \hat{\sigma} \) is estimated value of \( \sigma \).)

\[ Z = \frac{1540 - 1500}{2.97} = \frac{40}{2.97} = 13.47 \]

The value of \( \alpha = 0.05 \) and since it is a two-tailed test, the critical value \( Z \) is given by \(-Z_{\alpha/2}\) and \( Z_{\alpha/2} \) which could be obtained from the standard normal table given in Appendix 1 at the end of the book.
Rejection regions for Example 6.1

Since the computed value of $Z = 13.47$ lies in the rejection region, the null hypothesis is rejected. Therefore, it can be concluded that the average life of the bulb is significantly different from 1,500 hours.

**Example 6.2:** On a typing test, a random sample of 36 graduates of a secretarial school averaged 73.6 words with a standard deviation of 8.10 words per minute. Test an employer’s claim that the school’s graduates average less than 75.0 words per minute using the 5 per cent level of significance.

**Solution:**

\[ H_0 : \mu = 75 \]
\[ H_1 : \mu < 75 \]

$\bar{X} = 73.6, s = 8.10, n = 36$ and $\alpha = 0.05$. As the sample size is large ($n > 30$), though population standard deviation $\sigma$ is unknown, $Z$ test is appropriate.

The test statistic is given by:

\[
Z = \frac{\bar{X} - \mu_0}{\sigma / \sqrt{n}} = \frac{73.6 - 75}{1.35} = -1.4
\]

Since it is a one-tailed test and the interest is in the left hand tail of the distribution, the critical value of $Z$ is given by $-Z_{\alpha} = -1.645$. Now, the computed value of $Z$ lies in the acceptance region, and the null hypothesis is accepted as shown below:

![Rejection Region for Example 6.2](image)

Rejection region for Example 6.2

**Case of small sample**

In case the sample size is small ($n \leq 30$) and is drawn from a population having a normal population with unknown standard deviation $\sigma$, a $t$ test is used to conduct the hypothesis for the test of mean. The $t$ distribution is a symmetrical distribution just like the normal one. However, $t$ distribution is higher at the tail and lower at the peak. The $t$ distribution is flatter than the normal distribution. With an increase in the sample size (and hence degrees of freedom), $t$ distribution loses its flatness.
and approaches the normal distribution whenever \( n > 30 \). A comparative shape of \( t \) and normal distribution is given in Figure 6.2.

**Fig. 6.2 Shape of \( t \) and Normal Distribution**

The procedure for testing the hypothesis of a mean is similar to what is explained in the case of large sample. The test statistic used in this case is:

\[
\frac{\bar{X} - \mu}{s / \sqrt{n}}
\]

Where \( \bar{X} = \frac{\sum X}{n} \) (where \( s = \text{Sample standard deviation} \))

\( n - 1 = \text{degrees of freedom} \)

A few examples pertaining to ‘\( t \)’ test are worked out for testing the hypothesis of mean in case of a small sample.

**Example 6.3:** Prices of share (in \( \text{Rs} \)) of a company on the different days in a month were found to be 66, 65, 69, 70, 69, 71, 70, 63, 64 and 68. Examine whether the mean price of shares in the month is different from 65. You may use 10 per cent level of significance.

**Solution:**

\( H_0 : \mu = 65 \)

\( H_1 : \mu \neq 65 \)

Since the sample size is \( n = 10 \), which is small, and the sample standard deviation is unknown, the appropriate test in this case would be \( t \). First of all, we need to estimate the value of sample mean (\( \bar{X} \)) and the sample standard deviation (\( s \)). It is known that the sample mean and the standard deviation are given by the following formula:

\[
\bar{X} = \frac{\sum X}{n}, \quad s = \frac{1}{\sqrt{n-1}} \sqrt{\sum (X - \bar{X})^2}
\]

The computation of \( \bar{X} \) and \( s \) is shown in Table 6.3.

\[
\sum X = 675, \quad \bar{X} = \frac{\sum X}{n} = \frac{675}{10} = 67.5
\]

\[
\sum (X - \bar{X})^2 = 70.5
\]
The test statistic is given by:

\[ t = \frac{x - \mu_0}{s / \sqrt{n}} = \frac{67.5 - 65}{7.83 / \sqrt{10}} = \frac{2.5 \times \sqrt{10}}{7.83} = \frac{2.8}{2.8} = 2.82 \]

The critical values of \( t \) with 9 degrees of freedom for a two-tailed test are given by –1.833 and 1.833. Since the computed value of \( t \) lies in the rejection region (see figure below), the null hypotheses is rejected.

Therefore, the average price of the share of the company is different from 65.
Example 6.4: Past records indicate that a golfer has averaged 82 on a certain course. With a new set of clubs, he averages 7 over five rounds with a standard deviation of 2.65. Can we conclude that at 0.025 level of significance, the new club has an adverse effect on the performance?

Solution:

\[ H_0 : \mu = 82 \]
\[ H_1 : \mu < 82 \]

\[ \bar{X} = 7.9, n = 5, s = 2.65, \alpha = 0.025. \] As the population standard deviation is unknown and the sample size is small \((n < 30)\), a \(t\) test would be appropriate. The test statistic is given by:

\[ t = \frac{\bar{X} - \mu_0}{s/\sqrt{n}} = \frac{7.9 - 8.2}{2.65/\sqrt{5}} = -0.3/1.185 = -0.25 \]

The critical value of \(t\) at 0.025 level of significance with four degrees of freedom is given by \(-t_\alpha = -2.776\) (see Appendix 2). As the sample \(t\) value of \(-0.25\) lies in the acceptance region, the null hypothesis is accepted (see figure below).

Rejection region for Example 6.4

Therefore, there is no adverse effect on the performance due to a change in the club and the performance can be attributed to chance.

Tests for Difference between two Population Means

So far, we have been concerned with the testing of means of a single population. We took up the cases of both large and small samples. It would be interesting to examine the difference between the two population means. Again, various cases would be examined as discussed below:
Case of large sample

In case both the sample sizes are greater than 30, a Z test is used. The hypothesis to be tested may be written as:

\[ H_0 : \mu_1 = \mu_2 \]
\[ H_1 : \mu_1 \neq \mu_2 \]

Where,
\[ \mu_1 = \text{mean of population 1} \]
\[ \mu_2 = \text{mean of population 2} \]

The above is a case of two-tailed test. The test statistic used is:

\[ Z = \frac{\overline{X}_1 - \overline{X}_2 - (\mu_1 - \mu_2) \cdot \frac{s}{\sqrt{n_1} \cdot \sqrt{n_2}}} {\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \]

\[ \overline{X}_1 = \text{Mean of sample drawn from population 1} \]
\[ \overline{X}_2 = \text{Mean of sample drawn from population 2} \]
\[ n_1 = \text{size of sample drawn from population 1} \]
\[ n_2 = \text{size of sample drawn from population 2} \]

If \( \sigma \) and \( \sigma_1 \) are unknown, their estimates given by \( \hat{\sigma} \) and \( \hat{\sigma}_1 \) are used.

\[ \hat{\sigma} = \sqrt{\frac{1}{n_1} \sum (X_i - \overline{X})^2} \]
\[ \hat{\sigma}_1 = \sqrt{\frac{1}{n_2} \sum (X_i - \overline{X})^2} \]

The Z value for the problem can be computed using the above formula and compared with the table value to either accept or reject the hypothesis. Let us consider the following problem:

**Example 6.5:** A study is carried out to examine whether the mean hourly wages of the unskilled workers in the two cities—Ambala Cantt and Lucknow are the same. The random sample of hourly earnings in both the cities is taken and the results are presented in the Table 6.4.

**Table 6.4 Survey Data on Hourly Earnings in Two Cities**

<table>
<thead>
<tr>
<th>City</th>
<th>Sample Mean Hourly Earnings</th>
<th>Standard Deviation of Sample</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambala Cantt</td>
<td>₹ 8.95 (X₁)</td>
<td>0.40 (s₁)</td>
<td>200 (n₁)</td>
</tr>
<tr>
<td>Lucknow</td>
<td>₹ 9.10 (X₂)</td>
<td>0.60 (s₂)</td>
<td>175 (n₂)</td>
</tr>
</tbody>
</table>
Using a 5 per cent level of significance, test the hypothesis of no difference in the average wages of unskilled workers in the two cities.

**Solution:** We use subscripts 1 and 2 for Ambala Cantt and Lucknow respectively.

\[ H_0 : \mu_1 = \mu_2 \rightarrow \mu_1 - \mu_2 = 0 \]
\[ H_1 : \mu_1 \neq \mu_2 \rightarrow \mu_1 - \mu_2 \neq 0 \]

The following survey data is given:

\[ \bar{x}_1 = 8.95, \bar{x}_2 = 9.10, s_1 = 0.40, s_2 = 0.60, n_1 = 200, n_2 = 175, \alpha = 0.05 \]

Since both \( n_1, n_2 \) are greater than 30 and the sample standard deviations are given, a \( Z \) test would be appropriate.

The test statistic is given by:

\[
Z = \frac{\bar{x}_1 - \bar{x}_2 - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \]

As \( \sigma_1, \sigma_2 \) are unknown, their estimates would be used.

\[ s_1 = \sqrt{s_1^2}, \quad s_2 = \sqrt{s_2^2} \]

\[
\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}} = \sqrt{\frac{(0.4)^2}{200} + \frac{(0.6)^2}{175}} = \sqrt{0.0028} = 0.053
\]

\[ Z = \frac{(8.95 - 9.10) - 0}{0.053} = -2.83 \]

As the problem is of a two-tailed test, the critical values of \( Z \) at 5 per cent level of significance are given by \( Z_{\alpha/2} = -1.96 \) and \( Z_{\alpha/2} = 1.96 \). The sample value of \( Z = -2.83 \) lies in the rejection region as shown in the figure below:
Rejection regions for Example 6.5

Case of small sample

If the size of both the samples is less than 30 and the population standard deviation is unknown, the procedure described above to discuss the equality of two population means is not applicable in the sense that a t test would be applicable under the assumptions:

(a) Two population variances are equal.
(b) Two population variances are not equal.

Population variances are equal

If the two population variances are equal, it implies that their respective unbiased estimates are also equal. In such a case, the expression becomes:

\[
\frac{\hat{\sigma}_1^2}{n_1} + \frac{\hat{\sigma}_2^2}{n_2} = \hat{\sigma}^2 = \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}
\]

(Assuming \(\hat{\sigma}_1^2 = \hat{\sigma}_2^2 = \hat{\sigma}^2\))

To get an estimate of \(\hat{\sigma}^2\), a weighted average of \(\hat{s}_1^2\) and \(\hat{s}_2^2\) is used, where the weights are the number of degrees of freedom of each sample. The weighted average is called a 'pooled estimate' of \(\hat{\sigma}^2\). This pooled estimate is given by the expression:

\[
\hat{\sigma}^2 = \frac{(n_1 - 1)\hat{s}_1^2 + (n_2 - 1)\hat{s}_2^2}{n_1 + n_2 - 2}
\]

The testing procedure could be explained as under:

\(H_0\) : \(\mu_1 = \mu_2 \rightarrow \mu_1 - \mu_2 = 0\)

\(H_1\) : \(\mu_1 \neq \mu_2 \rightarrow \mu_1 - \mu_2 \neq 0\)

In this case, the test statistic \(t\) is given by the expression:

\[
t = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\hat{\sigma} \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}
\]

Where,

\[
\hat{\sigma} = \sqrt{\frac{(n_1 - 1)\hat{s}_1^2 + (n_2 - 1)\hat{s}_2^2}{n_1 + n_2 - 2}}
\]
Hypothesis

Once the value of $t$ statistic is computed from the sample data, it is compared with the tabulated value at a level of significance $\alpha$ to arrive at a decision regarding the acceptance or rejection of hypothesis. Let us work out a problem illustrating the concepts defined above.

Example 6.6: Two drugs meant to provide relief to arthritis sufferers were produced in two different laboratories. The first drug was administered to a group of 12 patients and produced an average of 8.5 hours of relief with a standard deviation of 1.8 hours. The second drug was tested on a sample of 8 patients and produced an average of 7.9 hours of relief with a standard deviation of 2.1 hours. Test the hypothesis that the first drug provides a significantly higher period of relief. You may use 5 per cent level of significance.

Solution: Let the subscripts 1 and 2 refer to drug 1 and drug 2 respectively.

$H_0: \mu_1 = \mu_2 \Rightarrow \mu_1 - \mu_2 = 0$
$H_1: \mu_1 \neq \mu_2 \Rightarrow \mu_1 - \mu_2 \neq 0$

The following survey data is given:

\[
\bar{x}_1 = 8.5, \bar{x}_2 = 7.9, s_1 = 1.8, s_2 = 2.1, n_1 = 12, n_2 = 8
\]

As both $n_1, n_2$ are small and the sample standard deviations are unknown, one may use a $t$ test with the degrees of freedom $= n_1 + n_2 - 2 = 12 + 8 - 2 = 18$ d.f.

The test statistics is given by:

\[
t = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)H_0}{\delta \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}
\]

Where,

\[
\delta = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}}
\]

\[
= \sqrt{\frac{12 - 1)(1.8)^2 + (8 - 1)(2.1)^2}{12 + 8 - 2}} = \sqrt{\frac{11 \times 3.24 + 7 \times (4.41)}{18}} = \sqrt{\frac{35.64 + 30.87}{18}} = \sqrt{\frac{66.51}{18}} = \sqrt{3.695} = 1.92
\]

\[
t = \frac{(8.5 - 7.9) - (0)}{1.92 \sqrt{\frac{1}{12} + \frac{1}{8}}} = 0.6 \times \frac{1}{0.2083} = 0.6 \times 0.785 = 0.685
\]

The critical value of $t$ with 18 degrees of freedom at 5 per cent level of significance is given by 1.734. The sample value of $t = 0.685$ lies in the acceptance region as shown in figure below:
Rejection region for Example 6.6

Therefore, the null hypothesis is accepted as there is not enough evidence to reject it. Therefore, one may conclude that the first drug is not significantly more effective than the second drug.

When population variances are not equal

In case population variances are not equal, the test statistic for testing the equality of two population means when the size of samples are small is given by:

\[ t = \frac{\bar{X}_1 - \bar{X}_2 - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \]

The degrees of freedom in such a case is given by the expression:

\[ df = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{1}{n_1 - 1}\left(\frac{s_1^2}{n_1}\right)^2 + \frac{1}{n_2 - 1}\left(\frac{s_2^2}{n_2}\right)^2} \]

The procedure for testing of hypothesis remains the same as was discussed when the variances of two populations were assumed to be same. Let us consider an example to illustrate the same.

Example 6.7: There were two types of drugs (1 and 2) that were tried on some patients for reducing weight. There were 8 adults who were subjected to drug 1 and seven adults who were administered drug 2. The decrease in weight (in pounds) is given below:

<table>
<thead>
<tr>
<th>Drug 1</th>
<th>10</th>
<th>8</th>
<th>12</th>
<th>14</th>
<th>7</th>
<th>15</th>
<th>13</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drug 2</td>
<td>12</td>
<td>10</td>
<td>7</td>
<td>6</td>
<td>12</td>
<td>11</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>
Do the drugs differ significantly in their effect on decreasing weight? You may use 5 per cent level of significance. Assume that the variances of two populations are not same.

**Solution:**

\[ H_0 : \mu_1 = \mu_2 \]
\[ H_1 : \mu_1 \neq \mu_2 \]

Let us compute the sample means and standard deviations of the two samples as shown in Table 6.4.

**Table 6.4 Intermediate Computations for Sample Means and Standard Deviations**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>( X_1 )</th>
<th>( X_2 )</th>
<th>((X_1 - \bar{X}_1)^2)</th>
<th>((X_2 - \bar{X}_2)^2)</th>
<th>((X_1 - \bar{X}_1)^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>12</td>
<td>-1.25</td>
<td>2</td>
<td>1.5625</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>10</td>
<td>-3.25</td>
<td>0</td>
<td>10.5625</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>7</td>
<td>0.75</td>
<td>-3</td>
<td>0.5625</td>
</tr>
<tr>
<td>4</td>
<td>14</td>
<td>6</td>
<td>2.75</td>
<td>-4</td>
<td>7.5625</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>12</td>
<td>-4.25</td>
<td>2</td>
<td>18.0625</td>
</tr>
<tr>
<td>6</td>
<td>15</td>
<td>11</td>
<td>3.75</td>
<td>1</td>
<td>14.0625</td>
</tr>
<tr>
<td>7</td>
<td>13</td>
<td>12</td>
<td>1.75</td>
<td>2</td>
<td>3.0625</td>
</tr>
<tr>
<td>8</td>
<td>11</td>
<td>7</td>
<td>-0.25</td>
<td>0</td>
<td>0.0625</td>
</tr>
<tr>
<td>Total</td>
<td>90</td>
<td>70</td>
<td>0</td>
<td>0</td>
<td>55.5</td>
</tr>
<tr>
<td>Mean</td>
<td>11.25</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ n_1 = 8, \quad n_2 = 7, \]

\[ \bar{X}_1 = \frac{\sum X_1}{n_1} = \frac{90}{8} = 11.25 \quad \bar{X}_2 = \frac{\sum X_2}{n_2} = \frac{70}{7} = 10 \]

\[ s_1^2 = \frac{\sum (X_1 - \bar{X}_1)^2}{n_1 - 1} = \frac{55.5}{7} = 7.93 \]

\[ s_2^2 = \frac{\sum (X_2 - \bar{X}_2)^2}{n_2 - 1} = \frac{38}{6} = 6.33 \]

\[ \hat{s} = \sqrt{\frac{s_1^2 + s_2^2}{n_1 + n_2}} = \sqrt{\frac{7.93 + 6.33}{8 + 7}} = \sqrt{0.99 + 0.90} = \sqrt{1.89} = 1.37 \]

\[ d.f. = \frac{1}{\frac{1}{n_1} + 1} + \frac{1}{\frac{1}{n_2} + 1} = \frac{1}{\frac{7.93}{8}} + \frac{1}{\frac{6.33}{7}} = 3.314 \]

\[ = \frac{3.314}{0.12 + 0.136} = 12.996 = 13 \text{ (approx.)} \]
Tests Concerning Population Proportion—the Case of Single Population

We have already discussed the tests concerning population means. In the tests about proportion, one is interested in examining whether the respondents possess a particular attribute or not.

The random variable in such a case is a binary one in the sense it takes only two values—yes or no. As we know that either a student is a smoker or not, a consumer either uses a particular brand of product or not and lastly, a skilled worker may be either satisfied or not with the present job. At this stage it may be recalled that the binomial distribution is a theoretically correct distribution to use while dealing with proportions. Further, as the sample size increases, the binomial distribution approaches the normal distribution in characteristic. To be specific, whenever both np and nq (where n = number of trials, p = probability of success and q = probability of failure) are at least 5, one can use the normal distribution as a substitute for the binomial distribution.

The case of single population proportion

Suppose we want to test the hypotheses,

\[ H_0 : p = p_0 \]

\[ H_1 : p \neq p_0 \]

For large sample, the appropriate test statistic would be:

\[ Z = \frac{\bar{p} - p_0}{\sqrt{\frac{p_0(1-p_0)}{n}}} \]

Where,

\[ \bar{p} = \text{sample proportion} \]

\[ p_{0} = \text{the value of } p \text{ under the assumption that null hypothesis is true} \]

\[ \frac{q}{\bar{p}} = \text{Standard error of sample proportion} \]
The value of $p$ is computed by using the following formula:

$$
p = \sqrt{\frac{p_{H_0} q_{H_0}}{n}}
$$

Where,

$$q_{H_0} = 1 - p_{H_0}$$

$n = \text{Sample size}$

For a given level of significance $\alpha$, the computed value of $Z$ is compared with the corresponding critical values, i.e. $Z_{\alpha/2}$ or $-Z_{\alpha/2}$, to accept or reject the null hypothesis. We will consider a few examples to explain the testing procedure for a single population proportion.

**Example 6.8:** An officer of the health department claims that 60 per cent of the male population of a village comprises smokers. A random sample of 50 males showed that 35 of them were smokers. Are these sample results consistent with the claim of the health officer? Use a level of significance of 0.05.

**Solution:**

Sample size $(n) = 50$

Sample proportion $\bar{p} = \frac{x}{n} = \frac{35}{50} = 0.70$

$H_0 : p = 0.60$

$H_1 : p > 0.60$

The test statistic is given by:

$$Z = \frac{\bar{p} - p_{H_0}}{\frac{\sigma}{n}} = \frac{0.70 - 0.60}{0.069} = 1.44$$

It is a one-tailed test. For a given level of significance $\alpha = 0.05$, the critical value of $Z$ is given by $Z_{\alpha} = Z_{0.05} = 1.645$. It is seen that the sample value of $Z = 1.44$ lies in the acceptance region as shown below (see figure).
Rejection region for Example 6.8

Therefore, there is not enough evidence to reject the null hypothesis. So it can be concluded that the proportion of male smokers is not statistically different from 0.60.

Tests for Difference between two Population Proportions

Here, the interest is to test whether the two population proportions are equal or not. The hypothesis under investigation is:

$H_0: \ p_1 = p_2 \rightarrow p_1 - p_2 = 0$
$H_1: \ p_1 \neq p_2 \rightarrow p_1 - p_2 \neq 0$

The alternative hypothesis assumed is two sided. It could as well have been one sided. The test statistic is given by:

$Z = \frac{\bar{p}_1 - \bar{p}_2 - (p_1 - p_2)H_0}{\sigma_{\bar{p}_1 - \bar{p}_2}}$

Where,

$\bar{p}_1$ = Sample proportion possessing a particular attribute from population 1

$\bar{p}_2$ = Sample proportion possessing a particular attribute from population 2

$\sigma_{\bar{p}_1 - \bar{p}_2}$ = Standard error of difference between proportions.

$(p_1 - p_2)_{H0}$ = Value of difference between population proportion under the assumption that the null hypothesis is true.

The formula for $\sigma_{\bar{p}_1 - \bar{p}_2}$ is given by:

$\sigma_{\bar{p}_1 - \bar{p}_2} = \sqrt{\frac{pq}{n_1} + \frac{pq}{n_2}}$

We do not know the value of $p_1$, $p_2$, etc., but under the null hypothesis $p_1 = p_2 = p$.

$\sigma_{\bar{p}_1 - \bar{p}_2} = \sqrt{\frac{pq}{n_1} + \frac{pq}{n_2}} = \sqrt{pq \left( \frac{1}{n_1} + \frac{1}{n_2} \right)}$

The best estimate of $p$ is given by:

$\hat{p} = \frac{X_1 + X_2}{n_1 + n_2}$
Hypothesis

\[ x_1 = \text{Number of successes in sample 1} \]
\[ x_2 = \text{Number of successes in sample 2} \]
\[ n_1 = \text{Size of sample taken from population 1} \]
\[ n_2 = \text{Size of sample taken from population 2} \]

It is known that \( \frac{x_1}{n_1} \) and \( \frac{x_2}{n_2} \).

Therefore, \( x_1 = n_1 \hat{p}_1 \) and \( x_2 = n_2 \hat{p}_2 \).

Therefore, \( \hat{p} = \frac{n_1 \hat{p}_1 + n_2 \hat{p}_2}{n_1 + n_2} \).

Therefore, the estimate of standard error of difference between the two proportions is given by:

\[ \hat{\sigma}_{\hat{p}_1 - \hat{p}_2} = \sqrt{\hat{p} \hat{q} \left( \frac{1}{n_1} + \frac{1}{n_2} \right)} \]

Where \( \hat{p} \) is as defined above and \( \hat{q} = 1 - \hat{p} \).

Now, the test statistic may be rewritten as:

\[ Z = \frac{\hat{p}_1 - \hat{p}_2 - (\hat{p}_1 - \hat{p}_2)}{\sqrt{\hat{p} \hat{q} \left( \frac{1}{n_1} + \frac{1}{n_2} \right)}} \]

Now, for a given level of significance \( \alpha \), the sample \( Z \) value is compared with the critical \( Z \) value to accept or reject the null hypothesis. We consider below a few examples to illustrate the testing procedure described above.

**Example 6.9:** A company is interested in considering two different television advertisements for the promotion of a new product. The management believes that advertisement A is more effective than advertisement B. Two test market areas with virtually identical consumer characteristics are selected. Advertisement A is used in one area and advertisement B in the other area. In a random sample of 60 consumers who saw advertisement A, 18 tried the product. In a random sample of 100 customers who saw advertisement B, 22 tried the product. Does this indicate that advertisement A is more effective than advertisement B, if a 5 per cent level of significance is used?

**Solution:**

\[ H_0 : p_a = p_b \]
\[ H_1 : p_a > p_b \]
\[ n_A = 60, \quad x_A = 18, \quad n_B = 100, \quad x_B = 22 \]

\[ \bar{x}_A = \frac{x_A}{n_A} = \frac{18}{60} = 0.3 \]

\[ \bar{x}_B = \frac{x_B}{n_B} = \frac{22}{100} = 0.22 \]

\[ Z = \frac{\bar{x}_A - \bar{x}_B - (p_A - p_B)H_0}{\sqrt{pq \left( \frac{1}{n_A} + \frac{1}{n_B} \right)}} = \frac{0.3 - 0.22 - 0}{\sqrt{0.25 \times 0.75 \left( \frac{1}{60} + \frac{1}{100} \right)}} = \frac{0.08}{0.08} = 1.3 \]

\[ p = \frac{x_A + x_B}{n_A + n_B} = \frac{18 + 22}{60 + 100} = \frac{40}{160} = 0.25 \]

The critical value of \( Z \) at 5 per cent level of significance is 1.645. The sample value of \( Z = 1.13 \) lies in the acceptance region as shown in the figure below:

Rejection region for Example 2.9

Check Your Progress

3. What is the first step in the testing of the hypothesis?

4. What is the basis of acceptance/rejection of a hypothesis?

6.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Few characteristics of a good hypothesis are the following:
   - It ensures that the sample is readily approachable.
   - It maintains a very apparent distinction with what is called theory, law, facts, assumptions and postulates.
A hypothesis is an approximate assumption that a researcher wants to test for its logical or empirical consequences.

A deductive reasoning can be defined as a type of reasoning that can be derived from previously known facts.

A hypothesis should be capable of being tested within a reasonable amount of time.

A well formulated or good hypothesis helps the researchers to focus/concentrate on the key points of investigation.

‘A hypothesis is never proved or disproved. In fact, an investigator or researcher who sets out to prove a hypothesis would lose the impartiality of the research investigation’ (Leedy and Ormrod, 2001).

Formulating a hypothesis helps by defining an initial explanation to be tested in the research process.

Several hypotheses in a branch of knowledge may be made by using analogies from other sciences. Models and theories developed in a discipline may help, through extrapolation, in the formulation of hypothesis in another discipline.

The hypotheses that are proposed with the intent of receiving a rejection for them are called null hypotheses. This requires that we hypothesize the opposite of what is desired to be proved.

Before a sample is drawn from the population, it is very important to specify the values of test statistic that will lead to rejection or acceptance of the null hypothesis.
6.7 KEY WORDS

- Hypothesis: It is an approximate assumption that a researcher wants to test for its logical or empirical consequences.
- Null hypothesis: The hypotheses that are proposed with the intent of receiving a rejection for them are called null hypotheses.
- Deductive reasoning: It can be defined as a type of reasoning that can be derived from previously known facts.

6.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short Answer Questions
1. What are the characteristics of a valid hypothesis?
2. Why is a hypothesis required?
3. Write a short note on Type I and Type-II errors.

Long Answer Questions
1. Discuss the steps involved in hypothesis generation.
2. Explain the sources of hypothesis.
3. Describe the procedure of hypothesis testing.

6.9 FURTHER READINGS

A research design is significant as it helps in the smooth functioning of various research operations, it helps to decide the methods and techniques to be used for collecting and analysing data. In this unit, you will learn about the types of research designs as well as about sampling and non-sampling designs.
7.1 OBJECTIVES

After going through this unit, you will be able to:

- Examine the significance of research design
- Outline the different types of research designs
- Discuss sampling and non-sampling designs

7.2 RESEARCH DESIGN: AN OVERVIEW

Research design is a structure that gives an outline of the overall research work. It is the result of better planning and implementation of a good strategy. Different authors have given different definitions for research design. According to Kerlinger, research design is the plan, structure and strategy of investigation conceived so as to obtain answers to research questions and to control variance. Bernard Phillips defines research design as the blueprint for collection, measurement and analysis of data.

The decisions that you need to take to formulate a research design should be based on the following questions:

- What is the research all about?
- Why is the research being done?
- What kind of data is required for the research?
- From where can the data be obtained?
- How much time will the research take?
- What is a sample research design?
- How should the data be analysed?
- What is the style of report preparation?

A research design helps a researcher to organize ideas and check for flaws and inadequacies in the collected data. It involves the following elements:

- A statement that clearly defines the problem for which the research is being done
- Procedures and techniques for gathering the information required for research design
- Methods that need to be implemented for processing and analysing the data required for research design

The overall research design can be divided into the following four parts:

(i) Sampling part: It includes the method of selecting items that are to be observed for the research study.
(ii) **Observational part:** It includes the conditions under which you need to make observations.

(iii) **Statistical part:** It is based on the number of items that need to be observed and the analysis technique to be used for the analysis of gathered data.

(iv) **Operational part:** It involves the techniques that help to implement the items specified in the sampling, statistical and observational designs.

### 7.2.1 Need for Research Design

Before starting the research process, it is important to formulate an efficient and appropriate research design. A research design is significant as it has the following advantages:

- It helps in the smooth functioning of various research operations.
- It requires less effort, time and money.
- It helps to decide the methods and techniques to be used for collecting and analysing data.

The researcher needs to consider the following factors before creating a research design:

- Source of the information
- Skills of the researcher and his coordinating staff
- Problem objectives
- Nature of the problem
- Availability of time and money for the research work

### 7.2.2 Features of a Good Research Design

A good research design is characterized by flexibility, efficiency and low cost, but it has many other features too. On the basis of the description of the design, a research design has the following features:

- It states the sources and types of information required for solving the problem for which the research is being carried out.
- It is a strategy for indicating the approach to be adopted for gathering and analysing data.
- It includes performing research work according to time and budget constraints.
- It minimizes preconception and maximizes the reliability of collected and analysed data.
- It minimizes experimental errors in an investigation.
- It provides various aspects for dealing with a problem.
A research design depends to a large extent on the type of research study that you are conducting. If the research study is exploratory, then emphasis is on the discovery of ideas. So, a research design should be flexible to implement the different aspects of a phenomenon. However, when the purpose is to obtain an accurate description of a research study, the design that maximizes reliability of the collected data is considered a good design. The availability of time, money, skills of the research staff and the method of obtaining information must be considered while creating experimental design, survey design and sample design.

7.2.3 Steps in Research Design

The steps in a research design primarily depend on the type of research being conducted. The steps involved in a research process are as follows:
1. Preparing the research question or problem
2. Assessing the available literature
3. Creating hypotheses
4. Constructing the research design
5. Collecting data
6. Analysing the data
7. Interpreting the results
8. Writing the research report

The fourth step, i.e., constructing the research design, involves three subordinate steps, which include the process of creating a research design. The three subordinate steps can further be explained as follows:

(i) Identifying the variables: This involves identifying the variables to be studied and determining their types. The most common types of variables are dependent, independent, controlled and other variables. Dependent variables are items such as responses of subjects and outcomes of survey or criterion variables. Independent variables, on the other hand, are those which are explanatory or predictor variables.

(ii) Formulating the functional definitions: Here, the researcher explores the possibilities and ways in which the variables can be operationalized.

(iii) Selecting the design for data analysis: This is the preliminary step of data collection, and hence, involves determination of appropriate design for analysing the data being collected.
7.3 EXPLORATORY, DESCRIPTIVE AND DIAGNOSTIC RESEARCH

Several research designs are classified on the basis of the study performed in the research. These research designs can be listed as follows:

- Research design in exploratory research studies
- Research design in descriptive studies
- Research design in quantitative studies
- Research design in qualitative studies
- Research design in experimental research studies

7.3.1 Exploratory Research Design

Exploratory research design is also known as formulative research design. In this research design, a specific subject is investigated. It helps to generate a set of hypotheses or research-based questions that can be used at a later stage. The three methods that are applied for explorative research studies are as follows:

1. Surveying the literature: It is the simplest method for formulating the research problem in which along with new literature, previous hypotheses are reviewed and evaluated for future research.

2. Experience survey: It is a type of research that involves practically experienced persons in the research work. For such a survey, people with more innovative ideas are carefully selected as respondents and then the investigators interview the respondents. Thus, experience survey enables the researcher to concisely define the problem. This survey also provides information about the practical possibilities for different research works.

3. Analysis of insight-stimulating examples: It includes an intensive study of selected instances of a phenomenon. In this method, the attitude of the investigator, intensity of study and ability of the researcher are required to unify the diverse information of the problem.

Thus, in exploratory research study, the applied method needs to be flexible, regardless of the type of the method, so that the different aspects of the problem can be considered. In exploratory research design, the following considerations are kept in mind:

- A small sample size is used.
- Data requirements are unclear.
- General objectives are considered, rather than specific objectives.
- No definite suggestions are made after research analysis.
7.3.2 Descriptive Research Design

A descriptive research study describes the characteristics of a particular problem or an individual or a group. Descriptive studies include specific predictions concerned with study, facts and characteristics concerning an individual, a group or situations. Most of the social research is based on descriptive research studies. In descriptive studies, the questions related to ‘what’, ‘why’, ‘where’ and ‘who’ need to be answered.

The following steps must be followed while designing a descriptive study:

1. **Formulating the objectives of the study:** This step specifies the objectives to ensure that the collected data is related to the study; otherwise, the research will not provide the desired result.

2. **Designing the data collection methods:** This step helps to select the method, that is, observation, questionnaires, interview or examination of records, for collecting the data.

3. **Processing and analysing the data:** The data collected for the research study must be processed and analysed. This includes analysing the data collected through interviews and observations, tabulating the data and performing statistical computations.

4. **Reporting the researched data:** For reporting the findings, the layout should be well planned, and presented in a simple and effective style.

In descriptive studies, the following considerations should be kept in mind:

- The phenomenon under study should be described.
- The data may be related to the behavioural variables of the respondent.
- The recommendations are definite.
- The objectives should be specific, data requirements should be clear and large samples should be used.

7.3.3 Diagnostic/Conclusive Research Design

A conclusive research design is more structured and formal than an exploratory research design. It is based on large representative samples, and the data obtained is subjected to quantitative analysis. The aim of conclusive research is to examine specific relationships and test specific hypotheses. To achieve these objectives, the researcher needs to clearly specify the required information. In this research, the findings are considered as conclusive in nature as they are used as inputs for managerial decision-making. The two categories of conclusive research designs are descriptive and causal. Descriptive research designs can further be either cross-sectional or longitudinal.

1. **Descriptive research design:** This design requires a clear specification of ‘when’, ‘where’, ‘who’, ‘what’, ‘why’, and ‘how’ of the research. Its
main purpose is to describe the characteristics or the function. Some of the conditions in which this research can be recommended are:

- To make a specific forecast
- Discovery of associations among variables
- Estimates of the proportions of a population that have some specific characteristics
- To describe the characteristics of a product, group, organization or market

Unlike exploratory research, the descriptive research design is marked by a specific hypothesis, clear statement of the problem, and detailed information needs. Generally, descriptive research follows surveys, panels, secondary data analysis and observation methods and can be classified into cross-sectional and longitudinal research.

(i) **Cross-sectional research:** This is the most frequently used research design in business research and involves information collection from a given sample of population elements, and that too only once. They may be either multiple cross-sectional or single cross-sectional. In single cross-sectional designs, only one sample of respondents is drawn from the target population, and the information from this sample is obtained only once. This design is also referred to as sample survey research design.

In multiple cross-sectional design, there are two or more samples of respondents, and the information from each of the sample is obtained only once. Often, information from different samples is obtained at different times over long intervals. Multiple cross-sectional designs allow comparisons at the aggregate level but not at the individual respondent level. Because a different sample is taken each time, a survey is conducted, there is no way to compare the measures on an individual respondent across surveys. One of the special interest, multiple cross-sectional designs is cohort analysis, which consists of a series of surveys conducted at appropriate time intervals, where the cohort serves as the basic unit of analysis. A group of respondents who experience the same event within the same time interval is referred to as a ‘cohort’.

(ii) **Longitudinal research design:** Unlike cross-sectional research design, a fixed sample(s) of population elements is measured repeatedly on the same variable. In other words, the same objects are studied over time and the same variables are measured. In contrast to the cross-sectional design, which provides a snapshot of the variables of interest at a single point in time, a longitudinal study gives a series of pictures that provide an in-depth view of the situation and the changes that have taken place over time. Sometimes, the term panel is used interchangeably with the term longitudinal design. A panel consists of a sample of respondents who have agreed to give information at specified intervals over an extended period.
2. **Causal research design:** This research design is used to obtain the evidence of cause-and-effect (causal) relationships. Like descriptive research design, causal research design also requires a plan and structure and is more appropriate for the following purposes:

- To understand cause (independent) variables and effect (dependent) variables of the phenomenon
- To determine the nature of the relationship between cause and effect variables to make predictions about effect

In this design, causal (independent) variables are manipulated in a relatively controlled environment, in which the other variables that may affect the dependent variable are controlled or checked as much as possible. The effect of this manipulation on one or more dependent variables is then measured to infer causality. The main method of causal research is experimentation.

### 7.3.4 Experimental Research Design

Experimental research design is usually applicable when we determine the cause and effect relationship or derive the cause and effect inferences in any experimental research study. Experimental research design is instrumental in answering some of the important psychological questions that are based on the concept of what causes what.

The objective of experimental research design is to establish the cause and effect relationship between variables. The four types of variables related to experimental research design are as follows:

- **(i) Independent variables:** These signify conditions or measures in the experimental design that can be changed.
- **(ii) Dependent variables:** These variables can be measured and signify the effect or result in the experimental design.
- **(iii) Control variables:** These variables remain constant in the experimental design.
- **(iv) Random variables:** These variables can vary their values in different conditions in the experimental design.

There are many variations in experimental designs which are created to achieve different results and resolve different problems. We can define the simplest form of experimental design by creating two similar groups, which are equivalent to each other in all respects, except for the fact that one group will receive the treatment and another group will not receive the treatment. The group that receives the treatment can be termed as the treatment group and the group that does not receive the treatment can be termed as the comparison or control group.

The formation of two similar groups that are equivalent to each other is ensured by randomly assigning people or participants into two groups from a common pool of people or participants. The success of the experiment is based on the concept of random assignment of people into two groups. However, as
two people cannot be exactly similar, in the experimental design, we refer to the idea of probability and say that two groups are probabilistically equivalent or equivalent in the probabilistic ranges.

<table>
<thead>
<tr>
<th>Check Your Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What do you understand by the term ‘research design’?</td>
</tr>
<tr>
<td>2. What decisions do you need to take while formulating a research design?</td>
</tr>
<tr>
<td>3. Highlight the significance of a research design.</td>
</tr>
<tr>
<td>4. What are the features of a good research design?</td>
</tr>
<tr>
<td>5. What are the steps involved in a research process?</td>
</tr>
<tr>
<td>6. What are the three methods applied in explorative research?</td>
</tr>
</tbody>
</table>

7.4 SAMPLING AND NON-SAMPLING DESIGNS

**Sampling design** refers to a definite plan for obtaining a sample from the sampling frame. It refers to the technique or procedure, which a researcher adopts in selecting some sampling units from where inferences about population are drawn. Sampling data is obtained before collecting the final data.

**7.4.1 Need for Sampling**

We can define sampling as the process of obtaining information about an entire population by examining only a part of it. Sampling is required for the following reasons:

- It saves time and money. A sample study is usually less expensive than a census study.
- It produces results at a faster speed.
- It enables more accurate measurement for a sample study as it is conducted by experienced investigators.
- It is the only method for an infinitely large population.

It usually enables you to estimate sampling errors and thus assists you in obtaining information concerning some characteristics of the population such as age group or gender.

The advantages of sampling are as follows:

- The solution to know the true or actual values of the various parameters of the population would be to take into account the entire population. This is not feasible due to the cost and time involved. Therefore, sampling seems more economical.
• As the magnitude of operation involved in a sample survey is small, the execution of the fieldwork and the analysis of results can be carried out at a faster rate and in a lesser time.

• Only a small staff is required for gathering and analysing information and preparing reports. Therefore, sampling is a very cheap process.

• A researcher can collect detailed information in a lesser time than is possible in a census survey.

• As the scale of operation involved in a sample survey is small, the quality of interviews, supervision and other related activities is better than the census survey.

• Sampling provides adequate information needed for the purpose and is sufficiently reliable for surveys.

7.4.2 Characteristics of Sampling

Usually, sampling involves determining a property or attribute to adhere to for the purpose of differentiating between items of a given population. These attributes, which are the objects of study, are called characteristics. The process of distinguishing the items is usually of two types, quantitative or qualitative. In quantitative sampling, characteristics pertaining to variables are dealt with. On the other hand, qualitative sampling is concerned with the characteristics related to attributes.

The basic idea behind sampling is to use the common characteristics of average items as samples for a larger entity. Thus, it involves choosing a subset of population elements for study. Thus, for example, if the population to be dealt with is, say that of roads, then the characteristics could be length, duration, roughness, carriage capacity, etc. Sampling proves to be a much cheaper and quicker mode of estimation where the population is absolutely huge.

However, it is absolutely necessary to take ample care while determining which characteristics should be sampled. Those characteristics, which are rare, should be avoided. Similarly, even if there are certain very common characteristics, which, however, do not contribute in any way to draw reliable estimates, then such characteristics should not be sampled.

7.4.3 Steps in Sampling

The sampling process involves the following seven tasks:

1. Defining the population: It involves completely defining the population by specifying the following terms:
   • Elements
   • Sampling units
   • Extent
   • Time
2. **Selecting the sampling frame**: The sampling frame should be selected in such a way that it consists of almost all the sampling units. A sample should be selected in such a way that it has all the characteristics of the population. Some of the popular sampling frames are census reports, and electoral registers.

3. **Specifying the sampling unit**: Sampling unit is the basic unit that contains elements of the target population.

4. **Specifying the sampling method**: This method depicts how the sample units are selected. The most important decision in this method is to determine, which of the two—probability and non-probability—samples is to be chosen.

5. **Determining the sample size**: This method includes decision-making about the number of elements to be chosen.

6. **Specifying the sampling plan**: This method dictates that one should indicate how decisions made so far are to be implemented. All the expected issues in relation to the sampling survey must be answered by the sample plan.

7. **Selecting the sample**: This is the final step in the sample process, which includes a good deal of fieldwork and office work. This is introduced in the actual selection of the sample elements. It mainly depends on the sampling plan and the sample size required.

7.4.4 **Representative Sample**

When a researcher carries out the research study, he may select a comparatively small number of subjects from the entire population. Thus, for example, he may choose salespersons of supermarkets from all supermarkets in the country. Literally, in this case, the researcher is using a representative sample. Thus, we can define representative sample as the sample which possesses the same characteristics as that of its parent population or variable. Thus, it factually represents the variation that exists in the parent variable on the general level.

The significance of a representative sample lies in the fact that it represents the population more accurately. For this, it is absolutely necessary that the sampling process be kept free from errors. Errors may occur when representative sampling is based on surveys that may be hampered with non-response errors or self-selection errors. By non-response errors, we mean that a survey is conducted in such a way that the researcher has targeted a large number of subjects, but only a small per cent has responded.

This can be explained with an example. Suppose that a supermarket tries to conduct a survey of its customers by offering feedback forms to every consumer and instructing them to put the filled-in form in a drop box. In this case, it is possible that some customers may fill the form, whereas some may just carry it and discard it outside. Suppose that the number of customers visiting every day is around 400. In case, just seventy-five of these have put in completely filled forms,
the management cannot infer these seventy-five customers as representing the total 400. As such, if these seventy-five are used for the process of sampling, inaccurate generalizations are bound to occur.

In the case of self-selection error, there may be, for example, a few customers who may have chosen to fill only half the form. As can be seen, in this case too, the sampling is not possible on such a self-selected partial feedback of the customers. Another possibility is that the researcher may be tempted to conduct sampling by personal standards, which can greatly obstruct the generalization purpose of sampling. In this case, there is a possibility of the measurement being distorted or miscalculated as a result of subjective influence on the part of the surveyor.

7.4.5 Sampling Techniques

Sampling involves the application of a number of predefined concepts and types for conducting the survey meant for research. It is also necessary for the researcher to get acquainted with the various terms involved for effective application of the sampling method.

Types of Sampling

Several types of sampling are commonly in use. These are:

- **Random sampling:** This type of sampling is not a chance selection but it ensures the addition of each and every sample of the population. The advantage of random sampling is that it is ideal for statistical purposes and the disadvantage is that it is hard to be achieved in practice and requires an accurate list of the whole population. It is also expensive to be conducted, as the samples may be scattered in the whole world. There are various methods of performing random sampling, which are as follows:
  - **Lottery method:** In this method, the numbers or names of various units of population are jotted on chits and put in a container. The chits are then drawn from the container after a thorough mixing and a survey on the matter written in the chits is carried out. This method is considered an outdated one, because it is less likely to select the appropriate sample.
  - **Selection of sample:** In this method, names are arranged under the intended plan alphabetically, geographically or simply serially. Then, out of the list, every tenth or any other number of cases is taken up. If every tenth unit is to be selected, the selection begins as seventh, seventeenth, twenty-seventh, and so on or fifth, fifteenth, twenty-fifth, and so on.
  - **Grid system:** In this method, selection of sample is made from a particular area. A map of the entire area is prepared and then a screen of squares is placed on map. The areas falling within the selected squares are taken as samples.
• **Purposive sampling:** This type of sampling depends more on the deliberate choice of researchers. Thus, such a selection of samples, defeats the purpose of research as the sample selection is purposely carried out by the researcher’s choice.

• **Stratified sampling:** In this method of sampling, the samples are divided into non-overlapping groups such as geographical areas, age groups and genders. This method is a combination of random sampling and purposive sampling. It is always easy to group a sample and it ensures better coverage of the population than simple random sampling. The disadvantage of stratified sampling is that it is difficult to identify appropriate groups and it is more complex to analyse and organize results.

• **Cluster sampling:** In this type of sampling, the units of samples close to each other are chosen in clusters, for example, households in the same street or successive items of a production-line. The population is divided into clusters and some of them are chosen randomly. Then, the clustered units are selected using the random sampling method. The advantage of this method is that it is cheaper as it saves travelling cost and is useful for surveying in a particular industry where individual companies can form a cluster. The disadvantage of this method is that the units close to each other may be similar and likely to represent the whole population. There is a larger amount of sampling error here than in random sampling.

• **Quota sampling:** In this method of sampling, the samples are given to the interviewer, who has been given quotas to fill from some specified subgroup of the population. For example, an interviewer may be told to sample 100 men between the age group of forty to fifty. This method is similar to the stratified method of sampling, but here the selection of sampling is not random. Anyone, who is keen to interview people, can do this sampling. Therefore, this method is not the most representative method. The advantage of this method is that it is cheap to organize. The disadvantage of this method is that it is not representative of the population as a whole and it is not possible to determine the sampling error, as this is a non-random sampling method.

• **Multi-stage sampling:** This type of sampling starts by dividing the country into a number of regions. Some of these regions are selected randomly and then divided further. For example, a country can be divided into cities, which can be further divided into rural areas and urban areas. Then, these areas are again divided at random into parliaments and wards. This process of division keeps on getting repeated until the smallest possible unit is achieved.

• **Convenience sampling:** This is a very simple type of sampling. It is mainly used in medical situations or where sample measurements are expensive to make. It contains all the useful samples that cannot be ignored.
Fundamental definitions in sampling

There are a few terms that are commonly used in sampling concepts and principles, which are as follows:

- **Universe/population**: The universe, from the statistical point of view, refers to all the items or units in any field of inquiry. Population, on the other hand, refers to the total items about which information is desired. Attributes that are the objects of study are called characteristics and the units that are used to process the attributes are called elementary units. The aggregate of such units is the population. These two terms are used interchangeably, but researchers should define these terms precisely.

Universe or population is of two types, finite and infinite. If the population contains a fixed number of elements so that it is possible to list them totally, it is called finite population. The population of a city or the workers in a factory are examples of finite population. The population where we cannot make out the total number of items is called infinite population. The number of stars in the sky is an example of infinite population.

- **Sampling frame**: The elementary units or a group of such units may form the basis of the sampling process, and in this case, they are called sampling units. A list containing all such sampling units is called a sampling frame. The sampling frame contains a list of items from which the sample can be taken. If the population is finite and the time frame is in the present or past, then it is possible for the frame to be identical to the population. However, in most cases, it is not identical as it is not possible to have an identical population. So, this frame is constructed by the researcher for the purpose of his study or may contain some existing list of population. For example, a telephone directory can be used as a frame for finding the population of a city.

- **Statistics and parameters**: Statistics is a characteristic of a sample and a parameter is a characteristic of a population. Working with mean, median and mode is called statistics. When these measures describe the characteristics of a population, they are called parameters. For example, population mean is a parameter, but sample mean is a statistic.

- **Sampling error**: A sample survey requires the study of small portions of a population as there can be certain amount of inaccuracy in the information collected during sampling analysis. This inaccuracy is called sampling error or error variance. In other words, those errors which arise on account of sampling and generally happen to be random variations in the sample estimates of the actual population values, are called sampling errors. Figure 7.1 shows sampling error.
Sampling errors occur randomly and are equally likely to be in either direction and the magnitude of sampling error depends on the nature of the universe. The more uniform the universe is, the smaller is the sampling error. Sampling error is inversely proportional to the size of the sample and vice-versa. Sampling error is the product of the critical value at a certain level of significance, and the standard error.

- **Precision**: It is the range within which the population average lies in accordance with the reliability specified in the confidence level as a percentage of the estimate or as a numerical quantity. For example, if the estimate is ₹5000 and the precision desired is ±4 per cent, then the true values would be not less than ₹4800 or not more than ₹5200. This is the range within which the answer should lie. But, the estimate should not go beyond this level.

- **Confidence level and significance level**: The confidence level is the expected percentage of times that the actual value will fall within the stated precision limits. Therefore, if we say that the confidence level is 90 per cent, then we mean that there are 90 chances in 100 that the sample result will give the true condition of the population within a specified range, as against the other 10 chances when the condition is not true. While precision is the range within which the answer may vary, the confidence level indicates the likelihood that the answer will fall within that range, and the significance level indicates the likelihood that the answer will fall outside that range.

- **Sampling distribution**: Sampling distribution is often required in sampling analysis. If we take samples and for each sample we compute several
statistical measures such as mean and standard deviation, we can find that
each sample may give its own value for the statistics under consideration.
We can have the sampling distribution of mean or standard deviation or of
any other statistical measure as well.

7.4.6 Sampling Distribution

The following types of sampling distribution are commonly used:

- **Sampling distribution of mean**: It refers to the probability distribution of
  all possible means of random samples of a given size. If the samples are
taken from a normal population, \( N(\mu, \sigma) \), the sampling distribution of mean
would be normal with mean \( \mu_x = \mu \) and the standard deviation = \( \sigma \sqrt{n} \),
where \( \mu \) is the mean of population, \( \sigma \) is the standard deviation of the
population and ‘n’ means the number of items in a sample. When the sampling
is from a population that is not normal, which may be positive or negative,
as per the Central Limit theorem, the sampling distribution of mean tends to
be quite close to the normal distribution, provided that the number of sample
items is larger than 30. If we want to reduce the sampling distribution of
mean to unit normal distribution, we can write as normal variants \( z = \frac{x - \mu}{\sigma / \sqrt{n}} \)
for the sampling distribution of mean. This characteristic of sampling
distribution of mean is very useful in several decision situations for acceptance
or rejection of hypotheses.

- **Sampling distribution of proportion**: This type of distribution is useful in
  statistics. For example, if we have worked out the proportion of defective
parts in a large number of samples such as 100 items that have been taken
from an infinite population, by plotting a probability distribution of the said
proportions you obtain the sampling distribution. If ‘p’ is the proportion of
defectives and ‘q’ is the proportion of non-defectives and if ‘p’ is treated
as a random variable, then the sampling distribution of proportion of success
has a mean = \( p \) with standard deviation as:

\[
p - q = \frac{n}{n}
\]

where ‘n’ is the sample size.

- **Student’s distribution**: When the population standard deviation (\( \sigma \)) is
  not known and the sample is of small size, ‘t’ distribution is used for the
sampling distribution of mean and workout t variable as:

\[
t = \frac{\bar{x} - \mu}{\sigma / \sqrt{n}}
\]

Where,

\[
\sigma_t = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}
\]
That is the sample standard deviation. ‘t’-distribution is also symmetrical and is close to the distribution of standard normal variant, ‘z’, except for small values of ‘n’. The variable ‘t’ differs from ‘z’ when we use sample standard deviation ($\sigma_s$) in the calculation of ‘t’, whereas we use standard deviation of population ($\sigma_p$) in the calculation of ‘z’. There is a different ‘t’ for every sample and the degree of freedom for a sample of size ‘n’ is $n-1$. The shape of the ‘t’ distribution becomes approximately equal to the normal distribution as the sample size becomes larger. But, when ‘n’ is small, the ‘t’ distribution is far from normal and when $n \rightarrow \infty$, t distribution is identical to the normal distribution.

- **F distribution:** If $(\sigma_1^2)$ and $(\sigma_2^2)$ are the variances of two independent samples of $n_1$ and $n_2$ respectively, taken from two independent populations, having the same variance, $(\sigma_p^2)$, the ratio $F = (\sigma_1^2) / (\sigma_2^2)$, where $(\sigma_p^2) = \frac{1}{n_1-1} \sum (X_i - \bar{X})^2 / (n_1-1)$ has an F distribution with $n_1-1$ and $n_2-1$ degrees of freedom.

- **Chi-square ($\chi^2$) distribution:** This type of distribution method is used when you are dealing with the collection of values that includes adding up of squares. Variance of samples requires adding a collection of squared quantities and thus having a distribution that is related to chi-square distribution. Collection of sample variances is divided by the known population variance and then the quotients are multiplied by $(n-1)$, where ‘n’ means the number of items in the sample. This way, you obtain the chi-square distribution. Chi-square distribution is not symmetrical and all the values are positive. You need to know the degrees of freedom for using the chi-square distribution. This method is used for judging the significance of the difference between the observed and expected frequencies. The generalized shape of $\chi^2$ distribution depends on the degree of freedom and $\chi^2$ is written as:

$$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

---

**Check Your Progress**

7. What terms are used to define the population in sampling?
8. What is a sampling unit?
9. What is a representative sample?
10. Define cluster sampling.
11. What are the two types of population?
7.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Research design is a structure that gives an outline of the overall research work. It is the result of better planning and implementation of a good strategy. Different authors have given different definitions of research design. According to Kerlinger, research design is the plan, structure and strategy of investigation conceived so as to obtain answers to research questions and to control variance. Bernard Phillips defines research design as the blueprint for collection, measurement and analysis of data.

2. The decisions that are required to be taken to formulate a research design should be based on the following questions:
   - What is the research all about?
   - Why is the research being made?
   - What kind of data is required for the research?
   - From where can the data be obtained?
   - How much time will the research take?
   - What is a sample research design?
   - How should the data be analysed?
   - What is the style of report preparation?

3. A research design is significant as it has the following advantages:
   - It helps in the smooth functioning of various research operations.
   - It requires less effort, time and money.
   - It helps to decide the methods and techniques to be used for collecting and analysing data.

4. A good research design can be characterized by flexibility, efficiency and low cost, but it has many other features too. On the basis of the description of design, a research design has the following features:
   - It states the sources and types of information required for solving the problem for which research is being carried out.
   - It is a strategy for indicating the approach to be adopted for gathering and analysing data.
   - It includes performing research work according to time and budget constraints.
   - It minimizes preconception and maximizes the reliability of collected and analysed data.
   - It minimizes experimental errors in an investigation.
   - It provides various aspects of dealing with a problem.
5. The steps involved in a research process are as follows:
   1. Preparing the research question or problem
   2. Assessing the available literature
   3. Creating hypotheses
   4. Constructing the research design
   5. Collecting data
   6. Analysing the data
   7. Interpreting the results
   8. Writing the research report
6. The three methods applied in explorative research studies are as follows:
   (i) Surveying the literature
   (ii) Experience survey
   (iii) Analysis of insight-stimulating examples
7. Population is defined in sampling by specifying the following terms:
   - Elements
   - Sampling units
   - Extent
   - Time
8. A sampling unit is the basic unit that contains elements of the target population.
9. Representative sample is the sample possessing the same characteristics as that of its parent population or variable. It factually represents the variation that exists in the parent variable on a general level.
10. In cluster sampling, units of samples close to each other are chosen in clusters; for example, households in the same street or successive items of a production line. The population is divided into clusters and some of them are chosen randomly. Then, the clustered units are selected using the random sampling method.
11. The two types of population are finite and infinite.

7.6 SUMMARY
- Research design is a structure that gives an outline of the overall research work. It is the result of good planning and proper strategy implementation.
- A research design helps a researcher to organize ideas and check for flaws and inadequacies in the collected data.
- Before starting the research process, it is important to formulate an efficient and appropriate research design.
A good research design can be characterized by flexibility, efficiency and low cost.

A research design depends on the type of research study that is being conducted. If the research study is exploratory, then the major emphasis is on the discovery of ideas. So, a research design should be flexible to implement the different aspects of a phenomenon.

The different types of research design include exploratory, descriptive, diagnostic, experimental.

Sampling is a technique adopted by the researcher to select some sampling units from which inferences about the population are drawn.

### 7.7 KEY WORDS

- **Research design**: It is a structure that gives an outline of the overall research work.
- **Dependent variables**: These include items such as responses of subjects and outcomes of survey or criterion variables.
- **Experience survey**: It is a type of research that involves practically experienced persons in the research work.
- **Descriptive research**: It entails the characteristics of a particular problem or an individual or a group.
- **Cohort**: It roles to a group of respondents who experience the same event within the same time interval.
- **Sampling design**: It is a definite plan for obtaining a sample from the sampling frame.
- **Universe**: It refers to all the items or units in any field of inquiry.
- **Sampling distribution of mean**: It refers to the probability distribution of all possible means of random samples of a given size.

### 7.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

**Short-Answer Questions**

1. What do you understand by conclusive research design?
2. Briefly mention descriptive research design and cross-sectional research.
3. What is the use of longitudinal research design?
**Long-Answer Questions**

1. In what situations is the causal research design more appropriate?
2. Describe the significance of research design.
3. Discuss the features of a good research design.
4. Explain the different types of research design.
5. Discuss the significance of sampling design.

**7.9 FURTHER READINGS**


UNIT 8 TOOLS/INSTRUMENTS

Structure
8.0 Introduction
8.1 Objectives
8.2 Steps Involved in Tool Construction For Research
  8.2.1 Meaning, Types and Uses of Scales
  8.2.2 Reliability and Validity of Tools
8.3 Scaling procedures
  8.3.1 Single Item vs Multiple Item Scale
  8.3.2 Comparative vs Non-Comparative Scales
  8.3.3 Semantic Differential Scale
  8.3.4 Stapel Scale
  8.3.5 Likert Scale
  8.3.6 Bogardus Scale
8.4 Interview Guide, Code Book, Pilot Study and Pre Test
8.5 Sources of Data: Primary and Secondary
  8.5.1 Primary Data
  8.5.2 Secondary Data
8.6 Answers to Check Your Progress Questions
8.7 Summary
8.8 Key Words
8.9 Self Assessment Questions and Exercises
8.10 Further Readings

8.0 INTRODUCTION

The term ‘measurement’ means assigning numbers or some other symbols to the characteristics of certain objects. When numbers are used, the researcher must have a rule for assigning a number to an observation in a way that provides an accurate description. We do not measure the object but some characteristics of it. Therefore, in research, people/consumers are not measured; what is measured only are their perceptions, attitude or any other relevant characteristics. There are two reasons for which numbers are usually assigned. First of all, numbers permit statistical analysis of the resulting data and secondly, they facilitate the communication of measurement results.

As mentioned earlier, the numbering is done based on certain rules. Therefore, the assignment of numbers to the characteristics must be isomorphic, i.e., there must be a one-to-one correspondence between the numbers and the characteristics being measured.

For example, same rupee figures should be assigned to a household with identical annual income. Only then numbers can be associated with specific characteristics of the measured object and vice versa. Further, they must not change over the objects or time. This means that the rules for a given assignment must be invariant over time or the object being measured.
Scaling is an extension of measurement. Scaling involves creating a continuum on which measurements on objects are located. Suppose you want to measure the satisfaction level towards Kingfisher Airlines and a scale of 1 to 11 is used for the said purpose. This scale indicates the degree of dissatisfaction, with 1 = extremely dissatisfied and 11 = extremely satisfied. Measurement is the actual assignment of a number from 1 to 11 to each respondent whereas the scaling is the process of placing the respondent on a continuum with respect to their satisfaction towards Kingfisher Airlines. In this unit, you will learn about the steps involved in tool construction, scaling techniques and sources of data.

8.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss the steps involved in tool construction
- Explain the scaling procedures
- Define code book, pilot study and pre test
- Examine the various sources of data

8.2 STEPS INVOLVED IN TOOL CONSTRUCTION FOR RESEARCH

Collecting relevant and appropriate data is the backbone of any research. It is very important in a research process that researchers choose the most appropriate instrument and procedures of research tools that lead to the collection and analysis of data upon which hypotheses may be tested.

In order to collect data which can be statistically analysed in an appropriate way the research tool must be carefully designed with significantly strong levels of reliability and validity.

Research tool may be defined as anything that becomes a means of collecting information for the study. The examples of research tools include observation forms, interview schedules, questionnaires, and interview guides. Constructing a research tool is the first practical step in carrying out the research process.

8.2.1 Meaning, Types and Uses of Scales

Different tools used for data collection which shall be discussed for the purpose of this section are the following:

- Questionnaires
- Interviews
- Observation Techniques
Questionnaires

The questionnaire which is easy to prepare and administer is one of the most used form of data collection. It is a form prepared and distributed to secure responses to certain questions and is filled by the respondent himself. It is a systematic compilation of questions and is an important instrument being used to gather information from widely scattered sources. The questionnaire is administered where the researcher cannot see people in person from whom he desires responses.

According to Johnson, “A questionnaire is a systematic compilation of questions that are submitted to a sampling of population from which information is desired.”

According to W. J. Goode, “In general, the word questionnaire refers to a device for securing answers to questions by using a form which the respondent fills in himself.”

Below are the characteristics of a good questionnaire.

- It deals with an important or significant topic.
- Its significance is carefully stated on the questionnaire itself or on its covering letter.
- It seeks only that data which cannot be obtained from the resources like books, reports and records.
- It is as short as possible, only long enough to get the essential data.
- It is attractive in appearance, neatly arranged and clearly duplicated or printed.
- Directions are clear and complete, important terms are clarified.
- The questions are objective, with no clues, hints or suggestions.
- Questions are presented in one order from simple to complex.
- The questions carry adequate number of alternatives.
- It is easy to tabulate, summarize and interpret.

Merits of a Questionnaire

- It is very economical.
- It consumes less time of the researcher.
- It covers the research in wide area.
- It is very suitable for special type of responses.
- It is most reliable in special cases.

Demerits of Questionnaire

- Chances of limited responses are high.
- There is no personal contact of the researcher.
High possibility of recording wrong answers.
Possibilities of receiving incomplete responses are more.
Illegible responses may not contribute towards the data.

Unlike the questionnaire, an interview method of collecting data establishes a physical contact between the respondent and researcher. The rapport established through face to face interaction which did not exist in the questionnaire method, a free flow of information is facilitated from both the parties. The use of interview method, therefore, facilitates more truthful responses.

You will get to study about the questionnaire method in detail in Unit 9.

According to P. V. Young, ‘The interview may be regarded as a systematic method by which a person enters more or less imaginatively into the inner life of a comparative stranger.’

According to Vivien Palmar, ‘The interview constitutes a social situation between two persons, the psychological process involved requiring both individuals mutually respond though the social research purpose of the interview call for a varied response from the two parties concerned.’

Characteristics of an Interview

- With physical presence it is possible for an interviewer to look into casual factors, determine attitudes and identify the origin of the problem.
- It is very useful while dealing with young children and illiterate people.
- Face to face presence makes cross questioning possible while collecting data.
- It assists the interviewer in forming an impression of the person concerned.
- It can deal with delicate, confidential and even intimate topics.
- It has flexibility where the researcher can decide the flow of questions.
- Sincerity, frankness, truthfulness and insight of the interviewee can be better judged through cross questioning.
- It gives no chance for respondent to modify his earlier answer.

The following are the merits of an interview.

- Interview facilitates direct and deep questioning.
- It assists mutual encouragement during the interaction.
- It facilitates cross examination of the data collected.

The following are the demerits of an interview.

- In an interview, the results gathered may be affected due to researcher bias.
- Result may be affected due to the difference in the mental outlook of interviewee and interviewer.

You will get to study about the questionnaire method in detail in Unit 9.
Observation Techniques

Unlike questionnaire and interview, where recording of information is the major focus, observation leads to a more natural and real data collection. Artificiality and formality of questionnaires and interview is replaced by reality and informality in observation. Observation is the most commonly used technique of evaluation research and finds its presence in evaluating cognitive and non-cognitive aspects of a person. Observation techniques are highly significant in performance, interests, attitudes, values towards their life problems and situations. It is most useful technique for evaluating the behaviours of children.

According to C.Y. Younge, 'It is thorough study based on visual observation. Under this technique group behaviours and social institutions problems are evaluated.'

Characteristics of observation include the following:

- It is a direct technique to study an object, an event or a problem.
- It is systematically recorded and related.
- It is based mainly on visual-audio scene.

Merits of Observation

- It is a reliable and valid technique of collecting data and information.
- We get first hand data through this method.
- Record of observation is also available immediately.

Demerits of Observation

- It has a limited scope for its use because all the events cannot be observed directly.
- It is subjective method.
- It is very time consuming process.

This topic has been discussed further in Unit 9.

8.2.2 Reliability and Validity of Tools

In any research a system of measurement is very important and highly desirable. According to S.S. Stevens, 'measurement is the assignment of numerals to objects or events according to rules.' His definition proposes that with certain established rules anything is possible to be measured. Further, measurement is only as good as the rules that direct its application. The 'goodness' of the rules brings forth the concepts of reliability and validity of the measurement.

In research a test is considered to be reliable when it can be used by a number of different researchers under stable conditions, with consistent results and the results not varying. Reliability reflects consistency and replicability over time.
Reliability concerns the extent to which a measurement of a phenomenon provides stable and consistent results. Reliability is also concerned with repeatability. For example, a scale or test is said to be reliable if repeat measurement made by it under constant conditions will give the same result.

Furthermore, reliability is seen as the degree to which a test is free from measurement errors, since the more measurement errors occur the less reliable the test.

In general, the concept of reliability explains the following aspects:

- Stability: Whether the measure employed repeatedly on the same individuals yield similar results?
- Equivalence: Whether the measure employed by different investigators yield similar results?
- Homogeneity: Whether a set of different operational definitions of the same concept employed on the same individuals, using the same data-collecting technique, yield a highly correlated result? Or, will all items of the measure be internally consistent?

In research it is very important to conduct tests for reliability. Testing for reliability is important as it refers to the consistency across the parts of a measuring instrument. The most commonly used internal consistency measure is the Cronbach Alpha coefficient. It is viewed as the most appropriate measure of reliability when making use of Likert scales.

Another important concept in the measurement is that of validity. Although reliability is important for study, it is not sufficient unless combined with validity. According to Wilson, for a test to be reliable, it also needs to be valid.

For a researcher, validity is first and the foremost means of measurement for getting valid outcomes. Validity is the core of any kind of a trustworthy and accurate research assessment.

According to Ghauri and Gronhaug, "Validity explains how well the collected data covers the actual area of investigation". Field defines validity as, "Validity basically means "measure what is intended to be measured".

In general validity tries to explain:

- Variable: Whether the measure employed really measure the theoretical concept.

Validity can further be divided into:

- Face Validity
- Content Validity
• Construct Validity
• Criterion Validity

According to Oluwatayo, ‘Face validity refers to researchers’ subjective assessments of the presentation and relevance of the measuring instrument as to whether the items in the instrument appear to be relevant, reasonable, unambiguous and clear’.11 Face validity evaluates the appearance of the questionnaire in terms of feasibility, readability, consistency of style and formatting and the clarity of the language used.

Content validity is defined as ‘the degree to which items in an instrument reflect the content universe to which the instrument will be generalized’.12 Lewis observes that, ‘In general, content validity involves evaluation of a new survey instrument in order to ensure that it includes all the items that are essential and eliminates undesirable items to a particular construct domain’.13

Construct validity refers to how well a researcher translated or transformed a concept, idea, or behaviour into a functioning and operating reality. The construct validity has two components including convergent and discriminant validity.

Criterion or concrete validity is the extent to which a measure is related to an outcome. It evaluates how well one measure predicts an outcome for another measure. A test has this type of validity if it is useful for predicting performance or behaviour in another situation (past, present, or future).

The table below presents a useful snapshot of both reliability and validity.

<table>
<thead>
<tr>
<th>Basis for Comparison</th>
<th>Validity</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meaning</td>
<td>Validity implies the extent to which the research instrument measures, what it is intended to measure.</td>
<td>Reliability refers to the degree to which scale produces consistent results, when repeated measurements are made.</td>
</tr>
<tr>
<td>Instrument</td>
<td>A valid instrument is always reliable</td>
<td>A reliable instrument need not be a valid instrument</td>
</tr>
<tr>
<td>Related to</td>
<td>Accuracy</td>
<td>Precision</td>
</tr>
<tr>
<td>Value</td>
<td>More</td>
<td>Comparatively less</td>
</tr>
<tr>
<td>Assessment</td>
<td>Difficult</td>
<td>Easy</td>
</tr>
</tbody>
</table>

Check Your Progress

1. Name the different tools used for data collection.
2. What are the characteristics of the observation method?

8.3 SCALING PROCEDURES

One of the ways of classifications of scales is in terms of the number of items in the scale. Based on this, the following classification may be proposed:
8.3.1 Single Item vs Multiple Item Scale

**Single item scale:** In the single item scale, there is only one item to measure a given construct. For example:

- How satisfied are you with your current job?
  - Very Dissatisfied
  - Dissatisfied
  - Neutral
  - Satisfied
  - Very satisfied

The problem with the above question is that there are many aspects to a job, like pay, work environment, rules and regulations, security of job and communication with the seniors. The respondent may be satisfied on some of the factors but may not on others. By asking a question as stated above, it will be difficult to analyze the problem areas. To overcome this problem, a multiple item scale is proposed.

**Multiple item scale:** In multiple item scale, there are many items that play a role in forming the underlying construct that the researcher is trying to measure. This is because each item forms some part of the construct (satisfaction) which the researcher is trying to measure. As an example, some of the following questions may be asked in a multiple item scale.

- How satisfied are you with the pay you are getting on your current job?
  - Very dissatisfied
  - Dissatisfied
  - Neutral
  - Satisfied
  - Very satisfied

- How satisfied are you with the rules and regulations of your organization?
  - Very dissatisfied
  - Dissatisfied
  - Neutral
  - Satisfied
  - Very satisfied

- How satisfied are you with the job security in your current job?
  - Very dissatisfied
  - Dissatisfied
  - Neutral
  - Satisfied
  - Very satisfied

8.3.2 Comparative vs Non-Comparative Scales

The scaling techniques used in research can also be classified into comparative and non-comparative scales (Figure 8.1).
Fig. 8.1 Types of Scaling Techniques

1. Comparative Scales

In comparative scales it is assumed that respondents make use of a standard frame of reference before answering the question. For example:

A question like ‘How do you rate Barista in comparison to Cafe Coffee Day on quality of beverages?’ is an example of the comparative rating scale. It involves the direct comparison of stimulus objects. For example, respondents may be asked whether they prefer Chinese or Indian food. Consider the following set of questions generally used to compare various attributes of Domino’s Pizza and Pizza Hut.

- Please rate Domino’s in comparison to Pizza Hut on the basis of your satisfaction level on an 11-point scale, based on the following parameters: (1 = Extremely poor, 6 = Average, 11 = Extremely good). Circle your response:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety of menu options</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value for money</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed of service (delivery time)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Promotional offers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Food quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Brand name</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Quality of service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Convenience in terms of takeaway location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Friendliness of the salesperson on the phone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Quality of packaging</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Adaptation of Indian taste</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Side orders/appetizers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
</tbody>
</table>
Comparative scale data is interpreted generally in a relative kind. The comparative scale includes paired comparison, rank order, constant sum scale and Q-sort technique to mention a few.

We will discuss below each of the scale under comparative rating scales in detail below:

(a) Paired Comparison Scales: Here a respondent is presented with two objects and is asked to select one according to whatever criterion he or she wants to use. The resulting data from this scale is ordinal in nature. As an example, suppose a parent wants to offer one of the four items to a child—chocolate, burger, ice cream and pizza. The child is offered to choose one out of the two from the six possible pairs, i.e., chocolate or burger, chocolate or ice cream, chocolate or pizza, burger or ice cream, burger or pizza and ice cream or pizza. In general, if there are $n$ items, the number of paired comparison would be $(n(n - 1)/2)$. Paired comparison technique is useful when the number of items is limited because it requires a direct comparison and overt choice. In case the number of items to be compared is large (say 10), it would result in 45 paired comparisons which would further result in fatigue for the respondents. Further, in reality, a respondent does not make the choice from two items at a time—there are multiple alternatives available to him.

There are many ways of analysing the paired comparison data. The analysis of paired comparison data would result in an ordinal scale and also in an interval scale measurement. This will be shown with the help of an example. Let us assume that there are five brands—A, B, C, D and E—and a paired comparison with two brands at a time is presented to the respondent with the option to choose one of them. As there are five brands, it will result in 10 paired comparisons. Suppose this is administered to a sample of 250 respondents with the results as presented in Table 8.2.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-</td>
<td>0.60</td>
<td>0.30</td>
<td>0.60</td>
<td>0.35</td>
</tr>
<tr>
<td>B</td>
<td>0.40</td>
<td>-</td>
<td>0.28</td>
<td>0.70</td>
<td>0.40</td>
</tr>
<tr>
<td>C</td>
<td>0.70</td>
<td>0.72</td>
<td>-</td>
<td>0.65</td>
<td>0.10</td>
</tr>
<tr>
<td>D</td>
<td>0.40</td>
<td>0.38</td>
<td>0.35</td>
<td>-</td>
<td>0.42</td>
</tr>
<tr>
<td>E</td>
<td>0.65</td>
<td>0.60</td>
<td>0.90</td>
<td>0.58</td>
<td>-</td>
</tr>
</tbody>
</table>

The above table may be interpreted by assuming that the cell entry in the matrix represents the proportion of respondents who believe that ‘the column brand is preferred over the row brand’. For example:

In brand A versus brand B comparison, it can be said that 60 per cent of the respondents prefer brand B to brand A. Similarly, 30 per cent of the respondents prefer brand C to brand A and so on.

To develop the ordinal scale from the given paired comparison data in the above table, we can convert the entries in the table to 0 – 1 scores. This is to show
whether the column brand dominates the row brand and vice versa. If the proportion is greater than 0.5 in the above table, a number of ‘1’ is assigned to that cell, which means that the column brand is preferred over the row brand. Whenever the proportion is less than 0.5 in the above table, a number of ‘0’ is assigned to that cell, which means column brand does not dominate the row brand. The results are in Table 8.3.

### Table 8.3 Conversion of Paired XComparison Data into 0 to 1 Form

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>D</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

To get the ordinal relationship among the brands, we total the columns. Here the ordinal scale of brands is D > B > A > C > E. This means brand D is the most preferred brand, followed by B, A, C and E.

In order to obtain the interval scale data from the paired comparison data as presented above, the entries in the table can be analysed by using a technique called **Thurston's law of comparative judgement**, which converts the ordinal judgements into the interval data. Here the proportions are assumed as probabilities and using the assumption of normality, Z-scores can be computed. Z-value has symmetric distribution with a mean of ‘0’ and variance of ‘1’. If the proportion is less than 0.5, the corresponding Z-value has a negative sign and for the proportion that is greater than 0.5, the Z-score takes a positive value. The Z-scores for the paired comparison data is given in Table 8.3.

Thurston scale comprises statements about a specific issue and each statement has a numerical value indicating the respondent’s attitude about the issue, either favourable or unfavourable. People indicate which of the statements with which they agree and the average response is computed.

### Table 8.3 Z-scores for Paired Comparison Data

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>0.255</td>
<td>-0.525</td>
<td>0.255</td>
<td>-0.38</td>
</tr>
<tr>
<td>B</td>
<td>-0.255</td>
<td>0</td>
<td>-0.58</td>
<td>0.525</td>
<td>-0.255</td>
</tr>
<tr>
<td>C</td>
<td>0.525</td>
<td>0.58</td>
<td>0</td>
<td>0.385</td>
<td>-1.28</td>
</tr>
<tr>
<td>D</td>
<td>-0.255</td>
<td>-0.525</td>
<td>-0.385</td>
<td>0</td>
<td>-0.2</td>
</tr>
<tr>
<td>E</td>
<td>0.38</td>
<td>0.255</td>
<td>1.28</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>Total Distance</td>
<td>0.395</td>
<td>0.565</td>
<td>-0.21</td>
<td>1.365</td>
<td>-2.115</td>
</tr>
<tr>
<td>Average Distance</td>
<td>0.079</td>
<td>0.113</td>
<td>-0.042</td>
<td>0.273</td>
<td>-0.423</td>
</tr>
<tr>
<td>Brand Distance</td>
<td>D</td>
<td>B</td>
<td>A</td>
<td>C</td>
<td>E</td>
</tr>
<tr>
<td>Interval scale value with change of origin</td>
<td>0.696</td>
<td>0.536</td>
<td>0.502</td>
<td>0.381</td>
<td>0</td>
</tr>
</tbody>
</table>
The entries in Table 8.3 show the distance between two brands. Assuming that the scores can be added, the total distance is computed. The average distance is computed by dividing the total score by the number of brands. This way one obtains the absolute position of each brand. Now the highest negative values among all the column is added to each entry corresponding to the average value so that by change of origin, interval scale values can be obtained. This is shown in the last row and the values are of interval scale, indicating the difference between brands. Brand D is the most preferred brand and E is the least preferred brand and the distance between the two is 0.696. The distance between brand C and E equals 0.381.

(b) Rank Order Scaling: In the rank order scaling, respondents are presented with several objects simultaneously and asked to order or rank them according to some criterion. Consider, for example the following question:

- Rank the following soft drinks in order of your preference, the most preferred soft drink should be ranked one, the second most preferred should be ranked two and so on.

<table>
<thead>
<tr>
<th>Soft Drinks</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coke</td>
<td></td>
</tr>
<tr>
<td>Pepsi</td>
<td></td>
</tr>
<tr>
<td>Limca</td>
<td></td>
</tr>
<tr>
<td>Sprite</td>
<td></td>
</tr>
<tr>
<td>Mirinda</td>
<td></td>
</tr>
<tr>
<td>Seven Up</td>
<td></td>
</tr>
<tr>
<td>Fanta</td>
<td></td>
</tr>
</tbody>
</table>

Like paired comparison, this approach is also comparative in nature. The problem with this scale is that if a respondent does not like any of the above-mentioned soft drink and is forced to rank them in the order of his choice, then, the soft drink which is ranked one should be treated as the least disliked soft drink and similarly, the other rankings can be interpreted. This scale is very commonly used to measure preferences for brands as well as attributes. The rank order scaling results in the ordinal data.

(c) Constant Sum Rating Scaling: In constant sum rating scale, the respondents are asked to allocate a total of 100 points between various objects and brands. The respondent distributes the points to the various objects in the order of his preference. Consider the following example:

- Allocate a total of 100 points among the various school into which you would like to admit your child. The more the points you allocate to a school, more preferred it is considered to be. The points should be allocated in such a way that the sum total of the points allocated to various schools adds up to 100.
Suppose Mother’s International is awarded 30 points, whereas Laxman Public School is awarded 15 points, one can make a statement that the respondent rates Mother’s International twice as high as Laxman Public School. This type of data is not only comparative in nature but could also result in ratio scale measurement. This type of scale is widely used in allocating points which the individual may assign to the various attributes of an object.

(d) Q-sort Technique: The Q-sort technique was developed to discriminate among a large number of objects quickly. This technique makes use of the rank order procedure in which objects are sorted into different piles based on their similarity with respect to certain criterion. Suppose there are 100 statements and an individual is asked to pile them into five groups, in such a way, that the strongly agreed statements could be put in one pile, agreed statements could be put in another pile, neutral statements form the third pile, disagreed statements come in the fourth pile and strongly disagreed statements form the fifth pile, and so on. The data generated in this way would be ordinal in nature. The distribution of the number of statements in each pile should be such that the resulting data may follow a normal distribution. The number of piles need not be restricted to 5. It could be as large as 10 or more as the large number increases the reliability or precision of the results.

2. Non-Comparative Scales

In the non-comparative scales, the respondents do not make use of any frame of reference before answering the questions. The resulting data is generally assumed to be interval or ratio scale. For example:

The respondent may be asked to evaluate the quality of food in a restaurant on a five point scale (1 = very poor, 2 = poor and 5 = very good). The non-comparative scales are divided into two categories, namely, the graphic rating scales and the itemized rating scales. The itemized rating scales are further divided into Likert scale, Semantic Differential scale and Stapel scale. All these come under the category of the multiple item scales.
(a) Graphic Rating Scale

This is a continuous scale, also called graphic rating scale. In the graphic rating scale respondents is asked to tick their preference on a graph. Consider for example the following question:

- Please put a tick mark (✓) on the following line to indicate your preference for fast food.

<table>
<thead>
<tr>
<th>Least Preferred</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Most Preferred</th>
</tr>
</thead>
</table>

To measure the preference of an individual towards fast food one has to measure the distance from the extreme left to the position where a tick mark has been put. Higher the distance, higher would be the individual preference for fast food. This scale suffers from two limitations—one, if a respondent has put a tick mark at a particular position and after ten minutes, he or she is given another form to put a tick mark, it will virtually be impossible to put a tick at the same position as was done earlier. Does it mean that the respondent’s preference for fast food has undergone a change in 10 minutes? The basic assumption in this scale is that the respondents can distinguish the fine shade in differences between the preference/attitude which need not be the case. Further, the coding, editing and tabulation of data generated through such a procedure is a very tedious task and researchers would try to avoid using it. Another version of graphic scale could be the following:

- Please put a tick mark (✓) on the following line to indicate your preference for fast food.

<table>
<thead>
<tr>
<th>Least Preferred</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Most Preferred</th>
</tr>
</thead>
</table>

This is a slightly better version than the one discussed earlier. It will overcome the limitation of the scale to some extent. For example, if a respondent had earlier ticked between 5 and 6, it is likely that he would remember the same and the second time, he would tick very close to where he did earlier. This means that the difference in the two responses could be negligible.

Another way of presenting the graphic rating scale is through smiling face scale. The following example would illustrate the same.

- Please indicate how much do you like fast food by pointing to the face that best shows your attitude and taste. If you do not prefer it at all, you would point to face one. In case you prefer it the most, you would point to face seven.
(b) Itemized Rating Scale

In the itemized rating scale, the respondents are provided with a scale that has a number of brief descriptions associated with each of the response categories. The response categories are ordered in terms of the scale position and the respondents are supposed to select the specified category that describes the best possible way an object is rated. Itemized rating scales are widely used in survey research. There are certain issues that should be kept in mind while designing the itemized rating scale. These issues are:

- **Number of categories to be used:** There is no hard and fast rule as to how many categories should be used in an itemized rating scale. However, it is a practice to use five or six categories. Some researchers are of the opinion that more than five categories should be used in situations where small changes in attitudes are to be measured. There are others that argue that the respondents would find it difficult to distinguish between more than five categories. It is, however, a fact that the additional categories need not increase the precision with the attitude being measured. It is generally seen that researchers use five-category scales and in special cases, may increase or decrease the number of categories.

- **Odd or even number of categories:** It has been a matter of debate among the researchers as to whether odd or even number of categories are to be used in survey research. By using even number of categories, the scale would not have a neutral category and the respondent will be forced to choose either the positive or the negative side of the attitude. If odd numbers of categories are used, the respondent has the freedom to be neutral if he wants to be so. The Likert scale (to be discussed later) is a balanced rating scale with an odd number of categories and a neutral point. It is generally seen that if respondents are not aware of the subject matter being measured by the scale, they would prefer to be neutral. However, if we have selected our unit of analysis to be one who are knowledgeable about the study being conducted and if they prefer to be neutral, we should not debar them from this opportunity.

- **Balanced versus unbalanced scales:** A balanced scale is the one which has equal number of favourable and unfavourable categories. Examples of balanced and unbalanced scale are given below.

The following is the example of a balanced scale:

(i) How important is price to you in buying a new car?

- Very important
- Relatively important
- Neither important nor unimportant
- Relatively unimportant
- Very unimportant
In this question, there are five response categories, two of which emphasize the importance of price and two others that do not show its importance. The middle category is neutral.

The following is the example of the unbalanced scale.

(ii) How important is price to you in buying a new car?
   - More important than any other factor
   - Extremely important
   - Important
   - Somewhat important
   - Unimportant

In this question, there are four response categories that are skewed towards the importance given to the price, whereas one category is for the unimportant side. Therefore, this question is an unbalanced question. In the unbalanced scale, the numbers of favourable and unfavourable categories are not the same. One could use an unbalanced scale depending upon the nature of attitude distribution to be measured. If the distribution is dominantly favourable, an unbalanced scale with more favourable categories than unfavourable categories should be appropriate. If an unbalanced scale is used, the nature and degree of the unbalance in the scale should be taken into account during the data analysis.

- **Nature and degree of verbal description**: Many researchers believe that each category must have a verbal, numerical or pictorial description. Verbal description should be clearly and precisely worded so that the respondents are able to differentiate between them. Further, the researcher must decide whether to label every scale category, some scale categories, or only extreme scale categories. It is argued that a clearly defined response category increases the reliability of the measurement.

- **Forced versus non-forced scales**: An important issue concerning the construction of an itemized rating scale is the use of a forced scale versus non-forced scale. In the forced scale, the respondent is forced to take a stand, whereas in the non-forced scale, the respondent can be neutral if he/she so desires. The argument for a forced scale is that those who are reluctant to reveal their attitude are encouraged to do so with the forced scale. Paired comparison scale, rank order scale and constant sum rating scales are examples of forced scales.

- **Physical form**: There are many options that are available for the presentation of the scales. It could be presented vertically or horizontally. The categories could be expressed in boxes, discrete lines or as units on a continuum. They may or may not have numbers assigned to them. The numerical values, if used, may be positive, negative or both.
Suppose we want to measure the perception about Jet Airways using a multi-item scale. One of the questions is about the behaviour of the crew members. Given below is a set of scale configurations that may be used to measure their behaviour. The following are some of the examples where various forms of presenting the scales are shown:

### The behaviour of the crew members of Jet Airways is:

1. **Very bad** ______ ______ ______ ______ ______ **Very good**
2. **Very bad** ______ ______ ______ ______ ______ **Very good**
3. **Very bad**
   - Neither bad nor good
   - **Very good**
4. **Very bad**______ **Bad** ______ **Neither bad nor good** ______ **Good** ______ **Very good**
5. **Very bad** ______ ______ **Neither bad nor good** ______ ______ ______ **Very good**

Below we will describe some of the itemized rating scales which are very commonly used in survey research.

### Likert Scale

This is a multiple item agree–disagree five-point scale. The respondents are given a certain number of items (statements) on which they are asked to express their degree of agreement/disagreement. The likert scale will be discussed in detail later in this unit.

### 8.3.3 Semantic Differential Scale

This scale is widely used to compare the images of competing brands, companies or services. Here the respondent is required to rate each attitude or object on a number of five-or seven-point rating scales. This scale is bounded at each end by bipolar adjectives or phrases. The difference between Likert and Semantic differential scale is that in Likert scale, a number of statements (items) are presented to the respondents to express their degree of agreement/disagreement. However, in the semantic differential scale, bipolar adjectives or phrases are used. As in the case of Likert scale, the information on the phrases and adjectives is obtained through exploratory research. At times there may be a favourable or unfavourable descriptor (adjectives) on the right-hand side and on certain occasions these may be presented on the left-hand side. This rotation becomes necessary to avoid the halo effect. This is because the location of previous judgments on the scale may influence the subsequent judgements because of the carelessness of the respondents.
The mid-point of a bipolar scale is a neutral point. In the Likert scale, ten statements were used where respondents were asked to express their degree of agreement/disagreement regarding the image of the company. Taking the same example further, the semantic differential scale corresponding to those ten statements in Likert scale is shown below where the bipolar adjectives/phrases are separated by seven points. These points can be numbered as 1, 2, 3, ..., 7 or +3, +2, +1, 0, −1, ..., −3 for a favourable descriptor positioned on the left hand side. For an unfavourable descriptor the numberings would be reversed. A typical semantic differential scale where bipolar adjectives/phrases are positioned at the two extreme ends is given in Table 8.4.

<table>
<thead>
<tr>
<th>Table 8.4 Select Bipolar Adjectives/Phrases of Semantic Differential Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Makes quality products</td>
</tr>
<tr>
<td>2. Leader in technology</td>
</tr>
<tr>
<td>3. Does not care about general public</td>
</tr>
<tr>
<td>4. Leads in R &amp; D</td>
</tr>
<tr>
<td>5. Not a good paymaster</td>
</tr>
<tr>
<td>6. Products go through stringent quality test</td>
</tr>
<tr>
<td>7. Does nothing to curb pollution</td>
</tr>
<tr>
<td>8. Does not care about community near plants</td>
</tr>
<tr>
<td>9. Company stocks good to buy</td>
</tr>
<tr>
<td>10. Does not have good labour relations</td>
</tr>
</tbody>
</table>

Once the scale is constructed and administered to the representative respondents, the mean score for each of the descriptor is calculated. The scale is administered under the assumption that the numerical values assigned to the response categories are of interval scale in nature. This is generally the practice adopted by many researchers. However, if the response categories are treated as ordinal scale, instead of computing the arithmetic mean, median may be computed. In this example, we are treating the responses as the interval scale and hence the mean is computed. Once the mean for all the bipolar adjectives/phrases is computed we put the result in the form of a pictorial profile so as to make the comparison easy. At this time, all the favourable descriptors are kept on one side and all the unfavourable descriptors are positioned at the other. In our example, we have positioned all the favourable descriptors for the two companies whose image we want to compare on the left hand side. This is shown in Table 8.5.
### Table 8.5 Pictorial Profile Based on Semantic Differential Ratings

<table>
<thead>
<tr>
<th></th>
<th>Company A</th>
<th>Company B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Makes quality products</td>
<td>Does not make quality products</td>
</tr>
<tr>
<td>2</td>
<td>Leader in technology</td>
<td>Backward in technology</td>
</tr>
<tr>
<td>3</td>
<td>Cares about general public</td>
<td>Does not care about general public</td>
</tr>
<tr>
<td>4</td>
<td>Leads in R &amp; D</td>
<td>Lagging behind in R&amp;D</td>
</tr>
<tr>
<td>5</td>
<td>A good paymaster</td>
<td>Not a good paymaster</td>
</tr>
<tr>
<td>6</td>
<td>Products go through stringent quality test</td>
<td>Products do not go through quality test</td>
</tr>
<tr>
<td>7</td>
<td>Done remarkable job in curbing pollution</td>
<td>Done nothing to curb pollution</td>
</tr>
<tr>
<td>8</td>
<td>Cares about community near plants</td>
<td>Does not care about community near plants</td>
</tr>
<tr>
<td>9</td>
<td>Company stocks good to buy</td>
<td>Not advisable to invest in company stock</td>
</tr>
<tr>
<td>10</td>
<td>Has good labour relations</td>
<td>Does not have good labour relations</td>
</tr>
</tbody>
</table>

#### 8.3.4 Stapel Scale

The Stapel scale is used to measure the direction and intensity of an attitude. At times it may be difficult to use semantic differential scales because of the problem in creating bipolar adjectives. The Stapel scale overcomes this problem by using only single adjectives. This scale generally has 10 categories involving numbering –5 to +5 without a neutral point and is usually presented in a vertical form. The job of the respondent is to indicate how accurately or inaccurately each term describes the object by selecting an appropriate numerical response category. If a positive higher number is selected by the respondent, it means the respondent is able to describe it more favourably. Suppose a restaurant is to be evaluated on quality of food and quality of service, then the Stapel scale would be presented as shown below:

**Restaurant**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>+5</td>
<td>+5</td>
</tr>
<tr>
<td>+4</td>
<td>+4</td>
</tr>
<tr>
<td>+3</td>
<td>+3</td>
</tr>
<tr>
<td>+2*</td>
<td>+2</td>
</tr>
<tr>
<td>+1</td>
<td>+1</td>
</tr>
</tbody>
</table>
In the above scale, the respondents are asked to evaluate how accurately each word or phrase describes the restaurant in question. They will choose a value of +5 if the restaurant very accurately describes the attribute and –5 if it does not describe at all correctly the word in question. Suppose a respondent has chosen his options as indicated by *. This shows that the respondent slightly prefers the quality of food and is of the opinion that the quality of service is totally useless.

8.3.5 Likert Scale

This is also called a summated scale because the scores on individual items can be added together to produce a total score for the respondent. An assumption of the Likert scale is that each of the items (statements) measures some aspect of a single common factor, otherwise the scores on the items cannot legitimately be summed up. In a typical research study, there are generally 25 to 30 items on a Likert scale.

To construct a Likert scale to measure a particular construct, a large number of statements pertaining to the construct are listed. These statements could range from 80 to 120. The identification of the statements is done through exploratory research which is carried out by conducting a focus group, unstructured interviews with knowledgeable people, literature survey, analysis of case studies and so on. Suppose we want to assess the image of a company. As a first step, an exploratory research may be conducted by having an informal interview with the customers, and employees of the company. The general public may also be contacted. A survey of the literature on the subject may also give a set of information that could be useful for constructing the statements. Suppose the number of statements to measure the constructs is 100 in number. Now samples of representative respondents are asked to state their degree of agreement/disagreement on those statements. Table 8.6 gives a few statements to assess the image of the company.

It may be noted that only anchor labels and no numerical values are assigned to the response categories. Once the scale is administered, numerical values are assigned to the response categories. The scale contains statements’ some of which are favourable to the construct we are trying to measure and some are unfavourable to it.
Table 8.6 Likert Scale Statements to Measure the Image of the Company

<table>
<thead>
<tr>
<th>No.</th>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The company makes quality products</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>It is a leader in technology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>It doesn’t care about the general public</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>The company leads in R&amp;D to improve products</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>The company is not a good paymaster.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>The products of the company go through stringent quality tests.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>The company has not done anything to curb pollution.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>It does not care about the community near its plant.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>The company’s stocks are good to buy or own.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>The company does not have good labour relations.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For example, out of the ten statements given, statements numbering 1, 2, 4, 6 and 9 in Table 8.6 are favourable statements, whereas the remaining are unfavourable statements. The reason for having a mixture of favourable and unfavourable statements in a Likert scale is that the responses by the respondent should not become monotonous while answering the questions. Generally, in a Likert scale, there is an approximately equal number of favourable and unfavourable statements. Once the scale is administered, numerical values are assigned to the responses. The rule is that a ‘strongly agree’ response for a favourable statement should get the same numerical value as the ‘strongly disagree’ response of the unfavourable statement. Suppose for a favourable statement, the numbering is done as Strongly disagree = 1, Disagree = 2, Neither agree nor disagree = 3, Agree = 4 and Strongly agree = 5.

Accordingly, an unfavourable statement would get the numerical values as Strongly disagree = 5, Disagree = 4, Neither agree nor disagree = 3, Agree = 2 and Strong agree = 1. In order to measure the image that the respondent has about the company, the scores are added.
For example, if a respondent has ticked (✓) statements numbering from one to ten as shown in Table 6.7, his total score would be $3 + 5 + 4 + 4 + 5 + 4 + 4 + 5 + 4 + 4 = 42$ out of 50. Now if there are 100 respondents and 100 statements, the score on the image of the company can be worked out for each respondent by adding his/her scores on the 100 statements. The minimum score for each respondent will be 100, whereas the maximum score would be 500.

As mentioned earlier, a typical Likert scale comprises about 25–30 statements. In order to select 25 statements from the 100 statements, we need to discard some of them. The rule behind discarding the statements is that those items that are non-discriminating should be removed. The procedure for choosing 25 (say number of statements) is shown.

As mentioned earlier, the score for each of the respondents on each of the statements can be used to measure his/her total score about the image of the company. The data may look as given in Table 8.7.

Table 8.7 Total Score and Individual Score of Each Respondent on Various Statements

<table>
<thead>
<tr>
<th>Scores of Statements</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>i</th>
<th>j</th>
<th>100</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resp. No.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>410</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>209</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Table 8.7 shows that the total score for respondent no. 1 is 410, whereas for respondent no. 2 it is 209. This means that respondent no. 1 has a more favourable image for the company as compared to respondent no. 2. Now, in order to select 25 statements, let us consider statements numbering i and j. We note that the statement no. j is more discriminating as compared to statement no. i. This is because the score on statement j is very highly correlated with the total score as compared to the scores on statement i. Therefore, if we have to choose between i and j, we will choose statement no. j. From this we can conclude that only those statements will be selected which have a very high correlation with the total score. Therefore, the 100 correlations are to be arranged in the ascending order of magnitudes corresponding to each statement and only top 25 statements having a high correlation with the total score need to be selected.
Another method of selecting the number of statements from a relatively large number of them is through the use of factor analysis.

### 8.3.6 Bogardus Scale

The Bogardus scale is also known as the Bogardus social distance scale. This scale was invented by Emory S. Bogardus in the 1930s and is used for measuring social distance.

The development of the social distance scale took place with regard to the relations between the West Coast Caucasian Americans and the immigrant Japanese in the early twentieth century. Bogardus (1931) explains, ‘While a number of Americans were openly expressing prejudice against the Orientals, there were other Americans who felt that the Japanese were being unjustifiably insulted. [The latter] urged that an investigation of the problem be made, feeling that a scientific inquiry would undermine much of the unfair tactics of those opposed to the Japanese.’ Dr Robert Park was hired by the Institute of Social and Religious Research to supervise this study, who in turn appointed Bogardus for this purpose. He was required to advance a quantitative measure of racial attitudes. To make the research work objective with the use of scientific methodology, they used the term ‘race relations survey’ with special emphasis on the term ‘survey’. Moreover, he had ‘undertaken the tabooed procedure of penetrating hidden subjective fields of experience and their resultant attitudes…and attempted to make those attitudes … measurable.’

The Bogardus scale is a psychological testing scale to measure through experiment or observation people’s willingness to contribute and take part in social meetings of varying degrees of closeness with people from different social backgrounds such as ethnic and racial groups. This technique is mostly applied to the study of social groups, social values and ethnic relations. The Bogardus scale helps in measuring the respondent’s response towards a particular social relationship like aggression, warmth, familiarity and indifference by acquiring views about various religious groups. For instance, would a group of people be accepted as a fellow citizen or a neighbour in another country through marriage? Further, the scales make the supposition that the qualities that are being measured maybe seen as a continuum of social distance. There are other examples of social distance scaling techniques like the socio-metric measurement and occupational prestige scales.

According to Bogardus, social distance is a function of emotional detachment between the members of two groups wherein it is basically a measure of how sympathetic the members of two group are towards each other. The scale also measures the extent to which each member of a group would be accepting the members of other group wherein a score of 1.00 is taken to indicate no social distance.

It was important for Bogardus to distinguish between ‘feeling’ and ‘thinking’ since social distance for him put emphasis on the feeling reactions of one group of people toward some other group of people. Feelings, he explained, are ‘spontaneous
expressions of the autonomic nervous system to whatever is happening in the organism. They are expressions in part of the urge for security. Moreover, feelings had a predictive power according to Bogardus since feelings suggest and guide the attitude of a person and it sheds more light on attitudes than anything else except the actual behaviour of the person. The test of the working of the scale was to capture the respondent’s ‘first feeling reaction’. This meant that Bogardus wanted people to complete this scale without the inclusion of thoughts or ‘without thinking’. ‘Feeling reactions’, he wrote, ‘indicate how a person would express himself toward his fellows if he acted “without thinking”, “just the way he feels”, and without regard to politeness, social amenities, or his own status’. (Bogardus, 1947).

The Bogardus social distance scale, hence, validates the point that scales can be used as an important data reduction tool.

Check Your Progress
3. Who invented the Bogardus scale?
4. What is the usage of code books?

8.4 INTERVIEW GUIDE, CODE BOOK, PILOT STUDY AND PRE TEST

Interview guide

An interview guide is a mechanism to help the interviewer conduct an effective semi-structured interview. It also usually means deciding on the spot how to word a question in the specific context of a particular interview, rather than reading from a script. It has been discussed in detail in Unit 9.

Code book

Code books are used by survey researchers to serve two main purposes: to provide a guide for coding responses and to serve as documentation of the layout and code definitions of a data file. Data files usually contain one line for each observation, such as a record or person (also called a “respondent”).

Pilot study and pre test

A pilot survey is a strategy used to test the questionnaire using a smaller sample compared to the planned sample size. In this phase of conducting a survey, the questionnaire is administered to a percentage of the total sample population, or in more informal cases just to a convenience sample. Conducting a pilot survey prior to the actual, large-scale survey presents many benefits and advantages for the researcher. One of these is the exploration of the particular issues that may potentially have an antagonistic impact on the survey results. These issues include the appropriateness of questions to the target population.
8.5 SOURCES OF DATA: PRIMARY AND SECONDARY

Finding the answers of questions for research study is called data collection. Data are facts, and other relevant materials, past and present service as bases for study and analysis. For the study of social science research, the data requirement can be classified as:

(a) Data relating to human beings,
(b) Data relating to organizations
(c) Data relating to territorial or geographical areas.

Personal data related to human beings consists of:

- **Demographic and socio-economic characteristics of individuals**: Family size, age, gender, social class, lifestyle, education, marital status, occupation, religion, income, race, location of the household etc.
- **Behavioral variables**: Intentions, opinions, knowledge, awareness, attitudes, practice, etc.
- **Organizational data consists of data relating to an ownership, organizational beginning, objectives, functions, resources, performance and growth.**
- **Territorial data are related to geo-physical characteristics, resource endowment, population pattern infrastructure, degree of development of special divisions like villages, tallukas, districts, cities, states and the nation.**

The data acts as basic raw materials for analysis. No study can be completed without proper analysis of available data. No results can be drawn on research questions. Correct answers are not presented through inferences based on imagination. The quality of findings in research study depends on adequacy, relevancy and reliability of data used in research study. In hypothesis formulation, data acts as a basic important tool. The facts and figures required for constructing measurement scales and tables are received from data, which are analysed with statistical techniques for conclusions. Inferences on the results of statistical analysis and tests of significance provide the answers to research questions. Therefore, the scientific process of measurements, analysis, testing and inferences depends on the relevant and accurate data availability.

The classification of data sources can be done as (a) primary sources and (b) secondary sources.

8.5.1 Primary Data

The data which is collected by researcher himself directly from original sources, is called primary data the original source is called primary source for data collection. e.g. data collected by researcher to understand the impact of children on buying
habits of parents in terms of mutual relationship of parents and children, age factor, education level, brand loyalty, brand awareness, etc. Primary data is collected through various methods such as observation, interviewing, mailing etc.

Advantages of primary data

The advantages of primary data are as follows:
- It is an original source of data, so the collected data can be used for several purposes in research study.
- It is possible to capture the changes occurring in the course of time. As time progresses, many facts get changed. In this context, secondary data may not be very useful and the researcher needs primary data which is relevant as well as accurate.
- It is flexible to the advantage of researcher the same data can be utilized by researcher for multiple dimensions scientifically.
- Extensive research study is based on primary data.

Disadvantages of primary data

The disadvantages of primary data are as follows:
- Primary data is expensive to obtain. A very high cost is involved in collecting data from primary sources. Use of manpower, survey tools etc. involve high cost.
- It is time consuming. A lot of time is required in collecting data from various primary sources.
- It requires extensive research personnel who are skilled. Availability of skilled people for research work is also a big challenge in research study at any place.
- It is difficult to administer.

Sources of primary data

Researcher uses original sources to collect primary data. In this regard, the researcher collects the data according to the needs of research. He collects the data according to the suitability of data, timeliness of data and need of data. It is true that primary data collection is a costly affair as well as time consuming. For many types of social science research, secondary data are not available. Therefore it becomes difficult to conduct the research further more.

In a situation where the available data is not pertinent to research study or available data are inappropriate, obsolete primary data have to be collected. Various methods can be used to collect the data for research study. A 'method' is different from a ‘tool’. The mode or way of gathering the data is known as method and a tool is an instruments used for the method. For example, a schedule is used for interviewing. The important sources are:
8.5.2 Secondary Data

The data which have been collected and compiled for some other purposes by someone else and is used by researcher for the interest of his research study is known as secondary data and source of information is called secondary source. The secondary sources contain previously analysed and compiled information and reports whose data can be utilized by researchers for their research work. Published records and reports are not the only secondary source of data collection, even unpublished records like accounting and financial records, personnel records, register of members, minutes of meeting, inventory records etc. can be also used as a secondary source.

Features of secondary sources

The contents of secondary sources are detailed and diversified, yet certain common characteristics are:

- First, secondary data is easily available to all researchers and do not consist the hassles of developing tools and using them.
- Second, the data contained in a secondary source is free from researcher's control in collection and classification of data. The content as well as form of secondary sources are not developed by researcher, in fact they are shaped by others. Thus the value of research conducted with the help of secondary data can be useless if it has not been tested correctly.
- Finally, researcher has to estimate the time, place and conditions of secondary sources and secondary data, which is not so easy. Practically, researcher is not required to be present at the time of collecting data from original source.

Uses of secondary data

There are three ways to use secondary data by researchers.

- First, secondary sources provide needed information to researcher for reference purposes. For example, the general statistical information in the number of co-operative credit societies in the country, their coverage of villages, their capital structure, volume of business etc., may be taken from...
published reports and quoted as background information in a study on the evaluation of performance of cooperative credit societies in a selected district/state.

- Second, secondary data is used as benchmark to test the findings of research for making comparative analysis, e.g., the findings of a local or regional survey may be compared with the national averages; the performance indicators of a particular bank may be tested against the corresponding indicators of the banking industry as a whole and so on.

- Finally, secondary data is used as the entire source of information for a research work.

- Such as market trend analysis, financial analysis of companies etc. Yearbooks, statistical report of government departments, reports of public organizations of bureau of public enterprises, censes reports etc. serve as major data sources for such research studies.

**Advantages of secondary data**

Secondary sources have some advantages:

1. Secondary data is easily accessible and does not cost much to researcher depending on its availability. Once their source of documents and reports are located, collection of data is just matter of desk work. Even the tediousness of copying the data from the source can now be avoided, thanks to photocopying facilities.

2. Wider and scattered geographical area and long historical period can be analysed by researcher with less cost, which is an added advantage of using secondary data. Therefore, secondary data's usage provides new horizons to the researcher's limits.

3. The secondary data's use ensures the availability of data for making scientific generalizations from the studies.

4. Environmental and cultural settings are required for the study.

5. The secondary data helps a researcher to test the findings obtained through primary data. It provides additional data for analysis of primary data. Thus researcher needs not to wait for the time to collect primary data for analysis.

**Disadvantages of secondary data**

Secondary data has its own limitations.

1. The secondary data availability cannot be as per the research study needs and it may be possible that available secondary data is not significant. Significance may vary as time progresses ahead. It may be possible that available data is not relevant to current conditions.

2. To assess the accuracy of secondary data we need to know the procedure how the data were collected.
3. Even up-to-date secondary data becomes obsolete when it is presented in printed form, because of time lag in producing the secondary data. For example population census data are published two or three years later after compilation, and no new figures will be available for another ten years.

4. Finally, information about the sources of secondary data may not be available to all researchers. Even if the location of the source is known, the accessibility depends primarily on proximity. For example, most of the unpublished official records and compilation are located in the capital city, and they are not within easy reach of researchers based in far-off places.

Sources of secondary data

Following are the important sources of secondary data:

- Textbooks
- Specialist books
- Journal papers
- Conference papers
- Magazine articles
- Government & industry reports
- Web pages
- Acts of Parliament
- Company reports

Evaluation of secondary data

When a researcher wants to use secondary data for his research, he should evaluate them before deciding to use them.

1. Data pertinence

The first consideration in evaluation is to examine the pertinence of the available secondary data to the research problem under study. The following questions should be considered.

- What are the definition and classifications? Are they consistent?
- What are the measurements of variables used? What is the degree to which they conform to the requirements of our research?
- What is the coverage of the secondary data in terms of topic and time? Does this coverage fit the needs of our research?

On the basis of above consideration, the pertinence of the secondary data to the research on hand should be determined, as a researcher who is imaginative and flexible may be able to redefine his research problem so as to make use of otherwise unusual available data.
2. **Data quality**

If the researcher is convinced about the available secondary data for his needs, the next step is to examine the quality of the data. The quality of data refers to their accuracy, reliability and completeness. The assurance and reliability of the available secondary data depends on the organization which collected them and the purpose for which they were collected. What is the authority and prestige of the organizational? Is it well recognized? Is it noted for reliability? It is capable of collecting reliable data? Does it use trained and well qualified investigators? The answers to these questions determine the degree of confidence we can have in the data and their accuracy. It is important to go to the original source of the secondary data rather than to use an immediate source which has quoted from the original. Then only, the researcher can review the cautionary ands other comments that were made in the original source.

3. **Data completeness**

The completeness refers to the actual coverage of the published data. This depends on the methodology and sampling design adopted by the original organization. Is the methodology sound? Is the sample size small or large? Is the sample method appropriate? Answers to these questions may indicate the appropriateness and adequacy of the data for the problem under study. The question of possible bias should also be examined. Whether the purpose for which the original organization collected the data had a particular orientation? Has the study been made to promote the organization’s own interest? How the study was conducted? These are important clues. The researcher must be on guard when the source does not report the methodology and sampling design. Then it is not possible to determine the adequacy of the secondary data for the researcher’s study.

---

**Check Your Progress**

5. State the advantages of using primary data.
6. What are the sources of secondary data?

---

**8.6 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS**

1. The different tools used for data collection are the following:
   - Questionnaires
   - Interviews
   - Observation Techniques
2. The characteristics of the observation method are the following:
   - It is a direct technique to study an object, an event or a problem.
   - It is systematically recorded and related.
   - It is based mainly on visual - audio scene.
3. The Bogardus scale was invented by Emory S. Bogordas in the 1930s and is used for measuring social distance.
4. Code books are used by survey researchers to serve two main purposes: to provide a guide for coding responses and to serve as documentation of the layout and code definitions of a data file.
5. The advantages of using primary data are the following:
   - It is an original source of data, so the collected data can be used for several purposes in research study.
   - It is possible to capture the changes occurring in the course of time. As time progresses, many facts get changed. In this context, secondary data may not be very useful and the researcher needs primary data which is relevant as well as accurate.
   - It is flexible to the advantage of researcher the same data can be utilized by researcher for multiple dimensions scientifically.
6. The sources of secondary data are the following:
   - Textbooks
   - Specialist books
   - Journal papers
   - Conference papers
   - Magazine articles
   - Government & industry reports
   - Web pages
   - Acts of Parliament
   - Company reports

8.7 SUMMARY

- Collecting relevant and appropriate data is the backbone of any research. It is very important in a research process that researchers choose the most appropriate instrument and procedures of research tools that lead to the collection and analysis of data upon which hypotheses may be tested.
- The questionnaire which is easy to prepare and administer is one of the most used form of data collection.
Unlike questionnaire and interview, where recording of information is the major focus, observation leads to a more natural and real data collection. Artificiarity and formality of questionnaires and interview is replaced by reality and informality in observation.

In any research a system of measurement is very important and highly desirable. According to S.S. Stevens, ‘measurement is the assignment of numerals to objects or events according to rules.’

For a researcher, validity is first and the foremost means of measurement for getting valid outcomes. Validity is the core of any kind of a trustworthy and accurate research assessment.

In comparative scales it is assumed that respondents make use of a standard frame of reference before answering the question.

Comparative scale data is interpreted generally in a relative kind. The comparative scale includes paired comparison, rank order, constant sum scale and Q-sort technique to mention a few.

The Q-sort technique was developed to discriminate among a large number of objects quickly. This technique makes use of the rank order procedure in which objects are sorted into different piles based on their similarity with respect to certain criterion.

In the non-comparative scales, the respondents do not make use of any frame of reference before answering the questions. The resulting data is generally assumed to be interval or ratio scale.

The Stapel scale is used to measure the direction and intensity of an attitude. At times it, may be difficult to use semantic differential scales because of the problem in creating bipolar adjectives.

The Bogardus scale is also known as the Bogardus social distance scale. This scale was invented by Emory S. Bogardus in the 1930s and is used for measuring social distance.

A pilot survey is a strategy used to test the questionnaire using a smaller sample compared to the planned sample size.

The completeness refers to the actual coverage of the published data. This depends on the methodology and sampling design adopted by the original organization.

8.8 KEY WORDS

- **Construct validity**: It refers to how well a researcher translated or transformed a concept, idea, or behaviour into a functioning and operating reality.
• **Q-sort Technique**: It was to discriminate among a large number of objects quickly. This technique makes use of the rank order procedure in which objects are sorted into different piles based on their similarity with respect to certain criterion.

• **Graphic rating scale**: In this scale, the respondents are asked to tick their preference on a graph.

### 8.9 SELF ASSESSMENT QUESTIONS AND EXERCISES

**Short Answer Questions**

1. What is the main use of a research tool?
2. Write short notes on the following:
   - (a) Paired comparison sales
   - (b) Non-Comparative scales
3. Mention the important sources of primary data.
4. What is the procedure for evaluating secondary data?

**Long Answer Questions**

1. Discuss the types and uses of scales as developed by WHO/ILO.
2. ‘In any research a system of measurement is very important and highly desirable.’ Justify the statement.
3. Illustrate the use of Likert scale with the help of an example.
4. Examine the advantages and disadvantages of secondary data.

### 8.10 FURTHER READINGS


Footnotes

UNIT 9  QUANTITATIVE METHODS

9.0 INTRODUCTION

Quantitative methods lay focus on objective measurements and the statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulating pre-existing statistical data using computational techniques. This unit deals with the meaning and types of interviews, meaning and types of questionnaires, participatory and rapid appraisal techniques, observation and types of document review, mixed and multi-method and triangulation.

9.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss the meaning and types of interview
- Explain the types of questionnaire
- Prepare an overview of participatory and rapid appraisal techniques
- Compare and contrast human observation and mechanical observation
- List the types of triangulation
9.2 INTERVIEW: MEANING AND TYPES

Another method of direct access to the respondents’ school of thought is the personal interview method. Personal interview is a one-to-one interaction between the investigator/interviewer and the interviewee. The purpose of the dialogue is research specific and ranges from completely unstructured to highly structured. The definition of the structure depends upon the information needs of the research study. The interview has varied applications in business research and can be used effectively in various stages.

- **Problem definition:** The interview method can be used right in the beginning of the study. Here, the researcher uses the method to get a better clarity about the topic under study. The interview can be carried out with the experts or with the members of the respondent population to get an indication about the variables to be studied in the actual research study. For example, in a study on devising a postgraduate management programme like what should be the research undertaken and what needs should it address; the investigator might carry out informal interviews with some academic experts as well as the student decision maker, to get a perspective on the information that needs to be collected. Thus, on the basis of the interviews, the following objectives would be formulated:
  - Identify the postgraduate options available to the students, both national and international.
  - Identify the selection process followed by benchmarked institutes.
  - Identify the process used by a typical undergraduate student in preparing a list of the institutes to apply in.
  - Based on the above objectives, identify the business model that a postgraduate institute needs to adapt to successfully reach out to the potential student group.

- **Exploratory research:** Once the steps or research objectives have been established, the researcher might need to do another round of semi-structured interviews to get a perspective on the variables to be studied, the definitions of these variables and any other information of relevance to the study topic. This helps in formulating the questions of the final measuring instrument of the study. For example, to achieve objective three in the above research study, it is imperative to find out the parameters considered by the students in selecting a professional management course. Thus, informal interviews would be held with a few undergraduate students to find out what measures they use to arrive at a decision. At the same time, interviews would also be held with the deans of a few selected universities to find out the same.

- **Primary data collection:** There are situations when the method is used as a primary method of data collection, this is generally the case when the
area to be investigated is high on subjectivity or individual sentiments and a structured method would not elicit any meaningful information. For example, if the study is about confidential, sensitive or embarrassing topics (impact of obesity on personal relations, the extent of unscrupulous dealings required for taking critical business decisions, etc.), and situations where conformity to social norms exists and the respondent is wary of deviant behaviour, may be easily swayed by group response (e.g., attitude towards cosmetic surgery), affective or compulsive consumption and situations where apparent explanations are not clear to the respondent also (superior–subordinate relations).

- **The interview process:** The steps undertaken for the conduction of a personal interview are somewhat similar in nature to a focus group discussion.
  - **Interview objective:** The information needs that are to be addressed by the instrument should be clearly spelt out as study objectives. This step includes a clear definition of the construct/variable(s) to be studied.
  - **Interview guidelines:** A typical interview may take from 20 minutes to close to an hour. A brief outline to be used by the investigator is formulated depending upon the contours of the interview.

- **Unstructured:** Absolutely no defined guidelines. Usually begins with a casually worded opening remark like “so tell us/me something about yourself”. The cues are usually taken from what the subject says. The direction the interview will take is not known to the researcher also. The probability of subjectivity is very high and generalization from such an investigation is extremely difficult.

- **Semi-structured:** This has a more defined format and usually only the broad areas to be investigated are formulated. The questions, sequence and language are left to the investigator’s choice. Probing is of critical importance in obtaining meaningful responses and uncovering hidden issues. After asking the initial question, the interviewer uses an unstructured format. The subsequent direction of the interview is determined by the respondent’s initial reply, the interviewer’s probes for elaboration and the respondent’s answers.

- **Structured:** This format has highest reliability and validity. There is considerable structure to the questions and the questioning is also done on the basis of a prescribed sequence. They are sometimes used as the primary data collection instrument also.

  - **Interviewing skills:** The quality of the output and the depth of information collected depend upon the probing and listening skills of the interviewer. Thus, he needs to be a sympathetic listener and alert to cues from the respondent’s answers, which might require further probing/clarification. He needs to be well-acquainted with the study...
objectives and aware about the deliverables of the study. His attitude needs to be as objective as possible and not in any way be directional or distorting the results or responses of the subject.

2. Analysis and Interpretation: The information collected is not subjected to any statistical analysis. Mostly the data is in narrative form, in the case of structured interviews it might be categorized after the conduction and be reported as ‘most students seem to be using placements and infrastructure as the primary reason…’ Sometimes the output of the interviews is subjected to a content analysis to achieve a better structure for the results obtained.

Given below is an interview guide created for a beverage purchase and consumption study.

**Interview guide: beverage purchase and consumption**

**Introduction and Warm Up**

Hi, I am conducting a short survey on soft drink consumption. Thus, I would just take some insights from you on your purchase. There are no right or wrong answers, however, since you consume soft drinks, your opinion is really important for understanding the purchase behaviour.

1. Tell me something about yourselves… what do you do—as in occupation…your hobbies…your interests? How would you describe yourself as a person? Do you generally plan and buy…

2. **PROBE FURTHER – PSYCHOGRAPHICS/LIFESTYLE**

3. **PURCHASE BEHAVIOUR:**

4. This soft drink that you have purchased…how do you generally consume it….Chilled/cool, can/bottle, stand alone or mixed with something.

5. If I were to ask you to list occasions for soft drinks’ purchase, they would be:

   __________________________________________

   __________________________________________

   __________________________________________

   __________________________________________

6. So when you are making this purchase, what triggers it:
   - brand
   - price
   - deals
   - taste
   - packaging
   - any other

   **PROBE ALL ATTRIBUTES FOR REASONS. For example, what kind of deals? Packaging? brand image?**

7. Supposing your favourite brand is not available for purchase….what do you do……(PROBE)……do you move on to another store or pick up another brand……(PROBE)……reason(s)
Supposing a company changes its packaging so that it is really eye catching, what is your reaction to it…….(PROBE)……reason(s)

EXPOSE PICTURE

I am going to show you some display pictures. Please tell me which one do you think looks attractive….. (let the respondent select)…….(PROBE reasons for liking)……would this move customers to go and look around and purchase…….(reason)…….would it influence you to buy…..(reasons)

EXPOSE PICTURE

I am going to show you a picture of a store. Where would you generally expect the soft drinks to be placed…….in your opinion, is this the right place or can it be put somewhere else…..REASON

Buy one get one free, a freebie, coupons, prizes. Do you get moved to try out and buy some of these?…….which ones did you try……REACTION

Soft drinks companies come up with a lot of ads….. can you tell me something about some ads? What do you recall…….(note-degrees of recall and if brand recalled was the right match)…….did it influence your purchase of the drink? PROBE

Thank you.

Categorization of Interviews

There are various kinds of interview methods available to the researcher. We have spoken earlier about a distinction based on the level of structure. The other classification is based on the mode of administering the interview. A classification table is presented in Figure 9.1.

- **Personal methods**: These are the traditional one-to-one methods that have been used actively in all branches of social sciences. However, they are distinguished in terms of the place of conduction. These may be categorized as at-home, mall-intercept, or computer-assisted interviews.
  - **At-home interviews**: This face-to-face interaction takes place at the respondent’s residence. Thus, the interviewer needs to initially contact the respondent to ascertain the interview time. The interviewer asks
the respondent study-related questions and records the responses. The cost and time involved in conducting these interviews is considerable, which is the reason why they are avoided. However, they are used for syndicate research studies like pantry audits. The advantage of the technique is that it can be used in collaboration with observation to ascertain the lifestyle of the subject as well as get his/her responses.

- **Mall-intercept interviews:** As the name suggests, this method involves conducting interviews with the respondents as they are shopping in malls. Sometimes, product testing or product reactions can be carried out through structured methods and followed by interviews to test the reactions. The advantage of the method is that a large number of subjects are accessible in a short time period, thus it is both cost and time effective. However, the time available is short, thus the questioning cannot be extensive and must get over in 20 to 30 minutes.

- **Computer-assisted personal interviewing (CAPI):** These techniques are carried out with the help of the computer. In this form of interviewing, the respondent faces an assigned computer terminal and answers a questionnaire on the computer screen by using the keyboard or a mouse. A number of pre-designed packages are available to help the researcher design simple questions that are self-explanatory and instead of probing, the respondent is guided to a set of questions depending on the answer given. Thus, predetermined branches are formulated for probing a particular line of thought. There is usually an interviewer present at the time of respondent’s computer-assisted interview and is available for help and guidance, if required. This is why they are called interviews and not questionnaires.

- **Telephone method:** The telephone method involves replacing the face-to-face interaction between the interviewer and interviewee, by questioning on telephones and calling up the subjects to asking them a set of questions. The advantage of the method is that geographic boundaries are not a constraint and the interview can be conducted at the individual respondent’s location. The format and sequencing of the questions remains the same.
  - **Traditional telephone interviews:** The process can be accomplished using the traditional telephone for conducting the questioning. With the improvement in wireless technology, it is possible to reach the subject in the remotest of locations with considerable ease.
  - **Computer-assisted telephone interviewing:** In this process, the interviewer is replaced by the computer and it involves conducting the telephonic interview using a computerized interview format. The interviewer sits in front of a computer terminal and wears a mini-headset, in order to hear the respondent answer. However, unlike the traditional method where he had to manually record the responses, the responses
are simultaneously recorded on the computer. Once the interview time is fixed, the call is made to the respondent by the computer. The interviewer reads questions as listed in front of him on the computer screen and hears the response on the head set and at the same time the answers are fed into the computer’s memory. The method has the advantage of the computer handling the sequencing of questions and the interviewer is free to conduct the interview in reduced time and with higher accuracy.

The structured interview is one of the most powerful tools of qualitative data collection methods available to the researcher. It provides information that is richer in content as compared to the focus group. There is no pressure for conformity and reactions which might be lost in group conduction are explored in depth in this technique. Also for selected groups, (for example experts or retailers or representatives of the competing organizations), information can be better sought by the personal interview method. And as we have seen, with the advent of technological assistance, these interviews can be carried out at remote and far-off locations with the help of a telephone or a computer.

However, since the interview requires a one-to-one dialogue to be carried out, it is more cumbersome and costly as compared to a focus group discussion. Also conduction of interview requires considerable skills on the part of the interviewer and thus adequate training in interviewing skills is needed for capturing a comprehensive study-related data.

9.3 QUESTIONNAIRES: MEANING AND TYPES

When one is designing the questionnaire, there are certain criteria that must be kept in mind.

The first and foremost requirement is that the spelt-out research objectives must be converted into clear questions which will extract answers from the respondent. This is not as easy as it sounds, for example, if one wants to know something like what is the margin that a company gives to the retailer? This cannot be converted into a direct question as no one will give the correct figure. Thus, one will have to ask a disguised question like may be a range of percentage estimates—2–5 per cent, 6–10 per cent, 11–15 per cent, 16–20 per cent, etc., or the retailer might not go beyond a yes, no or ‘industry standard’.

The second requirement is, like the Toyota questionnaire, it should be designed to engage the respondent and encourage a meaningful response. For example, a questionnaire measuring stress cannot have a voluminous set of questions which fatigue the subject. The questions, thus, should be non-threatening, must encourage response and be clear to understand. One needs to remember that the essential usage of the instrument is to administer the same to a large base, thus there must be clarity and interest that should be part of the measure itself.
Lastly, the questions should be self-explanatory and not confusing as then
the answers one gets might not be accurate or usable for analysis. This will be
discussed in detail later, when we discuss the wording of the questions.

Types of Questionnaire

There are many different types of questionnaire available to the researcher. The
categorization can be done on the basis of a variety of parameters. The two which
are most frequently used for designing purposes are the degree of construction or
structure and the degree of concealment, of the research objectives. Construction
or formalization refers to the degree to which the response category has been
defined. Concealed refers to the degree to which the purpose of the study is
explained or is clear to the respondent.

Instead of considering them as individual types, most research studies use a
mixed format. Thus, they will be discussed here as a two-by-two matrix (Table 9.1).

<table>
<thead>
<tr>
<th></th>
<th>Formalized</th>
<th>Non-Formalized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unconcealed</td>
<td>Most research studies use standardized questionnaires like these.</td>
<td>The response categories have more flexibility.</td>
</tr>
<tr>
<td>Concealed</td>
<td>Used for assessing psychographic and subjective constructs.</td>
<td>Questionnaires using projective techniques or sociometric analysis.</td>
</tr>
</tbody>
</table>

Formalized and unconcealed questionnaire: This is the one that is
indiscriminately and most frequently used by all management researchers. For
example, if a new brokerage firm wants to understand the investment behaviour of
the population under study, they would structure the questions and answers as
follows:

1. Do you carry out any investment(s)?
   Yes __________ No __________
   If yes, continue, else terminate.

2. Out of the following options, where do you invest (tick all that apply).
   Precious metals __________, real estate __________, stocks __________,
   government instruments __________, mutual funds __________,
   any other __________.

3. Who carries out your investments?
   Myself __________, agent __________, relative __________, friend
   __________,
   any other __________.

   *In case the option ticked is self, please go to Q. 4, else skip.*
4. What is your source of information for these decisions?

Newspaper __________, investment magazines __________, company records, etc. __________, trading portals __________, agent __________.

This kind of structured questionnaire is easy to administer, as one can see that the questions are self-explanatory and, since the answer categories are defined as well, the respondent needs to read and tick the right answer. Another advantage with this form is that it can be administered effectively to a large number of people at the same time. Data tabulation and data analysis is also easier to compute than in other methods.

This format, as a consequence of its predefined composition, is able to produce relatively stable results and is reasonably high in its reliability. The validity, of course would be limited as the comprehensive meaning of the constructs and variables under study might not be holistic when it comes to structured and limited responses. In such cases, variables are made a part of the study and some open-ended questions as well as administration/additional instructions/probing by the field investigator could help in getting better results.

**Formalized and concealed questionnaire:** The research studies which are trying to unravel the latent causes of behaviour cannot rely on direct questions. Thus, the respondent has to be given a set of questions that can give an indication of what are his basic values, opinions and beliefs, as these would influence how he would react to certain products or issues. For example, a publication house that wants to launch a newspaper wants to ascertain what are the general perceptions and current attitudes about newspapers. Asking a direct question would only reveal apparent information, thus, some disguised attitudinal questions would need to be asked in order to infer this.

Please indicate your level of agreement with the following statements:

<table>
<thead>
<tr>
<th></th>
<th>SA – Strongly Agree; A – Agree; N – Neutral; D – Disagree; SD – Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The individual today is better informed about everything than before.</td>
</tr>
<tr>
<td>2</td>
<td>I believe that one must live for the day and worry about tomorrow later.</td>
</tr>
<tr>
<td>3</td>
<td>An individual must at all times keep abreast of what is happening in the world around him/her.</td>
</tr>
<tr>
<td>4</td>
<td>Books are the best friends anyone can have.</td>
</tr>
<tr>
<td>5</td>
<td>I generally read and then decide what to buy.</td>
</tr>
<tr>
<td>6</td>
<td>My lifestyle is so hectic that I do not have time for reading the newspaper.</td>
</tr>
<tr>
<td>7</td>
<td>The advent of radio, television and Internet have made the traditional information sources-like newspapers, redundant.</td>
</tr>
<tr>
<td>8</td>
<td>A man/woman is known by what he/she reads.</td>
</tr>
</tbody>
</table>
The logic behind these tests of attitude is that the questions do not seem to be in a particular direction and are apparently non-threatening, thus the respondent gives an answer which would be in the general direction of his/her attitudes.

The advantage of these questions is that since these are structured, one can ascertain their impact and quantify the same through statistical techniques. Secondly, it has been found that psychographic questions like these increase the subject coverage and improve the validity of the instrument as well. Most studies interested in quantifying the primary response data make use of questions that are designed both as formalized unconcealed and formalized concealed.

**Non-formalized unconcealed:** Some researchers argue that the respondent is not really cognizant of his/her attitude towards certain things. Also, this method asks him to give structured responses to attitudinal statements that essentially express attitudes in a manner that the researcher or experts think is the correct way. This however might not be the way the person thinks. Thus, rather than giving them pre-designed response categories, it is better to give them unstructured questions where he has the freedom of expressing himself the way he wants to. Some examples of these kinds of questions are given below:

1. What has been the reason for the success of the ‘lean management drive’ that the organization has undertaken? Please specify FIVE most significant reasons according to YOU.
   (a) ___________________
   (b) ___________________
   (c) ___________________
   (d) ___________________
   (e) ___________________

2. Why do you think Maggi noodles are liked by young children?

3. How do you generally decide on where you are going to invest your money?

4. Give THREE reasons why you believe that the Commonwealth 2010 Games have helped the country?

   The advantage of the method is that the respondent can respond in any way he/she believes is important. For example, for the last question, some people might respond by stating that it has boosted tourism in the country and contributed to the country’s economy. Some might think it will encourage more international events to be held in the country. Some might also state that it is not a good idea and the government should instead be spending on improving the cause of the people who are below the poverty line.

   Thus, one gets a comprehensive perspective on what the construct/product/policy means to the population at large; and at the micro level, what it means to
people in different segments. The validity of these measures is higher than the previous two. However, quantification is a little tedious and one cannot go beyond frequency and percentages to represent the findings. The other problem is the researcher’s bias which might lead to clubbing responses into categories which might not be homogenous in nature.

**Non-formalized, concealed:** If the objective of the research study is to uncover socially unacceptable desires and latent or subconscious and unconscious motivations, the investigator makes use of questions of low structure and disguised purpose. The presumption behind this is that if the argument, the situation or question is ambiguous, it is most likely that the revelation it would result in would be more rich and meaningful. In Chapter 6, there was a discussion on projective techniques; these kinds of questionnaires are designed on the above-stated lines. The major weakness of these types of questionnaires is that being of a low structure, the interpretation required is highly skilled. Cost, time and effort are additional elements which might curtail the use of these techniques. A study conducted to measure to which segment should men’s personal care toiletries (especially moisturizers and fairness creams) be targeted, the investigator designed two typical bachelors’ shopping lists. One with a number of monthly grocery products as well as the normal male toiletries like shaving blades, gels, shampoos, etc., and the other list had the same grocery products and male toiletries but it had two additional items—Fair and Handsome fairness cream and sensitive skin moisturizer. The list was given to 20 young men to conceptualize/describe the person whose list this is. The answers obtained were as follows:

<table>
<thead>
<tr>
<th>List with Cream and Moisturizer</th>
<th>List without Cream and Moisturizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>65 per cent said this person was good looking</td>
<td>10 per cent said this man was good looking</td>
</tr>
<tr>
<td>3 per cent said typical male</td>
<td>39 per cent said 30 plus in age</td>
</tr>
<tr>
<td>25 per cent said a 20-year-old</td>
<td>90 per cent said rugged and manly</td>
</tr>
<tr>
<td>48 per cent said has a girlfriend</td>
<td>38 per cent said has a girlfriend</td>
</tr>
<tr>
<td>36 per cent said has a boyfriend</td>
<td>No one spoke of boyfriend</td>
</tr>
<tr>
<td>32 per cent said spendthrift</td>
<td>21 per cent said thrifty</td>
</tr>
<tr>
<td>21 per cent said ‘girly’</td>
<td>32 per cent said normal Indian male</td>
</tr>
<tr>
<td>73 per cent said a boyfriend</td>
<td>No one spoke of boyfriend</td>
</tr>
</tbody>
</table>

Thus, as we can see, the normal Indian adult male is still going to take time to include beauty or cosmetic products into his normal personal care basket. Thus, it is wiser for the marketers to target the younger metrosexual male who is a heavy spender.

Another useful way of categorizing questionnaires is on the method of administration. Thus, the questionnaire that has been prepared would necessitate a face-to-face interaction. In this case, the interviewer reads out each question and makes a note of the respondent’s answers. This administration is called a schedule. It might have a mix of the questionnaire type as described in the section above and might have some structured and some unstructured questions. The investigator might also have a set of additional material like product prototypes or copy of advertisements. The investigator might also have a predetermined set of standardized questions or clarifications, which he can use to ask questions like...
The other kind is the self-administered questionnaire, where the respondent reads all the instructions and questions on his own and records his own statements or responses. Thus, all the questions and instructions need to be explicit and self-explanatory.

The selection of one over the other depends on certain study prerequisites. Population characteristics: In case the population is illiterate or unable to write the responses, then one must as a rule use the schedule, as the questionnaire cannot be effectively answered by the subject himself.

Population spread: In case the sample to be studied is large and dispersed, then one needs to use the questionnaire. Also when the resources available for the study, time, cost and manpower are limited, then schedules become expensive to use and it is advisable to use self-administered questionnaire.

Study area: In case one is studying a sensitive topic, like organizational climate or quality of working life, where the presence of an investigator might skew the answers in a more positive direction, then it is better that one uses the questionnaire. However, in case the motives and feelings are not well-developed and structured, one might need to do additional probing and in that case a schedule is better. If the objective is to explore concepts or trace the reaction of the sample population to new ideas and concepts, a schedule is advisable.

Check Your Progress

1. List the objectives of to be formulated on the basis of the interview.

2. State the foremost requirement in designing a questionnaire.

9.4 PARTICIPATORY AND RAPID APPRAISAL TECHNIQUES

In participatory action research, the researcher serves as a resource to those being studied, as an opportunity for them to act effectively in their own interest. The disadvantaged participants define their problems, the desired remedies, and take the lead in designing the research that will help them realize their aims. In this research, distinction between the researcher and the researched disappear because the subject who will be affected by research should also be responsible for its design. The basic presumption of participatory approach has been on poor and marginalized people who are capable of analysing their own realities. It focuses on how people generate their own realities and how they reflect upon them so as to bring about changes in their situation. A number of participatory approaches with different terminologies have since then come into practice over period of time such as Rapid Rural Appraisal (RPA), Participatory Rural Appraisal (PRA), Participatory Learning and Action (PLA), etc.
9.4.1 Phenomenology

Phenomenology refers to a philosophical paradigm for conducting qualitative research that stresses on people’s prejudiced experiences and analysis of the world. One form of phenomenology is heuristic inquiry, where researchers shed an effort to be detached observers and actually experience firsthand, the phenomenon they are studying. Introspection is used to examine their thoughts and feelings while experiencing that phenomenon. For instance, they might stay in a shelter for the homeless for a while, to better understand the meaning of that experience to the homeless, and perhaps to better understand why some homeless people refuse to use shelter. This is guided by the principle of ‘Verstehen’ which means ‘understanding’. By using this, researchers try to know about the people they observe from the perspective of understanding their feelings and their views on reality. Thus, the term verstehen corresponds to concept of empathy used in social work practice.

9.4.2 Ethnography

Ethnography is a form of qualitative research. It emphasizes observation in natural settings and focuses on providing detailed and accurate descriptions of the way people in a particular culture live and the way they interpret things. Ethnographic studies most relevant to social work will describe subcultures within our dominant culture, such as homeless, street gangs, and so on. Ethnographic researchers try to see the world through the eyes of the people they are studying and to understand their idiosyncratic belief systems and behavioural norms.

9.4.3 Participatory Research Design

Participatory research design (previously known as collaborative design) is an approach to design that tries to involve all stakeholders in a dynamic way. Participatory research is an acknowledged type of experimental research that revolves around the effects of a researcher’s direct actions of practice within a community that participates. It aims at improving the quality of performance of the community or an area of concern.

Participatory research seeks to remove the mystery that influences research. Thus, it renders research as an intellectual tool, which people can normally use for improving their lives. Participatory research presents ways for increasing the relevance of conservative science, by creation of an environment wherein new knowledge can be created. Participatory attitude and approach can act like a powerful force that fuels development. Eventually, participatory research involves respect and consideration for the people with and for whom researchers work. It is about creating a feeling that local people have knowledge and researchers can work with them for analysing and providing solutions. It also comprises recognition of the rights of those involved in the research by giving them the authority to establish their own schedule for research and development and giving them possession of the procedure.
9.5 OBSERVATION AND TYPES OF DOCUMENT REVIEW

This direct method of data collection is one of the most appropriate methods to use in case of descriptive research. Yet, it most often gets ignored as it appears too simplistic a procedure. Observation is a skill that most of us use consciously and unconsciously in our everyday life as well. It might be carried out in a naturalistic environment where there are no control elements or it might be carried out in a simulated environment under certain controlled conditions. There are arguments in support of both the approaches. The task of the observer-investigator is not to question or discuss with the individuals whose behaviour is being studied. The event being observed might involve a live observation and reporting or it might involve observing and inferring from a recording of the event. Thus, the method of observation involves viewing and recording individuals, groups, organizations or events in a scientific manner in order to collect valuable data related to the topic under study.

The mode of observation could be in a standardized and structured format. Here, the nature of content to be recorded and the format and the broad areas of recording are predetermined. Thus, the observer’s bias is reduced and the authenticity and reliability of the information collected is higher. For example, Fisher Price toys carry out an observational study whenever they come out with a new toy. The observer is supposed to record the appeal of the toy for a child, i.e., how often does he/she pick it up from a collection of the toys available. What is the attention span in terms of how long is it able to engage the child? Is there any safety issue with the toy? What was the reaction of the child while/after playing with the toy? Thus, for a clearly defined information need, in terms of parameters to be noted, it is an extremely useful and a non-intrusive method. This method is useful for cross-sectional descriptive studies.

The antithesis of this is called the unstructured observation. Here, the observer is supposed to make a note of whatever he understands as relevant for the research study. This kind of approach is more useful in exploratory studies where there is a lack of clearly-defined objectives and one is still trying to identify what parameters need to be investigated and the nature of relationship between these and the causal variable. Since it lacks structure, the chances of observer’s bias are high as the observer has his/her own presumptions about the situation being observed. To overcome the shortcomings of this, one generally has multiple observers for the same situation in order to get different perspectives about the same instance. An example of this is the observation of consumer experiences at a service location—this could be a bank, a restaurant or a doctor’s clinic to get an insight into the intangible needs and individual behaviour of service personnel. It could give clear indications of the elements that might create an unhappy experience or might lead to customer delight. In this case, giving clear mandates about what to
observe might miss out on important elements of the service experience which might be critical in delivering a superior value. However, one needs to remember that the observation is always of behavioural variables, assumptions about the affective or cognitive element impacting the behaviour have to be assumed and hypothesized and later validated through consumer response through other methods.

However, it is critical here to understand that the researcher must have a preconceived plan to capture the observations made. It is not to be treated as a blank sheet where the observer reports what he sees. The aspects to be observed might be clearly listed as in an audit form, or they could be indicative areas on which the observation is to be made. Presented here is an observation sheet that was used in the organic food products study. This sheet includes both an audit form and broad indicative areas.

**Observation Sheet: Organic Retailer**

<table>
<thead>
<tr>
<th>Product</th>
<th>Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEA</td>
<td>CEREALS</td>
</tr>
<tr>
<td>Organic Tea</td>
<td>Amaranth</td>
</tr>
<tr>
<td>Flavoured</td>
<td>Amaranth Popped</td>
</tr>
<tr>
<td>SNACKS</td>
<td>Amaranth Breakfast Cereal</td>
</tr>
<tr>
<td>Cookies (Ragi/Radish)</td>
<td>Jhangara</td>
</tr>
<tr>
<td>Bread</td>
<td>Ragi</td>
</tr>
<tr>
<td>Namkins</td>
<td>Ragi Atta</td>
</tr>
<tr>
<td>SPICES</td>
<td>Maize</td>
</tr>
<tr>
<td>Chilli Powder</td>
<td>Maize Atta</td>
</tr>
<tr>
<td>+Chilli Red</td>
<td>Wheat Atta</td>
</tr>
<tr>
<td>Dhania Powder</td>
<td>Wheat Dalia</td>
</tr>
<tr>
<td>Dhania Seeds</td>
<td>Wheat Puffed</td>
</tr>
<tr>
<td>Haldi Whole</td>
<td>PULSES</td>
</tr>
<tr>
<td>Haldi Powder</td>
<td>Ahar Dal</td>
</tr>
<tr>
<td>Mustard Powder</td>
<td>Bhat Dal</td>
</tr>
<tr>
<td>Sesame/Til</td>
<td>Kulath Dal</td>
</tr>
<tr>
<td>Zero</td>
<td>Mmamor Dal</td>
</tr>
<tr>
<td>PRESERVES</td>
<td>Moong Sabut</td>
</tr>
<tr>
<td>Mango Pickle</td>
<td>Moreg Hat</td>
</tr>
</tbody>
</table>
### NOTES

<table>
<thead>
<tr>
<th>Garlic Pickle</th>
<th>Kabuli Channa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed Pickle</td>
<td>Naurangi Dal</td>
</tr>
<tr>
<td>Amla Chutney</td>
<td>Rajma (Brown/White)</td>
</tr>
<tr>
<td>Ginger Ale</td>
<td>Rajma (Chikabra)</td>
</tr>
<tr>
<td>Hurran Squash</td>
<td>Rajma (Mix)</td>
</tr>
<tr>
<td>Lemon Squash</td>
<td>Rajma (Red Small)</td>
</tr>
<tr>
<td>Malai Squash</td>
<td>Urad Dal</td>
</tr>
<tr>
<td>Pinda Squash</td>
<td>Urad Whole</td>
</tr>
<tr>
<td><strong>RICE</strong></td>
<td></td>
</tr>
<tr>
<td>ANY OTHER</td>
<td>Basmati Delhisimm</td>
</tr>
<tr>
<td>Rice Khanda</td>
<td></td>
</tr>
<tr>
<td>Rice Rakhwa</td>
<td>Rice Unpolished</td>
</tr>
<tr>
<td>Rice Hamraj</td>
<td>Rice Red</td>
</tr>
<tr>
<td>Rice Red</td>
<td>Rice Kasturi</td>
</tr>
<tr>
<td>Rice Kelas</td>
<td>Rice Punjab Basmati</td>
</tr>
<tr>
<td>Rice Ramjipan</td>
<td>Rice Sela</td>
</tr>
</tbody>
</table>

Another way of distinguishing observations is the level of respondent consciousness about the scrutiny. This might be *disguised*; here the observation is done without the respondent’s knowledge who has no idea that he/she is being observed. The advantage of this method is that since the respondent does not know, one is able to record the natural manner in which the person behaves and interacts with others in his environment. Sometimes this may be accomplished by having observers who are a part of the group or are employees of the organization. It is also possible to use other devices like a one way mirror or a hidden camera or a recorder. The only disadvantage is the privacy issue, as this is ethically an intrusion of an individual’s right to privacy. On the other hand, the knowledge that the person is under observation can be conveyed to the respondent, and this is *undisguised observation*. There are different perspectives on the degree of artifice of the behaviour. The proponents state that the influence of the observer’s presence is brief and does not really have any effect on the natural way a person behaves. While the other school of thought is that it distorts an individual’s behaviour pattern drastically. The decision to choose one over the other depends upon the nature of the study. Whenever the objective is to study the latent, subconscious or an intangible aspect of human behaviour, it is recommended that one opts for disguised approach. However, when the observation is accepted as non-intrusive as it is a part of the process, for example in a group discussion or a formal meeting or moving around in a retail store under a close circuit TV surveillance, the undisguised approach can be used.

The observation method can also be distinguished on the basis of the setting in which the information is being collected. This could be natural observation, which as the name suggests, is carried out in real time locations, for example the observations of how employees interact with each other during breaks. On the
other hand, it could be an artificial or simulated environment in which the respondent is to be observed. This is actively done in the armed forces where stress tests are carried out to measure an individual’s tolerance level.

Thus, evaluating the reactions of respondents to the phenomena or strategies under study can be carried out at a smaller scale in a contrived situation, as these would help predict the behaviour likely to occur, in the actual situation. However, when the object is to study true reactions and not the supposed ones, natural observation is recommended.

There is a more recent differentiation that has come about and this has been effected through alternative technologically-advanced gadgets replacing human observations. Thus, the observation could be done by a human observer or a mechanical device.

1. Human observation: As the name suggests, this technique involves observation and recording done by human observers. The investigator is considered to be like a ‘fly on the wall’, there has to be absolutely no contribution in any way to the situation being observed. This means he has to send no verbal or non-verbal cues to the respondent, which might impact the behaviour being observed.

Human observation has both advantages and disadvantages of the human element. The analytical ability of the recorder makes this mode far superior to mechanical recording. As the observer observes, accordingly he infers and then records. Thus, if the observer views a supervisor giving a piece of his mind to his subordinate, the inference might be of non-supportive behaviour or autocratic and domineering attitude of the supervisor.

However, this very advantage might prove to be a negative of the technique as well, for example based on the observer’s own experience, he might report this as absolutely ‘normal handling of a junior’s mistake by the supervisor, or he might state this as ‘an inhuman act to curtail an individual’s basic human right to be.’ Thus, maintaining objectivity while reporting and inferring is of critical importance. The exact definition of what are the parameters to be observed in the case of structured observation are extremely important. For example, if we need to observe them on the level of initiative that they take in delivering service, then it is essential to define the kind of behaviour that is part of the job role and that which might be construed as initiative. This is critical if observation is the major data-collection instrument for a descriptive study. This will ensure the reliability of the findings. The second concern is that of validity, for example a pleasant demeanour of a restaurant waiter might be stated as a positive predictor of consumer delight; however, the validity of such findings becomes questionable as for one observer this might be simply a pleasant smile, while the others might include an overall handling of the order right from the greeting to the final collection of payment. Thus, the construct validity (to be
discussed in the chapter on Attitude and Measurement) of the method requires that the relation being studied of personnel attitude and customer satisfaction must have some theoretical base.

This also has implications for the generalizability and applicability of the findings. Sometimes, the situation constructed like a packaging option or an advertisement might have indications only for the study situation, whereas others, like the supervisor–subordinate relations might have a wider application.

The task of the observer is simple and predefined in case of a structured observation study as the format and the areas to be observed and recorded are clearly defined. In an unstructured observation, the observer records in a narrative form the entire event that he has observed. Subsequently, he assigns the behaviour to different categories. The reporting must ensure that these categories are exhaustive in covering the details noted and they are mutually exclusive. Another aspect to be noted is that the observer needs to be trained to report using ‘natural’ rather than ‘judgemental’ words. For example, if the narration involved reporting of the supervisor–subordinate relationship, then, rather than reporting it as aggressive or normal, one needs to spell out what, according to the researcher, constitutes normal or aggressive behaviour, as what is normal according to one might be reported as aggressive by the other. Thus, it is advisable to record behaviour manifestations and then analyse the type of relationship.

In a **mechanical observation**, the recording is done through electronic medium; and is later subjected to an interpretation and analysis.

2. **Mechanical observation**: In these methods, man is replaced by machine. This might or might not involve directives by human hand. Generally, the recording is done continuously and later subjected to an interpretation and analysis.

Store cameras and cameras in banks and other service areas also provide vital information about consumer movement and behaviour patterns; as well as reaction to shelf placement or store displays. AC Nielsen and others also record Internet usage through their Net scanners. The net surfing behaviour in terms of the time spent, sites visited and links used are extremely valuable insights into mapping consumer interests, as this helps in designing product and promotion offering, thus, catering to the needs and interests of the potential users.

Another device is the input used for media panel audits using people meter and audio meter.

In contrast to the ones stated above, a number of mechanical observation devices need the respondent to be active in assisting the recording. To measures the impact on the skin, a popular technique is the psychogalvanometer, which measures galvanic skin response (GSR) or
changes in the electrical resistance of the skin. Small electrodes are attached to the individual’s skin and these electrodes are in turn attached to a monitor. The rationale behind this test is that any affective reaction of the individual results in a higher perspiration which, in turn, results in a change in the electrical resistance of the skin. This is recorded on the galvanometer. Thus, the respondent could be exposed to different kinds of packaging, advertisements and product composition, to note his reaction to them. The strength of the movement shown on the monitor indicates the respondent’s reaction and impression about the stimuli.

There are a number of equipment to measure the impact of various stimuli on the sense of sight. Eye-tracking equipment such as oculometers, eye cameras or eye view minuters, record the movements of the eye. These devices can be used to determine how a respondent reacts to various aspects like advertisements, packaging options, shelf or store displays. The oculometer determines what the individual is looking at, while the pupillometer measures the interest of the person in the stimulus. The pupillometer measures changes in the diameter of the respondent’s pupils. The technique involves exposing the individual to various images on a screen. A before- and after-test is conducted to measure any change in the pupil movement. The theoretical assumption is that any change in a cognitive activity is immediately reflected in the change in pupil size. The hypothesis being that more the increase in the size of the pupil, more positive is the attitude of the individual towards the stimulus.

Voice pitch meters measure emotional reactions of the individual by reporting on any change in the respondent’s voice. The audio-compatible computer devices measure any change in the voice pitch of the person. The basic premise behind the usage of these devices is that certain affective and cognitive responses manifest themselves through the sensory outputs and thus can be subsequently measured. However, these are expensive to use and record and thus have not really found a widespread usage. Another problem is the impact of the simulated or artificial environment required to carry out these analysis, which might mask the true response or exaggerate it.

A related technique is that of Trace analysis; in this the remains or the leftovers of the consumers’ basket—like his credit card spend, his recycle bin on his computer, his garbage (garbology) are evaluated to measure current trends and patterns of usage and disposal. The make and condition of cars in a parking lot near a locality can be used to ascertain the lifestyle and prosperity of the residents in the locality.

Observational techniques are an extremely useful method of primary data collection and are always a part of the inputs, whether accompanying other techniques, like interviews, discussions or questionnaire administration, or as the prime method of data collection. However, the disadvantage which
they suffer from is that they are always behaviourally driven and cannot be used to investigate the reasons or causes of the observed behaviour. Another problem is that if one is observing the occurrence of a certain phenomenon, one has to wait for the event to occur.

Document review is a way of collecting data by reviewing existing documents. The documents may be internal or external. Documents may be hard copy or electronic and may include reports, program logs, performance ratings, funding proposals, meeting minutes, newsletters, and marketing materials.

Check Your Progress

3. Name some of the participatory approaches that have come into practice with the passage of time.

4. How is the human observation mode superior to the mechanical recording mode?

9.6 MIXED AND MULTI-METHOD

Qualitative in-depth interview

A qualitative in-depth interview is a structured social interaction between a researcher and a subject who is identified as a potential source of information. Normally, the interviewer initiates and controls the exchange to derive information appropriate to the topic at hand.

Qualitative interviews (conducted face-to-face or via telephone) are well suited to gathering information on complicated topics and can also be used to gather some quantitative information. They are an excellent tool for in-depth exploratory research.

Mixed and multi method

Mixed methods and multi-methods are endeavors which address the topic of social phenomena being complex enough to elicit looking at it from different vantage points. However, the two terms differ in their meaning. The difference between the two is primarily derived from differences in paradigmatic influences. Paradigms influence not only the theoretical background from which research strategies emanate, but also how particular data could be read and whether particular and specific forms of data makes sense or not, could be compared or not, and so on.

Multiple Method and Mixed Methods

Multiple methods usually tend to fall within the same paradigmatic influence. Each method could answer different sub-questions. The goals of multiple methods are usually:
• outcome triangulation—seeing social phenomena in its multiple dimensions
• data triangulation—use of two or more methods which are exhaustive and rigorous in themselves, leading to several forms of data in studying the same phenomenon.

Mixed methods could employ research strategies from different paradigms, whereby the goals are just not convergence or comparison of data, but:

  i. **corroboration** through convergence of findings,
  ii. **elaboration**, by providing richness and detail, and
  iii. **initiation**, by prompting new interpretations and suggesting areas of further exploration through recasting the entire research question.

### 9.7 TRIANGULATION

The origin of the term triangulation can be cited to navigational and land surveying techniques. "The concept of triangulation is borrowed from navigational and land surveying techniques that determine a single point in space with the convergence of measurements taken from two other distinct points."¹

The use of triangulation in social sciences and particularly in reference to research methods has increased considerably over time. In the social sciences, triangulation refers to the application and combination of several research methods in the study of the same phenomenon.²

Essentially, triangulation is a powerful technique that aims at validating data through cross verification from two or more sources. It is the application and combination of varied research methods in the study of the same phenomenon.

Cohen and Manion (2000) define triangulation as an “attempt to map out, or explain more fully, the richness and complexity of human behavior by studying it from more than one standpoint.”³

According to O’Donoghue and Punch (2003), triangulation is a “method of cross-checking data from multiple sources to search for regularities in the research data.”⁴

Altrichter et al. (2008) contend that triangulation “gives a more detailed and balanced picture of the situation.”⁵

A review of several definitions of triangulation clearly indicates that:

• It can be used in both quantitative (validation) and qualitative (inquiry) studies.
• It is a method-appropriate strategy of founding the credibility of qualitative analyses.
• It becomes an alternative to traditional criteria like reliability and validity.
• It is the preferred line in the social sciences.
Denzin has identified five types of triangulation. These include the following:

- Methodological Triangulation
- Researcher Triangulation
- Data Triangulation
- Theoretical Triangulation
- Environmental Triangulation

Methodological triangulation is the most widely-used triangulation. In this type of triangulation the researcher off-sets the weaknesses of one method with the strengths of another as a means of improving the reliability and validity of their research. Methodological triangulation can further be divided into within-method triangulation and between-method triangulation.

Bryman explains within-method triangulation as the use of varieties of the same method to investigate a research issue. In reality this might involve including and asking open and closed ended questions in the same questionnaire.

Between-method triangulation on the other hand involves the use of contrasting research methods. An example of this method is reflected in combining a structured interview with some form of observational research.

Harvey and MacDonald have put forward three basic tenets of methodological triangulation. These include:

- Two or more researchers using same research technique
- One researcher using two or more research techniques
- Two or more researchers using two or more research techniques.

Researcher triangulation is a very popular method to control reliability and validity. The method is used by employing different researchers in studies that rely heavily on researcher interpretations to generate data.

Data triangulation refers to collection of data through different sampling strategies at different times, in different contexts and from different people.

Theoretical triangulation also referred to as methodological pluralism, involves a researcher combining different research methodologies, such as interpretivism and feminism and methods (quantitative and qualitative) in an attempt to improve research reliability and validity.

Environmental triangulation uses a range of environmental factors - different locations, times of day, seasons and so forth - to check data validity.

A review of work on triangulation suggests several advantages of the method. Major advantages include the following:

- Getting a complete and holistic picture of the issue
- Improved reliability and validity of the data
• Offsetting weaknesses wherever required
• Increased confidence in accuracy of data

Trochim argues that if all research methods contain the capacity for error, the only sensible thing is to combine methods so that one type of error cancels out another. Triangulation can be used for:

• Checking data reliability and validity
• Comparisons, where different researchers using the same method can compare data for similarities and differences
• Confirmations - verifying the accuracy of different types of data

Check Your Progress
5. What is the main use of the triangulation technique?
6. Name the types of triangulation.

9.8 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. On the basis of the interview, the following objectives would be formulated:
• Identify the postgraduate options available to the students, both national and international.
• Identify the selection process followed by benchmarked institutes.
• Identify the process used by a typical undergraduate student in preparing a list of the institutes to apply in.
• Based on the above objectives, identify the business model that a postgraduate institute needs to adapt to successfully reach out to the potential student group.

2. The first and foremost requirement is that the spelt-out research objectives must be converted into clear questions which will extract answers from the respondent.

3. Some of the participatory approaches that have come into practice with the passage of time are Participatory Rural Appraisal (PRA), Participatory Learning and Action (PLA) and so forth.

4. The analytical ability of the recorder makes the human recording mode far superior to mechanical recording.

5. Essentially, triangulation is a powerful technique that aims at validating data through cross verification from two or more sources. It is the application and combination of varied research methods in the study of the same phenomenon.
6. The types of triangulation are the following:
   - Methodological Triangulation
   - Researcher Triangulation
   - Data Triangulation
   - Theoretical Triangulation
   - Environmental Triangulation

9.9 SUMMARY

- Another method of direct access to the respondents’ school of thought is the personal interview method. Personal interview is a one-to-one interaction between the investigator/interviewer and the interviewee.
- Once the steps or research objectives have been established, the researcher might need to do another round of semi-structured interviews to get a perspective on the variables to be studied, the definitions of these variables and any other information of relevance to the study topic.
- The quality of the output and the depth of information collected depend upon the probing and listening skills of the interviewer.
- There are various kinds of interview methods available to the researcher.
- The telephone method involves replacing the face-to-face interaction between the interviewer and interviewee, by questioning on telephones and calling up the subjects to asking them a set of questions.
- There are many different types of questionnaire available to the researcher. The categorization can be done on the basis of a variety of parameters.
- The research studies which are trying to unravel the latent causes of behaviour cannot rely on direct questions.
- Ethnography is a form of qualitative research. It emphasizes observation in natural settings and focuses on providing detailed and accurate descriptions of the way people in a particular culture live and the way they interpret things.
- Participatory research design (previously known as collaborative design) is an approach to design that tries to involve all stakeholders in a dynamic way.
- A qualitative in-depth interview is a structured social interaction between a researcher and a subject who is identified as a potential source of information. Normally, the interviewer initiates and controls the exchange to derive information appropriate to the topic at hand.
- The origin of the term triangulation can be cited to navigational and land surveying techniques.
Essentially, triangulation is a powerful technique that aims at validating data through cross verification from two or more sources. It is the application and combination of varied research methods in the study of the same phenomenon.

Methodological triangulation is the most widely-used triangulation. In this type of triangulation the researcher off-sets the weaknesses of one method with the strengths of another as a means of improving the reliability and validity of their research.

### 9.10 KEY WORDS

- **Personal interview**: It is a one-to-one interaction between the investigator/interviewer and the interviewee.
- **Phenomenology**: It refers to a philosophical paradigm for conducting qualitative research that stresses on people’s prejudiced experiences and analysis of the world.
- **Ethnography**: It is a form of qualitative research. It emphasizes observation in natural settings and focuses on providing detailed and accurate descriptions of the way people in a particular culture live and the way they interpret things.
- **Data triangulation**: It refers to collection of data through different sampling strategies at different times, in different contexts and from different people.

### 9.11 SELF ASSESSMENT QUESTIONS AND EXERCISES

#### Short Answer Questions

1. Write a short note on formalized and unconcealed questionnaire.
2. Briefly mention the participatory and rapid appraisal techniques.
3. Define triangulation in your own words.

#### Long Answer Questions

1. What are the steps undertaken in the interview process?
2. Discuss the categorization of interviews.
3. Compare and contrast human observation and mechanical observation.
4. Which is the most widely used type of triangulation and why?
9.12 FURTHER READINGS


Footnotes

UNIT 10 DATA PROCESSING

10.0 INTRODUCTION

In this unit, we will begin our discussion on the processing and analysis of data. The process of inspecting, cleaning, transforming and modelling data with the specific purpose of highlighting useful information, suggesting conclusions and supporting decision making is termed as analysis of data. There are multiple facets and approaches to data analysis. The data that is acquired must be identified as a matter of utmost importance. This is followed by the processing and analysis of the same in order to infer proper and accurate results. This unit also focuses on the meaning, importance and the process of data analysis.

10.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss the meaning and importance of data analysis
- Explain the process of data analysis
- Examine the importance and significance of coding
- Classify data according to the various class intervals
10.2 MEANING, IMPORTANCE AND PROCESS OF DATA ANALYSIS

Research does not merely consist of data that is collected. Research is incomplete without proper analysis of the collected data. Processing of data involves analysis and manipulation of the collected data by performing various functions. The data has to be processed in accordance with the outline laid down at the time of developing the research plan. Processing of data is essential for ensuring that all relevant data has been collected to perform comparisons and analyses. The functions that can be performed on data are as follows:

- Editing
- Coding
- Tabulation
- Classification

Usually, experts are of the opinion that the exercise of processing and analysing of data is inter-related. Therefore, the two should be thought as one and the same thing. It is argued that analysis of data generally involves a number of closely-related operations, which are carried out with the objective of summarizing the collected data and organizing it in such a way that they are able to answer the research questions associated with it.

However, in technical terms, processing of data involves data representation in a way that it is open to analysis. Similarly, analysis of data is defined as the computation of certain measures along with searching for the patterns of relationship that may exist among data groups.

10.2.1 Editing of Data

Editing of data involves the testing of data collection instruments in order to ensure maximum accuracy. This includes checking the legibility, consistency and completeness of the data. The editing process aims at avoiding equivocation and ambiguity. The collected raw data is also examined to detect errors and omissions, if any. A careful scrutiny is performed on the completed questionnaires and schedules to assure that the data has the following features:

- Accuracy
- Consistency
- Unity
- Uniformity
- Effective arrangement

The stages at which editing should be performed can be classified as follows:

- **Field editing**: This involves reviewing the reporting forms, by the investigator, that are written in an abbreviated or illegible form by the informant at the
time of recording the respondent’s responses. Such type of editing must be done immediately after the interview. If performed after some time, such editing becomes complicated for the researcher, as it is difficult to decipher any particular individual’s writing style. The investigator needs to be careful while field editing and restrain the researcher from correcting errors or omission by guesswork.

- **Central editing**: This kind of editing involves a thorough editing of the entire data by a single editor or a team of editors. It takes place when all the schedules created according to the research plan have been completed and returned to the researcher. Editors correct the errors such as data recorded in the wrong place or the data recorded in months when it should be recorded in weeks. They can provide an appropriate answer to incorrect or missing replies by reviewing the other information in the schedule. At times, the respondent can be contacted for clarification. In some cases, if the answer is inappropriate or incomplete and an accurate answer cannot be determined on any basis, then the editor should delete or remove that answer from the collected data. He/She can put a note as ‘no answer’ in this case. The answers that can be easily deciphered as wrong should be dropped from the final results.

Besides using the above-stated methods according to the data source, the researcher should also keep in mind the following points while editing:

- Familiarity with the instructions given to interviewers and coders
- Know-how of editing instructions
- Single line striking for deleting of an original entry
- Standardized and distinctive editing of data
- Initialization of all answers that are changed

10.2.2 Coding of Data

The coding of data can be defined as representing the data symbolically using some predefined rules. Once data is coded and summarized, the researcher can analyse it and relationships can be found among its various categories.

**Checklist for coding**

This enables the researcher to classify the responses of the individuals according to a limited number of categories or classes. Such classes should possess the following important characteristics:

- Classes should be appropriate and in accordance to the research problem under consideration.
- They must include a class for every data element.
- There should be a mutual exclusivity, which means that a specific answer can be placed in one and only one cell of a given category set.
• The classes should be one-dimensional. This means that every class is defined in terms of only one concept.

Significance of coding

Coding of data is necessary for its efficient analysis. Coding facilitates reduction of data from a variety to a small number of classes. Thus, only that information which is important and critical for analysis is retained in the research. Coding decisions are usually taken at the designing stage of the questionnaire. This makes it possible to pre-code the questionnaire choices, which in turn, is helpful for computer tabulation.

However, in case of hand coding, some standard method should be used. One such method is to code in the margin with a coloured pencil. The other method is to transcribe data from the questionnaire to a coding sheet. Whatever method is adopted, you should ensure that coding errors are altogether eliminated or reduced to a minimum level.

10.2.3 Classification of Data

Research studies involve extensive collection of raw data and usage of the data to implement the research plan. To make the research plan easier, the data needs to be classified in different groups for understanding the relationship among the different phases of the research plan. Classification of data involves arrangement of data in groups or classes on the basis of some common characteristics. The methods of classification can be divided under the following two headings:

• Classification according to attributes
• Classification according to class intervals

Figure 10.1 shows the categories of data.
Classification of data according to attributes

Data is classified on the basis of similar features as follows:

- **Descriptive classification:** This classification is performed according to the qualitative features and attributes which cannot be measured quantitatively. These features can be either present or absent in an individual or an element. The features related to descriptive classification of attributes can be literacy, sex, honesty, solidarity, etc.

- **Simple classification:** In this classification the elements of data are categorized on the basis of those that possess the concerned attribute and those that do not.

- **Manifold classification:** In this classification two or more attributes are considered simultaneously and the data is categorized into a number of classes on the basis of those attributes. The total number of classes of final order is given by \(2^n\), where \(n\) = number of attributes considered.

Classification of data according to class intervals

Classifying data according to the class intervals is a quantitative phenomenon. Class intervals help categorize the data with similar numerical characteristics, such as income, production, age, weight, etc. Data can be measured through some statistical tools like mean, mode, median, etc. The different categories of data according to class intervals are as follows:

- **Statistics of variables:** This term refers to the measurable attributes, as these typically vary over time or between individuals. The variables can be discrete, i.e., taking values from a countable or finite set, continuous, i.e., having a continuous distribution function, or neither. This concept of variable is widely utilized in the social, natural and medical sciences.

- **Class intervals:** They refer to a range of values of a variable. This interval is used to break up the scale of the variable in order to tabulate the frequency distribution of a sample. A suitable example of such data classification can be given by means of categorizing the birth rate of a country. In this case, babies aged zero to one year will form a group; those aged two to five years will form another group, and so on. The entire data is thus categorized into several numbers of groups or classes or in other words, class intervals. Each class interval has an upper limit as well as a lower limit, which is defined as ‘the class limit.’ The difference between two class limits is known as class magnitude. Classes can have equal or unequal class magnitudes.

  The number of elements, which come under a given class, is called the frequency of the given class interval. All class intervals, with their respective frequencies, are taken together and described in a tabular form called the frequency distribution.
Problems related to classification of data

The problems related to classification of data on the basis of class intervals are divided into the following three categories:

(i) **Number of classes and their magnitude:** There are differences regarding the number of classes into which data can be classified. As such, there are no pre-defined rules for the classification of data. It all depends upon the skill and experience of the researcher. The researcher should display the data in such a way that it should be clear and meaningful to the analyst. As regards the magnitude of classes, it is usually held that class intervals should be of equal magnitude, but in some cases unequal magnitudes may result in a better classification. It is the researcher’s objective and judgement that plays a significant role in this regard. In general, multiples of two, five and ten are preferred while determining class magnitudes. H.A. Sturges suggested the following formula to determine the size of class interval:

\[
i = \frac{R}{N}
\]

where,

- \(i\) = size of class interval
- \(R\) = Range (difference between the values of the largest element and smallest element among the given elements)
- \(N\) = Number of items to be grouped

Sometimes, data may contain one or two or very few elements with very high or very low values. In such cases, the researcher can use an open-ended interval in the overall frequency distribution. Such intervals can be expressed below two years; or twelve years and above. However, such intervals are not desirable, yet cannot be avoided.

(ii) **Choice of class limits:** While choosing class limits, the researcher must determine the mid-point of a class interval. A mid-point is, generally, derived by taking the sum of the upper and lower limit of a class and then dividing it by two. The actual average of elements of that class interval should remain as close to each other as possible. In accordance with this principle, the class limits should be located at multiples of two, five, ten, twenty and hundred and such other figures. The class limits can generally be stated in any of the following forms:

- **Exclusive type class intervals:** These intervals are usually stated as follows:
  - 10–20
  - 20–30
  - 30–40
  - 40–50
These intervals should be read in the following way:

- 10 and under 20
- 20 and under 30
- 30 and under 40
- 40 and under 50

In the exclusive type of class intervals, the elements whose values are equal to the upper limit of a class are grouped in the next higher class. For example, an item whose value is exactly thirty would be put in 30–40-class interval and not in 20–30-class interval. In other words, an exclusive type of class interval is that in which the upper limit of a class interval is excluded and items with values less than the upper limit, but not less than the lower limit, are put in the given class interval.

**o Inclusive type class intervals:** These intervals are normally stated as follows:

- 11–20
- 21–30
- 31–40
- 41–50

This should be read as follows:

- 11 and under 21
- 21 and under 31
- 31 and under 41
- 41 and under 51

In this method, the upper limit of a class interval is also included in the concerning class interval. Thus, an element whose value is twenty will be put in 11–20-class interval. The stated upper limit of the class interval 11–20 is twenty but the real upper limit is 20.999999 and as such 11–20 class interval really means eleven and under twenty-one. When data to be classified happens to be a discrete one, then the inclusive type of classification should be applied. But when data happens to be a continuous one, the exclusive type of class intervals can be used.

**(iii) Determining the frequency of each class:** The frequency of each class can be determined using tally sheets or mechanical aids. In tally sheets, the class groups are written on a sheet of paper and for each item a stroke (a small vertical line) is marked against the class group in which it falls. The general practice is that after every four small vertical lines in a class group, the fifth line for the element falling in the same group is indicated as a diagonal line through the above said four lines. This enables the researcher to perform the counting of elements in each one of the class groups. Table 10.1 displays a hypothetical tally sheet.
In case of large inquiries and surveys, class frequencies can be determined by means of mechanical aids, i.e., with the help of machines. Such machines function, either manually or automatically and run on electricity. These machines can sort out cards at a speed of around 25,000 cards per hour. Although this method increases the speed, it is an expensive method.

10.2.4 Tabulation of Data

In simple terms, tabulation means placing the results and data collected from research in a tabular form.

Methods of tabulation

Tabulation can be done either manually or mechanically using various electronic devices. Several factors like the size and type of study, cost considerations, time pressures and availability of tabulating machines decide the choice of tabulation. Relatively large data requires computer tabulation. Manual tabulation is preferred in case of small inquiries, when the number of questionnaires is small and they are of relatively short length. The different methods used in hand tabulation are as follows:

- **Direct tally method**: This method involves simple codes, which the researcher can use to directly tally data with the questionnaire. The codes are written on a sheet of paper called tally sheet and for each response, a stroke is marked against the code in which it falls. Usually, after every four strokes against a particular code, the fifth response is indicated by drawing a diagonal or horizontal line through the strokes. These groups are easy to count and the data is sorted against each code conveniently.

- **List and tally method**: In this method, code responses may be transcribed into a large worksheet, allowing a line for each questionnaire. This facilitates listing of a large number of questionnaires in one worksheet. Tallies are then made for each question.

- **Card sort method**: This is the most flexible hand tabulation method, where the data is recorded on special cards that are of convenient sizes and shapes and have a series of holes. Each hole in the card stands for a code. When

<table>
<thead>
<tr>
<th>Income group (Response)</th>
<th>Tally mark</th>
<th>Number of families (Class frequency)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 600</td>
<td>III</td>
<td>8</td>
</tr>
<tr>
<td>601-900</td>
<td>III</td>
<td>11</td>
</tr>
<tr>
<td>901-1200</td>
<td>III</td>
<td>11</td>
</tr>
<tr>
<td>1301-1500</td>
<td>III</td>
<td>19</td>
</tr>
<tr>
<td>1501 and above</td>
<td>III</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>91</strong></td>
</tr>
</tbody>
</table>
the cards are stacked, a needle passes through a particular hole representing a particular code. These cards are then separated and counted. In this way, frequencies of various codes can be found out by the repetition of this technique.

**Significance of tabulation**

Tabulation enables the researcher to arrange data in a concise and logical order. It summarizes the raw data and displays the same in a compact form for further analysis. It helps in the orderly arrangement of data in rows and columns. The various advantages of tabulation of data are as follows:

- A table saves space and reduces descriptive and explanatory statements to the minimum.
- It facilitates and eases the comparison process.
- Summation of elements and detection of omissions and errors becomes easy in a tabular description.
- A table provides a basis for various statistical computations.

**Checklist for tables**

A table should communicate the required information to the reader in such a way that it becomes easy for him/her to read, comprehend and recall information when required. Certain conventions have to be followed during tabulation of data. These are as follows:

- All tables should have a clear, precise and adequate title to make them intelligible enough without any reference to the text.
- Tables should be featured with clarity and readability.
- Every table should be given a distinct number to facilitate an easy reference.
- The table should be of an appropriate size and tally with the required information.
- Headings for columns and rows should be in bold font letters. It is a general rule to include an independent variable in the left column or the first row. The dependent variable is contained in the bottom row or the right column.
- Numbers should be displayed such that they are neat and readable.
- Explanatory footnotes, if any, regarding the table should be placed directly beneath the table, along with the reference symbols used in the table.
- The source of the table should be indicated just below the table.
- The table should contain thick lines to separate data under one class from the data under another class and thin lines to separate the different subdivisions of the classes.
- All column figures should be properly aligned.
- Abbreviations should be avoided in a table to the best possible extent.
• If data happens to be large, then it should not be crowded in a single table. It makes the table unwieldy and inconvenient.

Tabulation can also be classified as complex and simple. The former type of tabulation gives information about one or more groups of independent variables, whereas, the latter shows the division of data in two or more categories.

10.2.5 Graphical Presentation

The data we collect can often be more easily understood for interpretation if it is presented graphically or pictorially. Diagrams and graphs give visual indications of magnitudes, groupings, trends and patterns in the data. These important features are more simply presented in the form of graphs. Also, diagrams facilitate comparisons between two or more sets of data.

The diagrams should be clear and easy to read and understand. Too much information should not be shown in the same diagram; otherwise, it may become cumbersome and confusing. Each diagram should include a brief and self-explanatory title dealing with the subject matter. The scale of the presentation should be chosen in such a way that the resulting diagram is of appropriate size. The intervals on the vertical as well as the horizontal axis should be of equal size; otherwise, distortions would occur.

Diagrams are more suitable to illustrate the data which is discrete, while continuous data is better represented by graphs. We will study about diagrammatic elucidation in detail in the next unit.

10.3 TYPES OF ANALYSIS

Analysis of data is the process of transforming data for the purpose of extracting useful information, which in turn facilitates the discovery of some useful conclusions. Finding conclusions from the analysed data is known as interpretation of data. However, if the analysis is done, in the case of experimental data or survey, then the value of the unknown parameters of the population and hypothesis testing is estimated.

Analysis of data can be either descriptive or inferential. Inferential analysis is also known as statistical analysis. The descriptive analysis is used to describe the basic features of the data in a study such as persons, work groups and organizations. The inferential analysis is used to make inferences from the data, which means that we are trying to understand some process and make some possible predictions based on this understanding.

The three types of analyses are as follows:

(i) Multiple regression analysis: This type of analysis is used to predict a single dependent variable by a set of independent variables. In multiple regression analysis, the independent variables are not correlated to each other.
(ii) **Multiple discriminant analysis:** In multiple discriminant analysis, there is one single dependent variable, which is very difficult to measure. One of the main objectives of this type of analysis is to understand the group differences and predict the likelihood that an entity, i.e., an individual or an object, belongs to a particular class or group based on several metric-independent variables.

(iii) ** Canonical correlation analysis:** It is a method for assessing the relationship between variables. This analysis also allows you to investigate the relationship between two sets of variables.

### 10.3.1 Univariate, Bivariate and Multivariate Analysis

Many types of analyses are performed according to the variance that exists in the data. Such analyses is carried out to check if the differences between three or more variables are significant enough to evaluate them statistically. There are three types of such analyses; namely, univariate, bivariate and multivariate analyses. These types are explained below:

(i) **Univariate analysis:** In this analysis, only a single variable is taken into consideration. It is usually the first activity pursued while analysing the data. It is performed with the purpose of describing each variable in terms of mean, median or mode, and variability. Examples of such analysis are averages or a set of cases that may come under a specific category amidst a whole sample.

(ii) **Bivariate analysis:** This type of examines the relationship between two variables. It tries to find the extent of association that exists among these variables. Thus, a bivariate analysis may help you; for example, to find whether the variables of irregular meals and migraine headaches are associate; and up to what extent. Here, two variables are thus statistically measured simultaneously.

(iii) **Multivariate analysis:** This type of analysis involves observation and analysis of three or more than three statistical variables at a time. Such an analysis is performed using statistical tests or even in a tabular format. Thus, for example, you can study the variables of age, educational qualification and annual income of a given set of population at the same time using the multivariate analysis method.

Usually, these types of analyses are more convenient when performed in a tabular format. This involves, using a cross-classification or contingency table. Such a table is made of two columns and two rows, showing the frequencies of two variables that are displayed in rows and columns. This is more popularly known as constructing the bivariate table. Traditionally, the independent variable
is displayed in columns and the dependent ones in rows. A multivariate table, if related to the same data, is the result of combining the bivariate tables. In this case, each bivariate table is known as partial table. Usually, a multivariate table is created with the purpose of explaining or replicating the primary relationship that is found in the bivariate table. Table 10.2(a) and (b) shows an example of a bivariate table and a multivariate table.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of students failed</td>
<td>33 per cent</td>
<td>38 per cent</td>
<td>42 per cent</td>
</tr>
<tr>
<td>Percentage of students passed</td>
<td>67 per cent</td>
<td>62 per cent</td>
<td>58 per cent</td>
</tr>
</tbody>
</table>

Table 10.2 (b) Multivariate Table

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>First Attempt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage of students who passed in Maths</td>
<td>27 per cent</td>
<td>35 per cent</td>
<td>--</td>
</tr>
<tr>
<td>Second Attempt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage of students who passed in English</td>
<td>53 per cent</td>
<td>60 per cent</td>
<td>44 per cent</td>
</tr>
<tr>
<td>Third Attempt</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although the data in both tables is related, except the variable of “attempts”, the multivariate table has been displayed separately in this example. However, you should note that the tables have dealt simultaneously with two or more variables of the data.

Data interpretation

Data interpretation refers to the identification of trends in different variables. The researcher uses statistics for this purpose. The researcher is required to be familiar with the knowledge of the scales of measurement. This enables him/her to choose the appropriate statistical method for his/her research project. The scales of measurement facilitate the allotment of numerical values to characteristics adhering to any specific rules. This measurement is also related to such levels of measurement of data like nominal, ordinal and internal and ratio levels. These levels can be explained as follows:

- **Nominal measurement**: The nominal measurement assigns a numeral value to a specific characteristic. It is the fundamental form of measurement. The nominal measurement calculates the lowest level of data available for measurement.

- **Ordinal measurement**: This type of measurement involves allotting a specific feature to numeral value in terms of a specific order. The ordinal scale displays the way in which the entity is measured. The ordinal scale of measurement is used to calculate and derive data pertaining to the median, percentage, rank order, correlations and percentile.

- **Interval measurement**: A researcher can depict the difference between the first aspect of a data and another aspect using this level of measurement.
The interval scale of measurement is useful for the researcher in several ways. It can be applied in the calculation of arithmetic mean, averages, standard deviations and determining correlation between different variables.

- **Ratio measurement**: In this method, there are fixed proportions (ratio) between the number numerical and the amount of the characteristics that it represents. A researcher should remember while measuring the ratio levels that, a fixed zero point exists. The ratio level of measurement facilitates researchers in determining, if the aspects possess any certain characteristic. Almost any type of arithmetical calculations can be executed using this scale of measurement.

The most important feature of any measuring scale is its reliability and validity, which is explained as follows:

- **Reliability**: It is the term used to deal with accuracy. A scale measurement can be said to be reliable, when it exactly measures, only that what it is supposed to measure. In other words, when the same researcher repeats a test, i.e., with a different group but resembling the original group, he/she should get the same results as the former.

- **Validity**: According to Leedy, validity is the assessment of the soundness and the effectiveness of the measuring instrument. There are four types of validity, which can be stated as follows:
  - **Content validity**: It deals with the accuracy with which an instrument measures the factors or content of the course or situations of the research study.
  - **Prognostic validity**: It depends on the possibility to make judgements from results obtained by the concerned measuring instrument. The judgement is future oriented.
  - **Simultaneous validity**: This involves comparing of one measuring instrument with another; one that measures the same characteristic and is available immediately.

**Multiple regression analysis**

Multiple regression analysis is a statistical tool that helps the researchers to evaluate the effect of different factors on the consequences occurring at the same time. It analyzes the relationship between several independent or predictor variables and a dependent variable. In research technology, regression analysis is used to investigate a particular set of predictors and to show differences in the consequences that occur. Generally, regression is used to determine the effect of the specific factors along with the other factors that influence these consequences. The researchers use algebraic methods to analyze the result by making a group of factors associated with a particular phenomenon as a constant. According to the dictionary meaning, the multiple regression is a statistical technique that predicts values of one variable on the basis of two or more other variables.
NOTES

Multiple regression and statistics: The term ‘multiple regression’ was first given by Pearson. The regression is of two types, simple and multiple and both the regression techniques are related to the Analysis Of Variance (ANOVA). Of these, multiple regression is the simplest method in comparison to other multivariate statistical techniques.

Multiple regression and mathematics: The multiple regression technique is used in mathematics to formulate simple regression equations, and to evaluate the best fitting curve for a straight line along the dots on an x-y plot or a scattergram.

Check Your Progress
1. What do you mean by processing of data?
2. List the functions that can be performed on data.
3. What is ‘field editing’?
4. Data can be classified into three categories. What are they?
5. List three types of analyses.

10.4 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Research is incomplete without proper analysis of the collected data. Processing of data involves analysis and manipulation of the collected data by performing various functions.

2. The functions that can be performed on data are:
   - Editing
   - Coding
   - Tabulation
   - Classification

3. The method of field editing involves reviewing reporting forms by the investigator that are written in an abbreviated form by the informant. This kind of editing is usually done immediately after the interview.

4. Data can be classified into three categories, they are, descriptive classification, simple classification and manifold classification.

5. Three types of analyses are:
   - Multiple regression analysis
   - Multiple discriminant analysis
   - Canonical correlation analysis
10.5 SUMMARY

- Research does not merely consist of data that is collected. Research is incomplete without proper analysis of the collected data.
- Data processing involves analysis and manipulation of the collected data by performing various functions. The data has to be processed in accordance with the outline laid down when the research plan is being developed.
- Editing of data involves the testing of data collection instruments in order to ensure maximum accuracy.
- A collected data must have five features, such as accuracy, consistency, unity, uniformity and effective arrangement.
- Representing the data symbolically by using some predefined rules is termed as coding of data. Coding of data is very much essential for performing efficient analysis.
- Data can be classified into three categories according to attributes and into two as per class intervals.
- Tabulation means placing the results and data collected from research in a tabular form. Tabulation can be done either mechanically or manually using various electronic devices.
- The process of tabulation enables the researcher to arrange data in a concise and logical order. It summarizes raw data and displays the same in a compact form for further analysis.
- Analysis of data is the process of transforming data for the purpose of extracting useful information, which in turn facilitates the discovery of some useful conclusions.
- Analysis of data can be either descriptive or inferential. Inferential analysis is also known as statistical analysis.
- The descriptive analysis is used to describe the basic features of the data in a study such as persons, work groups and organizations.
- The inferential analysis is used to make inferences from the data, which means that we are trying to understand some process and make some possible predictions based on this understanding.
- Many types of analyses are performed according to the variance that exists in the data. Such analyses are carried out to check if the differences between three or more variables are significant enough to evaluate them statistically.
- Data interpretation refers to the identification of trends in different variables. The researcher uses statistics for this purpose.
- Multiple regression analysis is a statistical tool that helps the researchers to evaluate the effect of different factors on the consequences occurring at the same time.
Multiple regression analyses the relationship between several independent or predictor variables and a dependent variable.

10.6 KEY WORDS

- **Coding of Data**: It refers to a symbolic representation of data using some predefined rules.
- **Analysis of Data**: It refers to the process of transforming data for the purpose of extracting useful information.
- **Multiple Regression Analysis**: It is a statistical tool that helps the researchers to evaluate the effect of different factors on the consequences occurring at the same time.

10.7 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short Answer Questions

1. What is processing and data analysis?
2. What is central editing?
3. Briefly mention the significance of coding.
4. Write a short note on the classification of data according to attributes.

Long Answer Questions

1. Examine the classification of data.
2. What are the problems related to classification of data? Discuss.
3. Define tabulation and explain its methods. What is its significance?

10.8 FURTHER READINGS


UNIT 11 REPORT WRITING

Structure
11.0 Introduction
11.1 Objectives
11.2 Overview of Writing Research Reports
  11.2.1 Contents of a Research Report
  11.2.2 Format of a Research Report
  11.2.3 Precautions While Writing Research Report
11.3 Preparation of Research Project Proposal
11.4 Agencies Involved in Social Work Research
11.5 Answers to Check Your Progress Questions
11.6 Summary
11.7 Key Words
11.8 Self Assessment Questions and Exercises
11.9 Further Readings

11.0 INTRODUCTION

A research report is a formal statement of the research process and its results. A research activity is concluded by presenting results that include both major and minor recommendations. The reporting of a research study depends on the purpose with which it was undertaken. 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. They narrate the problem studied, method used for studying it, and the findings and conclusions of the study. The purpose of writing a research report is to communicate to interested people, the methodology and results of the study in such a manner as to enable them to understand the research process and to determine the validity of the conclusions. The aim of the report is not to convince the reader about the value of the result, but to convey to him what was done, why it was done and what was the outcome. In this unit, you will learn about the content and format; mechanics of writing research reports and precautions of writing reports and the preparation of research project proposal along with agencies involved in social work research.

11.1 OBJECTIVES

After going through this unit, you will be able to:
- Examine the content, format, mechanics of writing research reports and precautions
- Describe the preparation of research project proposal
- Discuss the agencies involved in social work research
11.2 OVERVIEW OF WRITING RESEARCH REPORTS

The utility of a research report is proved only after others know about its findings. A genuine research experience essentially comprises preparing a detailed documented research report. Every student of research should know about this requirement. However, though this is an added benefit, it cannot replace a complete report that has been documented well. A well-written report is created by a student with absolute analysis and is corrected as required by the faculty mentor. It demonstrates that the student has thorough knowledge about the range of the problem, the means/instrumental methods used and development of the outcome. It is very important for any undergraduate research project to result in a systematic and well-documented report. The outcome of the research should always be recorded and made available to the general public.

Thus, documentation of a research report is an important affair. Generally, the activities of presenting research results, or documenting the report, are considered important for a research project. Actually speaking, documentation of the report is the final step of a research study, which requires different skill sets. These skills are not the same as those used in the earlier stages of research. The researcher should be very careful in achieving this objective, for which he is likely to seek the assistance and guidance of experts.

Steps in Report Writing

A good number of scientific research reports, irrespective of the subject, use similar methods of scientific interpretation. That is: the problem is defined, a hypothesis is created and experiments are worked out for testing the hypothesis and drawing conclusions. The exact format of scientific reports is often regulated in terms of variations in order and content. The student is motivated to use the style that is most suited to the discipline of the research. Many journals offer a formatting template to aid the author. Tedious, measured and precise inductive efforts are involved in creating research reports. The common steps involved in writing reports are:

- Logical analysis of the subject matter
- Preparation of the final outline
- Preparation of the rough draft
- Rewriting and polishing
- Preparation of the final bibliography
- Writing the final draft

Though all these steps are self-explanatory, yet a brief mention of each one of these will be appropriate for their better understanding.
Logical analysis of the subject matter: It is the first step which is primarily concerned with development of a subject. There are two ways in which to develop a subject: (i) Logical, and (ii) Chronological.

Logical developments are based on rational associations and links between concerned entities, by means of analysis. Logical treatment often comprises developing the material from the simplest possible to the most complex structures. The basis of chronological development is connectivity or sequence between time and occurrence. The instructions for creating or working on something, normally have a chronological flow.

Preparation of the final outline: It is the next step in writing the research report. Outlines are the framework on which long written works are constructed. They support the logical functioning of material and reminder of the points to be focused on in the report.

Preparation of the rough draft: This follows a logical analysis of the subject and preparation of the final outline. Such a step is of utmost importance to the researcher, who now sits to write what he has done in the context of his research study. He will write down the procedure adopted by him in collecting the material for his study, along with various limitations faced by him, the technique of analysis adopted by him, the broad findings, and generalizations and various suggestions he wants to offer regarding the concerned problem.

Rewriting and polishing of the rough draft: This step happens to be the most difficult part of formal writing. Usually this step requires more time than writing of the rough draft. A careful revision marks the difference between a mediocre and a good piece of writing. While rewriting and polishing, one should check the report for weaknesses in logical development or presentation. The researcher should also see whether or not, the material, as it is presented, has unity and cohesion; and whether the report stand upright and firm, and exhibit a definite pattern, like a marble arch. In addition, the researcher should give due attention to consistency factor in his rough draft. He should check the mechanics of writing—grammar and spelling.

Preparation of the final bibliography: Next in order comes the task of the preparation of the final bibliography. The bibliography, which is generally appended to the research report, is a list of books, which is in some way pertinent to the research which has been done. It should contain all those works consulted by the researcher. The bibliography should be arranged alphabetically and may be divided into two parts; the first part may contain the names of books and pamphlets and the second part may contain the names of magazine and newspaper articles. Generally, this pattern of bibliography is considered convenient and satisfactory from the point of view of the reader, though it is not the only way of presenting bibliography.

Writing the final draft: This constitutes the last step. The final draft should be written in a concise and objective style and in simple language, avoiding vague
expressions such as ‘it seems’, ‘there may be’, etc. At the time of documenting the final draft, a researcher must elude intangible terms and scientific slangs. Exhibits and instances of common experiences should be made integral part of the final draft because they prove very helpful to communicate the outcome of the research to others.

A research report should attract interest and be original. People should find it enthusiastic and appealing. However, it should be kept in mind that the focus of every report should be directed at solving some intellectual problem, must contribute to the solution of a problem, and must add to the knowledge of both the researcher and the reader.

11.2.1 Contents of a Research Report

The content of a research report may vary according to institutional or publication requirements. Before a researcher sits down to write, he should find out the requirements of the academic institution, funding agency or the publication agency. An outline of the contents of a typical report is given in this section.

This part introduces the topic or problem under investigation and its importance. This gives a theoretical background to the specific area of investigation and states the problem under investigation with specific reference to its placement in the broader area under study. This also describes the significance of the present problem. It also states about objectives of the study, important terms used in the study that would be tested through statistical analysis of data, and the scope and limitations of the investigation.

Background of the problem: Outlines the problem area, studies done in this area, the findings of such studies, the areas not explored, and areas that need further investigation. This section summarizes the theory or conceptual framework within which the problem has been investigated.

Need for the study: In this section, the reason and method of selecting the problem are stated. The problem is clearly defined and its facets and significance are pointed out. The researcher explains the need for the study by quoting available statistics, where needed. He also mentions the recommendations of other researchers suggesting further investigation of the problem and justifying the need for doing the present study.

Problem statement: The problem statement should indicate the nature of the study, e.g., to find the relationship between two entities, to compare the performance of both, to explore or to answer specific questions, etc.

Statement of objectives: The objectives of the study and the investigative questions relating to each of the objectives are presented. The objectives are written in observable and measurable terms. Each objective states one purpose, which may be stated in declarative or question format. For example: do families prefer to use untrained dais when trained personnel are available?
This can be stated in a declarative form: e.g., to identify the preference of families, regarding their choice of untrained dais when trained personnel are available, etc.

**Rationale for the study:** This could be developed into a theoretical/conceptual framework to support the investigation, development of hypothesis, construction of instrument, and analysis and interpretation of findings.

**Operational definitions:** All variables are defined in a way that indicates how they are observed and measured.

**Scope and limitation:** Scope indicates the areas that are covered and where the results could be applied, whereas the delimitation indicates what the researcher is not investigating, and the limitations that are taken into consideration while planning the research.

For writing a thesis or a monograph, these points are usually taken into consideration, whereas in the case of an article, these descriptions are included in the introductory section of the article covering three to four paragraphs.

**Review of Literature**

Review of literature is the first task for a research, in order to decide on a specific problem for investigation. It also helps in formulating a theoretical framework for the entire study. It helps the researcher in formulating broader assumptions about the factors/variables involved in the problem, and the latter develops a hypothesis for the study. There are different sections in the report on review of literature. The first paragraph usually contains the reviewed areas of the related literature and outline of the presentation. While organizing a written report, the broad areas should be presented first followed by specific areas.

In a thesis while presenting the review of research literature, a brief description of the research is given, including design, analysis and findings. The reviewer also emphasizes on what areas are explored and what is yet to be studied. It must keep in mind that the reviewed literature has to be critically analysed and summarized in terms of agreements and disagreements among authors and researchers. This is done in order to justify the necessity for conducting the investigation.

Sometimes non-research literature is also included in the review, but this mostly comprises theories and principles. The writer should acknowledge all sources of literature, using accepted form of presentation. At the end of the chapter, he may summarize the review presented.

A theoretical framework may follow the review of literature. It is important to bring out a comprehensive summary in the last paragraph of the literature. For an article, usually a paragraph or two are written on the related research review.

**Mechanics Involved**

This part of report-writing consists of the following:

(i) Description of research methodology

(ii) Description of dependent and independent variables
(iii) Sample defining the population and the sampling procedure, followed by selection of the sample

(iv) Description of the tool and techniques used in the study

(v) Description of statistical techniques used in the analysis of data

The summary of the chapter is a necessity if the chapter is long. This is the third chapter of the thesis report. The organization of different section may vary on which comes first or second because there is no hard-and-fast rule about it. The writer uses his intuition and logic. At times, the use of figures becomes necessary to show the design or relation of variables.

If the researcher has used a standardized tool or an instrument prepared by some other researcher, he needs to take the author’s (instrument) permission. There are tests that are confidential in nature, in which case the instrument is not given in the Appendix. This is also a major section in an article. A brief description of each of the sub-section is mentioned. Usually the content is presented under the heading of method or research design and covers at least 4–5 paragraphs in the article.

Data Analysis and Interpretation

This is one of the major chapters/sections which present: (a) Methods used for analysis, and (b) Findings of the study.

It is a logical development of analysis presented according to the objectives and hypothesis stated earlier. The most common methods of presentation of descriptive analysis are: (i) use of table and graphs to present data, (ii) statistical analysis for the test of significance by stating the null-hypothesis, and (iii) indicating the result of the test of significance.

Usually, interpretation of statistical analysis is done as the author presents each table or graph. Testing of hypothesis should indicate rejection or acceptance of null hypothesis and all its interpretation. At the end of analysis chapter, a summary of major findings are present following a discussion of findings. In a thesis or monograph, sometimes a chapter is written on discussion of the findings where the author compares the present result with findings of other studies indicating the similarities and differences. This may be presented in one or chapter 1 forming either the fourth chapter or the fourth and fifth chapters. Data analysis and discussion constitute the main body of the article. The article also includes essential tables and figures. Discussion is presented under a separate heading.

Summary, Conclusion, Implication and Recommendations

This part of the text should be a self-contained summary of the whole report, containing a synopsis of essential background information, findings, conclusions and recommendations. Research steps, including a list of major findings, usually tables and figures, are not used.
All expected and unexpected findings and conclusions drawn from each of the findings are presented. Findings are statements of factual information, based upon the analysis of data. It also explains the extent to which generalization of results can be made. The researcher also mentions the reasons due to which the hypothesis tested is not found to be significant.

The implication indicates the author’s reflective thinking, in terms of possible application of the result. For example, if the survey indicates that 70 per cent of pregnant women are anaemic, the implications may be written on the probable reasons for anaemia and what health care strategies can be adopted to improve the status. In other words, the implications suggest the values of these findings in terms of patient care for educational changes or the administrative strategies to be adopted.

Limitations of the present study are noted here. Limitations are those restrictions or a problem, which the researcher had not deliberately planned out but comes across while conducting the study.

The recommendations give direction to future research and suggestions for improving the present study. They should be specific and should not merely be vague statements. Recommendations indicate other aspects of the action suggested.

Besides a summary, an abstract is prepared (executive summary) which usually contains 500–1000 words.

In an article, two or three paragraphs are written to discuss implications. A short summary is made, which usually works as a synopsis at the beginning of the article.

Appendices, Bibliography, References

An appendix is the first of the terminal items presented at the end of the research report. 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 only include studies, books or papers that have actually been referred to, in the text of the research report. An approved style is to be adopted to write the references and bibliography.

Acknowledgement, Preface, Table of Content

Acknowledgement, table of content, list of tables and figures, are included in the first part of the research report. The monograph, in addition, also includes a page on preface. Articles do not require this section.

11.2.2 Format of a Research Report

Research reports usually follow the structure given below or modified according to institution’s specification.
### Beginning
- Cover or title page
- Acknowledgement
- Table of contents
- List of tables
- List of figures and illustrations
- Glossary

### The main body
- Introduction
- Review of literature
- Design of study
- Analysis and interpretation of data
- Major findings
- Conclusions and discussions
- Summary

### Research Abstracts
As the name suggests, this refers to the short summary of the entire report made to serve as the guide for quick ascertainment of the paper’s purpose. It should be less than 250 words or approximately of a paragraph’s length. It should contain vital elements like the introduction, purpose, brief description of methodology, summary of results obtained and conclusion. The report writers should keep in mind that it is supposed to be a stand-alone, independent document.

### Bibliography and references
References include all books/journals/reports, etc., referred or quoted by the author. A **bibliography** includes the entire literature source, surveyed and found relevant and useful, which may or may not have been quoted or referred to in the text.

### Appendix
This section contains:
(i) Important correspondence, mainly with reference to permission for the study, subjects, willingness, request to experts, etc.
(ii) Instrument; the final form of the tool and the key sheet for storing the master data sheet.
(iii) Description of treatment variable.
(iv) Any other important and relevant document that explains or brings clarity to the report.
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., (Kothari, 1988). If a few lines or sentences are actually quoted from a source, the page number too, should be noted, e.g., 'Kothari, 1988: 120–124'. Besides, full reference should be placed in the ‘Reference’ section of the report. Usually, though traditional style of giving references is to place them as 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 the tedious effort of consulting references at the end of the report, time and again. In certain cases, footnotes include explanatory statements, full form of 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 for these types of footnotes.

Difference Between Footnotes, References, And Bibliography

- Footnotes are presented at the bottom of the page they are mentioned, numerically. Bibliography on the other hand, always appears at the end of the entire text in an alphabetical order. References are mentioned in numerical order as per the in-text citations and appear before the bibliography.
- Footnotes contain all the material that has been referenced in the text, with corresponding marking (number or symbol) at the bottom of the page. However, in case of a bibliography, the referenced texts are not numbered and the author might choose to only include topics which he/she considers important. As mentioned earlier, the bibliography contains all the materials which have been consulted for authorizing the text, this means that the may also contain texts which are not directly mentioned in the text itself.

Methods of Referencing

There are many different styles of referencing available which the can be used as a standard in the particular organization. The selection will vary as per the norms and company needs. Various referencing styles include the American Psychological Association (APA) styles, the Chicago Manual of Style, Modern Language Association citation, Harvard referencing, Oxford referencing, MHRA referencing, etc.

Each referencing style has its own manner of citing information. For example, the author-date style in the text is used in APA, MLA and Harvard style, whereas Oxford and Chicago styles use the document-note style to mention the author’s name in the footnote or the endnote. Other information like the date, page number, etc. are also presented differently.
11.2.3 Precautions While Writing Research Report

A research report is a channel that communicates the results of a research to those who read it. A good research report performs this task in an efficient and effective manner. The points to be kept in mind while preparing a report are as follows:

(i) At the time of deciding the length of the report (since research reports vary greatly in length), it is important to bear in mind that it should be sufficiently long to cover the subject and equally short to capture interest.

(ii) As far as possible, care should be taken to ensure that no research report is dull. It should have the ability to sustain the reader’s interest.

(iii) A research report should not have non-figurative terms and technical jargon. The language of the report should be as simple as possible. This means that the style of the report should objective and easy to understand, without expressions of uncertainty like ‘it seems’, ‘there may be’, etc.

(iv) A reader would always prefer that the design of the report is such that he can get maximum information with minimum effort. This can be facilitated by using charts, graphs and statistical tables within the main report, in addition to the summary of important findings.

(v) The layout of the report should be planned well and should be suitable to the purpose of the research problem.

(vi) There should be no grammatical errors in the report and it should follow the techniques of composition of report-writing, such as the use of quotations, footnotes, documentation, proper punctuation, abbreviations in footnotes, etc.

(vii) The report must present a logical analysis of the subject matter. It must reflect a structure wherein the different pieces of analysis relating to the research problem fit well.

(viii) A research report should be original and should essentially be directed at solving an intellectual problem. It must contribute to the solution of a problem and add to the store of knowledge.

(ix) Towards the end, the report must also state the policy implications relating to the problem under consideration. It is usually considered desirable, if the report makes a forecast of the probable future of the subject concerned and indicates the kinds of research that still needs to be done in that particular field.

(x) Appendices should be enlisted with respect of all technical data in the report.

(xi) Bibliography of sources consulted is a must for a good report and must necessarily be given.

(xii) The index is also considered an essential part of a good report and as such must be prepared and appended at the end.
A report must be attractive in appearance, neat and clean, whether typed or printed.

Calculated confidence limits must be mentioned and various constraints experienced in conducting the research study may also be stated in the report.

The objective of the study, nature of the problem, methods employed and the analysis techniques adopted must all be clearly stated in the beginning of the report, in the form of introduction.

Check Your Progress
1. Mention the two ways of developing a subject for a research.
2. What should a researcher avoid while writing a final draft of a research?
3. How does a review of literature help the researcher?
4. What are the most common methods of presenting a descriptive analysis of a report?

11.3 PREPARATION OF RESEARCH PROJECT PROPOSAL

Proposals, like letters and reports, constitute a widely used piece of written communication in business. In the market place, in business organizations, varied proposals are put up from one party to the other or from one authority to the other for their consideration. Proposal refers to an act of proposing or suggesting a plan, task, event, etc. Proposals are examples of persuasive communication. In general, proposals are put up for the consideration of the appropriate party or authority. A proposal is an offer to do something or a request for some sanction or permission. Proposals relate to an idea that needs to be sold. The purpose of any proposal is to persuade the reader to consider the idea favorably and permit to put into action. Proposals put up in business organizations are of a wide variety.

Business Proposals are of a wide variety such as credit sanction proposal, new premises proposal, new office proposal, staff allocation proposal, sales proposal and project proposal. Any proposal in the business context seeks allocation of resources. These resources may be funds, men and material, office space, vehicles and so on. A proposal while seeking the allocation of resources should substantiate the need and make out a case. The details to be included and the format to be selected in putting up a proposal would vary depending upon the nature of the proposal. Those proposals seeking grants and allocation of substantial funds and other resources need to include elaborate details and should be as per the format prescribed, if any.
Proposals, in general, should feature the following points:

- **State your idea or plan:** The proposal should start with a clear statement of the idea or plan of the proposer. The nature and scope of the proposal or idea and its purpose and limitations should be clearly defined. If the reader is familiar with the idea, no detailed background need be given. On the other hand, when the reader or the sanctioning authority is not very familiar, a suitable note explaining the context would be appropriate.

- **Be logical and persuasive:** Any good proposal should make a logical and persuasive pitch. The purpose to be achieved and the advantages or benefits that would follow should be clearly brought out. Step by step, the proposal document should build up the case for pursuing the proposal or plan proposed. The stronger and more irrefutable the case, better would be the chances of their being considered favourably.

- **Elucidate how to proceed:** Having defined and logically presented the proposal, follow it up by stating how to proceed. Mention the actions involved in taking the proposal forward, the constraints to be dealt with, the time frame and other logistics involved in putting the proposal into action. Like in any business document, the following aspects of the proposal should be clear.
  - **Title of the proposal:** Give a catchy title to your proposal that clearly states the central idea. For example, “Proposal for Creating a Marketing Taskforce”, or “Proposal for Reorganizing the Regional Offices”, or “Proposal for Grant of Funds for a Marketing Survey”.
  - **Headings and Sub-Headings:** Make the document reader-friendly and appealing by developing your case through several headings and sub-headings. Headings like Finance, Manpower and Premises with appropriate sub-headings like Capital Investment and Monthly Expenses; Managers and Technicians; Office Premises and Godowns, etc. would enhance readability and make the requirement explicit. The headings and sub-headings should cover all important aspects relevant in considering the proposal.

- **Anticipate challenges and objections:** A good proposal also anticipates likely objections and provides answers. It raises probable doubts and provides clarifications. Issues likely to arise such as staff constraints, environmental concerns and productivity and profitability aspects should be foreseen and addressed. Wherever possible, expert opinions, market related and competitor initiated measures, and cost-benefit analysis should be built into the proposal. The idea is to convince the recipient of the proposal that all relevant issues have been anticipated and addressed in putting up the proposal.

Proposals, as already noted, are a form of persuasive communication. They relate to an idea, suggestion or a plan that needs to be sold. It is put up for the
consideration of the authority concerned seeking resources, financial grants or permission to go ahead. Like a good sales letter or any good persuasive communication, proposals should be properly presented. The cover should be neat, elegant and appealing. The contents should be well organized and the page layout, font, spacing, margins and other such features need careful attention. When the document is lengthy, there should be a Summary at the beginning covering the synopsis and the highlights of the proposal details contained in the document.

Good proposals reflect the confidence and enthusiasm of the person putting up the proposal. A good proposal should have the right tone. It should radiate the confidence and urgency that are relevant for its favorable consideration. It should be prepared and put up without delay and well in time, especially when deadlines are involved. Good proposals should use vigorous words and should not follow a drab, matter-of-fact style.

**Project Proposals**

A project proposal, as the name indicates, is a proposal for undertaking a project. Since any proposal is a kind of persuasion, a project proposal puts forth clearly the nature of and need for undertaking the project. A project could be a plan, a task, a turn-key job, an assignment or a research study. A project proposal may be internal or external. It may be submitted by a department within an organization to the sanctioning authority or senior management. Externally, it may relate from one business organization to the other, which has a need for that facility. Preparation of a project report requires substantial skills.

A typical project may involve the following:

- **Technical feasibility:** To decide whether in terms of technical aspects, the project is doable. If so, then details of availability, expertise, time frame, quality and level of sophistication should be worked on.

- **Economic viability:** To decide whether the project has merits in terms of demand and supply, resources to be put to use, environmental and seasonal factors and so on.

- **Financial strength:** To decide what kinds of funds the project requires, both short term and long term, how the funds can be raised, cost-benefit analysis of the proposal, etc.

Some examples of projects would be a residential school project, a poultry development proposal, an irrigation or power project, a travel agency proposal and so on. It could be small or large, a new activity or an expansion, undertaken independently or jointly with other agencies. Each has its own implications for drafting or preparing the project proposal. Each aspect, whether technical or economic or financial should be properly presented. Cost-benefit details have to be clearly spelt out. The receiver of the proposal should be in a position to get a total view of what is proposed, and take an appropriate decision on merits. Sometimes large proposals are put up to committees and the person submitting
the proposal may be invited to make a presentation and clarify doubts. Technical jargon, if any, may have to be explained in clear terms.

It is worth noting that proposals are essentially a form of persuasion. The proposer has to state clearly the rationale, the merit or the “why” of the proposal. In other words, the purpose statement has to be very carefully drawn up in respect of large proposals. In a business context, given intense competition, it is likely that there are several competitors submitting their proposals for consideration and sanction or award. Clarity, completeness, forceful presentation, timeliness and a user-friendly approach have to be essential ingredients for any good project proposal.

Request for Proposal (RFP)

RFP is a method of seeking or inviting proposals. Government organizations, public sector undertakings and large institutions often resort to RFP to ensure transparency and competitive bids from competent bidders. While issuing an RFP, the organization concerned specifically lays down all the relevant details of the requirements. To make the RFP highly participative, these are publicized in the newspapers and are given wide publicity.

Let us take the example of a bank issuing an RFP inviting bids from consultants for undertaking a comprehensive management study. The RFP is a document that has been drawn up with due care. The RFP serves the purpose of inviting bids from the interested parties. The RFP documents should necessarily contain the following:

- A brief description of the party calling for RFP
- Whether the bids have to be submitted in two parts, viz, technical bid and price bid
- Specific eligibility conditions for the bidders
- Scope of the study or work
- Selection criteria such as credentials, exposure, prior experience, etc.
- Price schedule, i.e., how the price is to be quoted, whether in Indian rupees, escalation clauses, taxes, etc.
- Commercial terms and conditions such as terms of payment, documents to be submitted, etc.
- Validity period and last date
- Arbitration and applicable laws
- Cancellation of the contract and compensation
- Confidentiality obligations

Those responding to the RFP should scrupulously follow these requirements and submit their complete proposals.
Expression of Interest (EOI)

Expression of interest is another method by which large organizations invite offers from willing partners. EOI is sought after giving publicity and relevant details such as scope of study, eligibility criteria, etc. All preliminary proposals received in response to the EOI are duly evaluated and shortlisted. RFP calling for technical and commercial (price) bids are called only from those shortlisted parties. The process of shortlisting through EOI, while ensuring competitive response, provides an opportunity for screening of responses. Only those who meet all the eligibility criteria will be given RFP and asked to give their technical and price bids. EOI process helps in screening all the entries and restricting the issuing of RFP, and calls for technical and commercial bids only from the most eligible and qualified bidders.

11.4 AGENCIES INVOLVED IN SOCIAL WORK RESEARCH

There are numerous agencies both of governmental and non-governmental nature working in the social research area. The following are some of the examples:

- **Indian Council of Social Science Research (ICSSR)** was established in the year of 1969 by the Government of India to promote research in social sciences in the country. The Council aims to:
  i. Review the progress of social science research and give advice to its users;
  ii. Sponsor social science research programmes and projects and administer grants to institutions and individuals for research in social sciences;
  iii. Institute and administer scholarships and fellowships for research in social sciences;
  iv. Indicate areas in which social science research is to be promoted and adopt special measures for development of research in neglected or new areas;
  v. Give financial support to institutions, associations, and journals engaged in social science research;
  vi. Arrange for technical training in research methodology and to provide guidance for research;
  vii. Co-ordinate research activities and encourage programmes for interdisciplinary research;
  viii. Develop and support centers for documentation services and supply of data;
  ix. Organize, sponsor, and finance seminars, workshops and study groups;
x. Undertake publication and assist publication of journals and books in social sciences;

xi. Advise the Government of India on all matters pertaining to social science research as may be referred to it from time to time; and take such measures generally as may be necessary from time to time to promote social science research and its utilization

- Centre for Urban Economic Studies: The centre was established in 1978 as a research centre by the University under the special assistance programme of University Grants Commission in the Department of Economics with urban economics as the thrust area. For the last quarter of a century, it has established itself as a premier multi-disciplinary research centre of urban studies in India. A number of dissertations done under the guidance of faculty members have been awarded M.Phil and Ph.D degrees. Apart from publishing books, monographs, discussion papers and database for urban studies and a bi-annual newsletter, it has been regularly holding workshops, seminars and short-term courses on different aspects of urban studies. It has been engaged in different type of collaborative activities with other organisations like Indian Council of Social Science Research, Anthropological Survey of India. Other than the regular faculty members and research staffs of the Centre, it also accommodates eminent researchers on urban topics from related disciplines like Political Science, Sociology, Geography, History, as honorary associates. It also offers Urban Economics and Urban Planning as optional papers as a part of the post-graduate course in Economics. Urban Economics is also offered as an optional paper in MPhil (Economics) course.

- Sardar Patel Institute of Economic and Social Research: It is a leading Social Science Research Institute in India. It is an autonomous organisation registered as a Trust and Society under the relevant statutes in 1965. With the valuable cooperation of the Gujarat Government, businessmen, and industrialists of Gujarat, the Institute started academic activities in 1969 with Prof. D.T. Lakdawala as its founder Director. Appreciating the role of such an institution of higher learning and research in Gujarat, the Gujarat government had given full maintenance grant during the initial years of the Institute’s development. By the mid-seventies, the Institute established its unique identity at the national level. Government of India recognised it as a National Institute in 1975 and, consequently, the Indian Council of Social Science Research (ICSSR), New Delhi, started sharing the maintenance grant on a 50:50 basis. Over the years, the Institute has evolved a diversified programme of research, training and extension activities within the framework of the following main objectives:
o To conduct research on economic and social problems of basic and applied nature.

o Give due attention to the problems of the Gujarat economy and work on problems of the national economy.

o To foster training of young research scholars in India through training programmes.

o To actively engage in dissemination of knowledge in the social sciences particularly through cooperation with other educational institutions in the region.

Organizing Seminars, Conferences and Workshops at the Institute and participation by the research staff of the Institute at regional, national, and international level are the other important facets of the working of the Institute. Faculty members of the Institute have been appointed to various committees of the Government of India and Gujarat, Planning Commission, Universities, Reserve Bank of India, and international agencies like UNCTAD, World Bank and International Monetary Fund.

The Institute is a recognized institution of Gujarat University for Ph.D. degree in Economics and is one of the centres of the ICSSR Study Grant Scheme for Ph.D students. The Institute is also a centre for the Data Consultancy Scheme of ICSSR. Research scholars from all over the country visit the Institute for consultation regarding data analysis, research survey, methodology, etc. This scheme enables scholars to visit the Institute for six to eight weeks.

- Centre for Social Research: Founded in 1983, Centre for Social Research (CSR) is a non-profit organisation based in New Delhi. With the mission to empower the women and girls of India guarantee their rights, and increase understanding of social issues from a gender perspective. For nearly three decades, Centre for Social Research has been a leader in the Indian women’s movement due to its unique, tri-fold position as an experienced facilitator of grassroots programmes and trainings; an esteemed research institute; and a lobbyist, advocate and advisor to government institutions. CSR operates on local, national and regional levels in an effort to enhance the capacities of individuals, communities and institutions for creating a humane, equitable and gender-just society.

- The Institute for Social and Economic Change (ISEC): It is an All India Institute for Interdisciplinary Research and Training in the Social Sciences, established in 1972 by the late Professor V K R V Rao. It is registered as a Society under the Karnataka Societies Registration Act, 1960, to create a blend of field-oriented empirical research and advances in social science theories leading to better public policy formulation.
5. State the purpose of any proposal.
6. What are the essential ingredients for any good project proposal?
7. Name the social work research agency which was established with the mission to empower the women and girls of India guarantee their rights, and increase understanding of social issues from a gender perspective.

11.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. The two ways of developing a subject for a research are: (i) Logical, and (ii) Chronological.
2. While writing the final draft of a research, a researcher must avoid abstract terminology and technical jargon.
3. A review of literature helps the researcher in formulating broader assumptions about the factors/variables involved in the problem and the latter develops a hypothesis for the study.
4. The most common methods of presentation of descriptive analysis are: (i) use of table and graphs to present data, (ii) statistical analysis for the test of significance by stating the null-hypothesis, and (iii) indicating the result of the test of significance.
5. The purpose of any proposal is to persuade the reader to consider the idea favorably and permit to put into action.
6. Clarity, completeness, forceful presentation, timeliness and a user-friendly approach have to be essential ingredients for any good project proposal.
7. Centre for Social Research (CSR) is a non-profit organisation based in New Delhi established with the mission to empower the women and girls of India guarantee their rights, and increase understanding of social issues from a gender perspective.

11.6 SUMMARY

- The purpose of writing a research report depends on the reason behind undertaking the research study. It could be for obtaining a degree, for submitting a project report to the funding agency, etc.
- Once submitted, the funding agency and 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: (i) the beginning, (ii) the main body and (iii) the end.
• The beginning includes: cover or the title page, acknowledgements, table of contents, list of tables and list of figures.
• The main body normally contains an introduction, a review of the relevant literature, objectives, a hypotheses, research design (research methodology, population and sample, tools, procedure of collecting data), analysis and interpretation of data, main findings and conclusion (that also includes its educational implications and suggestions for further studies).
• While discussing the main body, the style of writing the report, placement of footnotes and references, the typing process and the format and placement of tables and figures have been discussed.
• The final part of the unit talked about notes on the style, arrangement and placement of references and appendices, which constitute the end of a research report.
• The length and form of each section of the report differ, according to the purpose of writing the report, space and time, and money available.
• Scientific communication should be presented as simply and as clearly as possible.
• Various styles of writing references exist to assist the researcher to adopt an acceptable style.
• Reporting a research demands certain acceptable format.
• Evaluating a research plan critically involves appraising both the merits and the demerits of the plan.
• A systematic assessment of various sections of a research plan is essential in judging the utility, value and scientific nature of the study.
• Proposals, like letters and reports, constitute a widely used piece of written communication in business. In the market place, in business organizations, varied proposals are put up from one party to the other or from one authority to the other for their consideration. Proposal refers to an act of proposing or suggesting a plan, task, event, etc. Proposals are examples of persuasive communication. In general, proposals are put up for the consideration of the appropriate party or authority.
• Good proposals reflect the confidence and enthusiasm of the person putting up the proposal. A good proposal should have the right tone. It should radiate the confidence and urgency that are relevant for its favorable consideration. It should be prepared and put up without delay and well in time, especially when deadlines are involved. Good proposals should use vigorous words and should not follow a drab, matter-of-fact style.
A project proposal, as the name indicates, is a proposal for undertaking a project. Since any proposal is a kind of persuasion, a project proposal puts forth clearly the nature of and need for undertaking the project. A project could be a plan, a task, a turn-key job, an assignment or a research study. A project proposal may be internal or external.

A typical project may involve the following:
- Technical feasibility
- Economic viability
- Financial strength

RFP is a method of seeking or inviting proposals. Government organizations, public sector undertakings and large institutions often resort to RFP to ensure transparency and competitive bids from competent bidders. While issuing an RFP, the organization concerned specifically lays down all the relevant details of the requirements. To make the RFP highly participative, these are publicized in the newspapers and are given wide publicity.

Expression of interest is another method by which large organizations invite offers from willing partners. EOI is sought after giving publicity and relevant details such as scope of study, eligibility criteria, etc. All preliminary proposals received in response to the EOI are duly evaluated and shortlisted.

11.7 KEY WORDS

- Social research: It is a part of research, which studies the behavior of human beings, as part of society.
- Bibliography: It refers to the entire literature source, surveyed and found relevant and useful, which may or may not have been quoted or referred to in the text
- Proposal: It is an offer to do something or a request for some sanction or permission.

11.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short Answer Questions
1. What are the usual steps involved in writing reports?
2. How is the subject matter for writing a report developed?
3. What does the methodology section of a research report contain?
4. What does the main body of a research report contain?
5. What are the constituents of a typical project?
Long Answer Questions

1. Explain the concept, meaning and steps involved in report writing.
2. Discuss the contents of a research report.
3. Write a note on the outline of the format of a research report.
4. Describe the precautions to be taken while writing a report.
5. Explain the features of proposals.
6. Examine the concept of Request for Proposal and Expression of Interest in project proposals.
7. Discuss some of the major agencies involved in social work research.

11.9 further readings


Websites

http://icssr.org/

https://www.caluniv.ac.in/academic/department/Urban_Eco.html

http://www.spiesr.ac.in/Home

http://www.csrindia.org/
UNIT 12 STATISTICS

Structure
12.0 Introduction
12.1 Objectives
12.2 Statistics: Meaning, Use and Limitation of Statistics in Social Work Research
  12.2.1 Use and Limitations of Statistics in Social Work Research
12.3 Measures of Central Tendency
  12.3.1 Arithmetic Mean
  12.3.2 Median
  12.3.3 Mode
12.4 Answers to Check Your Progress Questions
12.5 Summary
12.6 Key Words
12.7 Self Assessment Questions and Exercises
12.8 Further Readings

12.0 INTRODUCTION

Statistics is a mathematical science including methods of collecting, organizing and analyzing data in such a way that meaningful conclusions can be drawn from them. In general, its investigations and analyses fall into two broad categories called descriptive and inferential statistics.

Descriptive statistics deals with the processing of data without attempting to draw any inferences from it. The data are presented in the form of tables and graphs. The characteristics of the data are described in simple terms. Events that are dealt with include everyday happenings such as accidents, prices of goods, business, incomes, epidemics, sports data and population data.

Inferential statistics is a scientific discipline that uses mathematical tools to make forecasts and projections by analysing the given data. This is of use to people employed in such fields as engineering, economics, biology, the social sciences, business, agriculture and communications.

In this unit, you will learn about the meaning, use and limitation of statistics in social work research. You will also learn about the measures of central tendency. They give us the central value of a wide variety of data which can act as the representative value for the entire group. This includes measures such as mean, median and mode.
12.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss the meaning, use and limitation of statistics in social work research
- Explain the measures of central tendency

12.2 STATISTICS: MEANING, USE AND LIMITATION OF STATISTICS IN SOCIAL WORK RESEARCH

Statistics, as a word, connotes two different meanings when seen as a singular and as a plural. In that sense, the distinction between the two meanings is interestingly interwoven.

A layman knows statistics as data. For him, it generally means numerical information expressed in quantitative terms. Obviously, it is when seen as plural that statistics refer(s) to data, data of all types. With the various types of data discussed later in this unit, it is important to bear in mind that all data are statistical data.

Importantly, the more we think of data, the more are there to list and record. These may relate to objects, subjects, activities, phenomena, or regions of space. As a matter of fact, data have no limits as to their reference, coverage, and scope. It is, however, pertinent to cite a few more friendly cases to show that statistics are data, and data are statistical data.

- At the macro level, there are data on gross national product with break-up into shares of agriculture, manufacturing, and services. Also on distribution of national income as wages for labour, rent for land, profit for the entrepreneur, and interest for capital. Similarly, there are vast statistics available on savings and expenditure, investment by sectors or activity, production and prices, exports and imports, and so on. All these data are systematically compiled by the concerned official agencies on a regular basis.

- At the micro level, individual firms, howsoever small or large, produce extensive statistics on their operations. The annual reports of companies contain variety of data on sales, production, expenditure, inventories, capital employed, and other activities. Huge statistics are available even at the household level, all purposely and deliberately collected as an officially sponsored endeavour.

- Abundant statistical data also get generated through specific-purpose research studies undertaken at different levels. These data are often field data collected by employing scientific survey techniques. Unless regularly updated, such data are the product of a one-time effort and have limited use beyond the situation that may have called for their collection.
A student, on the other hand, knows statistics more intimately as a singular when it means a subject of study like economics, mathematics, chemistry, physics, and others. It is a discipline which scientifically deals with data, and is often described as the science of data. In dealing with statistics as data, statistics has developed appropriate methods of collecting, presenting, summarizing, and analysing data, and thus consists of a body of these methods. As these elements define the essential scope of statistics, we shall go into each of these separately as we proceed further.

**Meaning Restated**

Returning to statistics as data, no exercise involving data compilation and collection takes place without an objective. During ancient times, the objective was limited to maintaining the records of revenue collected through tax than to anything else.

Collecting data specifically for understanding and analysing problem situations and using the results for taking appropriate decisions was seldom thought of. Consequently, the scope of statistics as a subject had been limited for long only to Introduction to Statistics collection, compilation, and reporting of official data.

With the passage of time, both the objectives and, relatedly, the scope of data collection have undergone immense change. This owes to the philosophy of welfare state overtaking governance and, consequently, governments assuming more of the managerial role. In this new role, the state, directly and through its agencies specifically established for the task, collects variety of data on regular basis and with definite objectives.

This has followed the realization that the data so acquired could serve as effective means of problem analysis and reaching appropriate decisions. The consequent change in the vision and context has thus made it necessary to redefine statistics in keeping with its enhanced significance. Accordingly, as a subject, statistics consists of the processes, techniques, and methods of collecting, organizing, presenting, analysing, and interpreting statistical data for decision-making.

**Some Other Definitions of Statistics**

**As numerical data**

Waster has defined statistics as ‘classified facts respecting the condition of the people in a state... especially those facts which can be stated in numbers or in tables or in any other tabular or classified arrangement.’ No doubt, this definition was correct at a time when statistics were collected only for purposes of internal administration or for knowing, for purposes of war, the wealth of the State. The scope of statistics is now considerably wider and it has almost a universal application. Obviously, therefore, the definition is inadequate.

Bowley defines statistics as ‘numerical statements of facts in any department of inquiry placed in relation to each other.’ This is somewhat more accurate. It means that if numerical facts do not pertain to a department of inquiry or if such
facts are not related to each other they cannot be called statistics. The leads us to the conclusion that ‘all statistics are numerical facts but all numerical facts are not statistics.’ This definition is certainly better than the previous one But it is not comprehensive enough in as much as it does not give any importance either to the nature of facts or the standard of accuracy.

As statistical methods

Bowley has called it ‘the science of measurement of the social organism, regarded as a whole, in all its manifestations.’ This definition is too narrow as it confines the scope of statistics only to human activities. Statistics in fact has a much wider application and is not confined only to the social organism. Besides, statistics is not only the technique of measuring but also of analysing and interpreting. Again, statistics, strictly speaking, is not a science but a scientific method. It is a device of inferring knowledge and not knowledge itself.

Bowley has also called statistics ‘the science of counting,’ and ‘the science of average.’ These definitions are again incomplete in the sense that they pertain to only a limited field. True, statistical work includes counting and averaging, but it also includes many other processes of treating quantitative data. In fact, while dealing with large numbers, actual count becomes illusory and only estimates are made. Thus these definitions can also be discarded on the ground of inadequacy.

Two Major Divisions of Statistics

The way statistics is defined, it would look too broad and general in scope. This necessitates that we go further into the meaning of statistics, in terms of its two major divisions—descriptive statistics and inferential statistics. A broad understanding of the basic concern of each of these is, therefore, in point.

Descriptive Statistics

As the term obviously connotes, descriptive statistics deals with collecting, summarizing, and simplifying data, which are otherwise quite unwieldy and voluminous. It seeks to achieve this in a manner that meaningful conclusions can be readily drawn from the data. Descriptive statistics may thus be seen as comprising methods of bringing out and highlighting the latent characteristics present in a set. Introduction to Statistics of numerical data. It not only facilitates an understanding of the data and systematic reporting thereof in a manner that makes them amenable to further discussion, analysis, and interpretations.

Inferential Statistics

In contrast, inferential statistics, also known as inductive statistics, goes beyond describing a given problem situation by means of collecting, summarizing, and meaningfully presenting the related data. Instead, it consists of methods that are used for drawing inferences, or making broad generalizations, about a totality of observations on the basis of knowledge about a part of that totality.
12.2.1 Use and Limitations of Statistics in Social Work Research

In this section, you will learn about the general use and limitation of Statistics. These are also relevant to the field of social work research.

The proper function of statistics is to enlarge our knowledge of complex phenomena, and to lend precision to our ideas that would otherwise remain vague and indeterminate. Our knowledge of such things as 'national income,' 'population,' 'national resources,' etc., would not have been so definite and precise, if there were no reliable statistics pertaining to each one of these. To say that the per capita income in India is low is a vague statement. The term 'low' may mean one thing to one individual while to another it might mean something altogether different.

One may take it to be near about Rs. 100 while someone else may think it to be in the neighborhood of Rs. 5,000. But the moment we say that our per capita income is Rs. 750 we make a statement which is precise and convincing. Again a statement, viz., the per capita income in agricultural sector is lower than in the industrial sector, is vague and indefinite. But if the per capita incomes for both these sectors are ascertained; the comparison would be easier and even a layman would be able to appreciate the difference in the productivity of these two sectors. It can thus be said that 'statistics increases the field of mental vision, as an opera glass or telescope increases the field of physical vision. Statistics is able to widen our knowledge because of the following services that it renders.

- **It presents facts in a definite form.** It is the quality of definiteness which is responsible for the growing universal application of statistical methods. The conclusions stated numerically are definite and hence more convincing than conclusions stated qualitatively. This fact can be readily understood by a simple example.

- **Statistics simplifies unwieldy and complex mass of data and presents them in such a manner that they at once become intelligible.** The complex data may be reduced to totals; averages, percentages, etc., and presented either graphically or diagrammatically. These devices help us to understand quickly the significant characteristics of the numerical data, and consequently save us from a lot of mental strain. Single figures in the form of averages and percentages can be grasped more easily than a mass of statistical data comprising thousands of facts. Similarly, diagrams and graphs, because of their greater appeal to the eye and imagination tender valuable assistance in the proper understanding of numerical data. Time and energy of business executives are thus economized, if the statistician supplies them with the results of production, sales and finances in a condensed form.

- **Statistics classifies numerical facts.** The procedure of classification brings into relief the salient features of the variable that is under investigation. This can be clearly illustrated by an example. If we are given the marks in mathematics of each individual student of a class and if it is desired to
Statistics

judge the performance of the class on the basis of these data it will not be an easy matter. Human mind has its limitations and cannot easily grasp a multitude of figures. But if the students are classified i.e., if we put into one group all those boys who get more than second division marks, in still another group those who get third division marks, and have a separate group of those who fail to get pass marks, it will be easier for us to form a more precise idea about the performance of the class.

- **Statistics furnishes a technique of comparison.** The facts, having been classified, are now in a shape when they can be used for purposes of comparisons and contrasts. Certain facts, by themselves, may be meaningless unless they are capable of being compared with similar facts at other places or at other periods in time. We estimate the national income of India not essentially for the value of that fact itself, but mainly in order that we may compare the income of today with that of the past and thus draw conclusions as to whether the standard of living of the people is on the increase, decrease or is stationary. Statistics affords suitable technique for comparison. It is with the help of statistics that the cost accountant is able to compare the actual accomplishment (in terms of cost) with programmes laid out (in terms of standard cost). Some of the modes of comparison provided by statistics include totals, ratios, averages or measure of central tendencies, graphs and diagrams, and coefficients. Statistics thus "serves as a scale in which facts in various combinations are weighed and valued.

- **Statistics endeavours to interpret conditions.** Like an artist statistics renders useful service in presenting an attractive picture of the phenomenon under investigation- But it frequently does far more than this by enabling the interpretation of condition, by developing possible causes for the results described. If the production manager discovers that a certain machine is turning out some articles which are not up to the standard specifications, he will be able to find statistically if this condition is due to some defect in the machine or whether such a condition is normal.

**Limitations**

That statistical technique, because of its flexibility and economy, is growing in popularity and is being successfully employed by the seekers of truth in numerous fields of learning is a fact that cannot be denied. But it is not without limitations. It cannot be applied to all kinds of phenomena and cannot be made to answer all our queries.

- **Statistics deals with only those subjects of inquiry which are capable of being quantitatively measured and numerically expressed.** This is an essential condition for the application of statistical methods.
Now all subjects cannot be expressed in numbers. Health, poverty, intelligence (to name only a few) are instances of objects that defy the measuring rod, and hence are not suitable for statistical analysis. It is true that efforts are being made to accord statistical treatment to subjects of this nature also. Health of the people is judged by a study of its death rate, longevity of life and the prevalence of any disease or diseases. Similarly intelligence of the students may be compared on the basis of marks obtained by them in a class test. But these are only indirect methods of approaching the problem and subsidiary to quite a number of other considerations which cannot be statistically dealt with.

- **Statistics deals only with aggregates of facts and no importance is attached to individual items.** It is, therefore, suited only to those problems where group characteristic are desired to be studied. But where the knowledge about individual cases is necessary statistical techniques prove inadequate. The per capita consumption of food grains in a state will camouflage cases of starvation, if any. The scarcity felt by the poorer section may be more than made up by the extravagance of the rich. In such cases, therefore, statistics, will fail to reveal the real position.

- **Statistical data is only approximately and not mathematically correct.** Greater emphasis is being laid on the sampling technique of collecting data. This means that by observing, only a limited number of items we make an estimate of the characteristic of the entire population. This system works well so long as the mathematical accuracy is not essential. But when exactness is essential statistics will fail to do the job.

- **Statistics can be used to establish wrong conclusions and, therefore, can be used only by experts.** Since many of the statistical conclusions are based on sample studies, it is very common to come to wrong conclusions if one is not very careful about the techniques of analysis. In fact, one is so often deceived by 'correct' facts that there is a general distrust of things 'proved statistically'. Usually, most of these can be traced to incorrect application of methods.

### Check Your Progress

1. Name the type of statistics which goes beyond describing a given problem situation by means of collecting, summarizing, and meaningfully presenting the related data.
2. What is the first step in any scientific inquiry?
3. Define a population or a universe in statistics.
12.3 MEASURES OF CENTRAL TENDENCY

In this section, you will learn about the basics of measures of central tendency.

12.3.1 Arithmetic Mean

There are several commonly used measures such as arithmetic mean, mode and median. These values are very useful not only in presenting the overall picture of the entire data but also for the purpose of making comparisons among two or more sets of data.

As an example, questions like ‘How hot is the month of June in Delhi?’ can be answered generally by a single figure of the average for that month. Similarly, suppose we want to find out if boys and girls of age 10 years differ in height for the purpose of making comparisons. Then, by taking the average height of boys of that age and the average height of girls of the same age, we can compare and record the differences.

While arithmetic mean is the most commonly used measure of central tendency, mode and median are more suitable measures under certain set of conditions and for certain types of data. However, each measure of central tendency should meet the following requisites.

- It should be easy to calculate and understand.
- It should be rigidly defined. It should have only one interpretation so that the personal prejudice or the bias of the investigator does not affect its usefulness.
- It should be representative of the data. If it is calculated from a sample, the sample should be random enough to be accurately representing the population.
- It should have a sampling stability. It should not be affected by sampling fluctuations. This means that if we pick ten different groups of college students at random and compute the average of each group, then we should expect to get approximately the same value from each of these groups.
- It should not be affected much by extreme values. If few, very small or very large items are present in the data, they will unduly influence the value of the average by shifting it to one side or other, so that the average would not be really typical of the entire series. Hence, the average chosen should be such that it is not unduly affected by such extreme values.

Arithmetic mean is also commonly known as the mean. Even though average, in general, means measure of central tendency, when we use the word average in our daily routine, we always mean the arithmetic average. The term is widely used by almost everyone in daily communication. We speak of an individual being an average
student or of average intelligence. We always talk about average family size or average
family income or grade point average (GPA) for students, and so on.

For discussion purposes, let us assume a variable $X$ which stands for some
scores such as the ages of students. Let the ages of 5 students be 19, 20, 22, 22
and 17 years. Then variable $X$ would represent these ages as follows:

$X$: 19, 20, 22, 22, 17

Placing the Greek symbol $\Sigma$ (Sigma) before $X$ would indicate a command
that all values of $X$ are to be added together. Thus:

$\Sigma X = 19 + 20 + 22 + 22 + 17$

The mean is computed by adding all the data values and dividing it by the
number of such values. The symbol used for sample average is $\bar{X}$ so that:

$\bar{X} = \frac{19 + 20 + 22 + 22 + 17}{5}$

In general, if there are $n$ values in the sample, then

$\bar{X} = \frac{X_1 + X_2 + \ldots + X_n}{n}$

In other words,

$\bar{X} = \frac{\sum X_i}{n}, \quad i = 1, 2 \ldots n$

According to this formula, the mean can be obtained by adding up all values
of $X_i$, where the value of $i$ starts at 1 and ends at $n$ with unit increments so that $i = 1, 2, 3, \ldots n$.

If instead of taking a sample, we take the entire population in our calculations
of the mean, then the symbol for the mean of the population is $\mu$ (mu) and the size
of the population is $N$, so that:

$\mu = \frac{\sum X_i}{N}, \quad i = 1, 2 \ldots N$

If we have the data in grouped discrete form with frequencies, then the
sample mean is given by:

$\bar{X} = \frac{\sum f(X)}{\sum f}$

Here, $\sum f = \text{Summation of all frequencies}$

$\sum f(X) = \text{Summation of each value of } X\text{ multiplied by its}
\text{corresponding frequency (}f\text{)}$

**Example 12.1:** Let us take the ages of 10 students as follows:

19, 20, 22, 22, 17, 22, 20, 23, 17, 18
Solution: This data can be arranged in a frequency distribution as follows:

<table>
<thead>
<tr>
<th>(X)</th>
<th>(f)</th>
<th>f(X)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>2</td>
<td>34</td>
</tr>
<tr>
<td>18</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>19</td>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>20</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>22</td>
<td>3</td>
<td>66</td>
</tr>
<tr>
<td>23</td>
<td>1</td>
<td>23</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>200</td>
</tr>
</tbody>
</table>

In this case, we have \( \sum f = 10 \) and \( \sum f(X) = 200 \), so that:

\[
\bar{X} = \frac{\sum f(X)}{\sum f}
\]

\[
= \frac{200}{10} = 20
\]

Example 12.2: Calculate the mean of the marks of 46 students given in the following table.

<table>
<thead>
<tr>
<th>Marks (X)</th>
<th>Frequency (f)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td>17</td>
<td>2</td>
</tr>
<tr>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
</tr>
</tbody>
</table>

Solution: This is a discrete frequency distribution, and is calculated using the equation \( \bar{X} = \frac{\sum f(x)}{\sum f} \). The following table shows the method of obtaining \( \sum f(X) \).

<table>
<thead>
<tr>
<th>Marks (X)</th>
<th>Frequency (f)</th>
<th>f(X)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td>33</td>
</tr>
<tr>
<td>12</td>
<td>6</td>
<td>72</td>
</tr>
<tr>
<td>13</td>
<td>10</td>
<td>130</td>
</tr>
<tr>
<td>14</td>
<td>11</td>
<td>154</td>
</tr>
<tr>
<td>15</td>
<td>7</td>
<td>105</td>
</tr>
<tr>
<td>16</td>
<td>3</td>
<td>48</td>
</tr>
<tr>
<td>17</td>
<td>2</td>
<td>34</td>
</tr>
<tr>
<td>18</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>( \sum f = 46 )</td>
<td>( \sum f(X) = 623 )</td>
<td></td>
</tr>
</tbody>
</table>

\[
\bar{X} = \frac{\sum f(X)}{\sum f} = \frac{623}{46} = 13.54
\]
Statistics

Characteristics of the mean

The arithmetic mean has three interesting properties. These are as follows:

(i) The sum of the deviations of individual values of $X$ from the mean will always add up to zero. This means that if we subtract all the individual values from their mean, then some values will be negative and some will be positive, but if all these differences are added together then the total sum will be zero. In other words, the positive deviations must balance the negative deviations. Or symbolically:

$$\sum_{i=1}^{n} (X_i - \bar{X}) = 0, \ i = 1, 2, \ldots \ n$$

(ii) The second important characteristic of the mean is that it is very sensitive to extreme values. Since the computation of the mean is based upon inclusion of all values in the data, an extreme value in the data would shift the mean towards it, thus making the mean unrepresentative of the data.

(iii) The third property of the mean is that the sum of squares of the deviations about the mean is minimum. This means that if we take differences between individual values and the mean and square these differences individually and then add these squared differences, then the final figure will be less than the sum of the squared deviations around any other number other than the mean. Symbolically, it means that:

$$\sum_{i=1}^{n} (X_i - \bar{X})^2 = \text{Minimum, } i = 1, 2, \ldots \ n$$

The following examples will make the concept clear about properties of mean.

(iv) The product of the arithmetic mean and the number of values on which the mean is based is equal to the sum of all given values. In other words, if we replace each item in series by the mean, then the sum of the these substitutions will equal the sum of individual items. Thus, in the figures 3, 5, 7, 9, if we substitute the mean for each item 6, 6, 6, 6 then the total is 24, both in the original series and in the substitution series.

This can be shown like this.

$$\bar{X} = \frac{\Sigma X}{N}$$

$$\therefore \ N \bar{X} = \Sigma X$$

For example, if we have a series of values 3, 5, 7, 9, the mean is 6. The squared deviations are:

<table>
<thead>
<tr>
<th>X</th>
<th>$X - \bar{X}$</th>
<th>$X^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3 - 6 = -3</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>5 - 6 = -1</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>7 - 6 = 1</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>9 - 6 = 3</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>$\Sigma X^2 = 20$</td>
<td></td>
</tr>
</tbody>
</table>
This property provides a test to check if the computed value is the correct arithmetic mean.

**Example 12.3:** The mean age of a group of 100 persons (grouped in intervals 10–, 12–, etc.) was found to be 32.02. Later, it was discovered that age 57 was misread as 27. Find the corrected mean.

**Solution:** Let the mean be denoted by \( X \). So, putting the given values in the formula of arithmetic mean, we have,

\[
32.02 = \frac{\sum X}{100}, \text{ i.e., } \sum X = 3202
\]

\[
\text{Correct } \sum X = 3202 - 27 + 57 = 3232
\]

\[
\text{Correct AM } = \frac{3232}{100} = 32.32
\]

**Example 12.4:** The mean monthly salary paid to all employees in a company is ₹ 500. The monthly salaries paid to male and female employees average ₹ 520 and ₹ 420, respectively. Determine the percentage of males and females employed by the company.

**Solution:** Let \( N_1 \) be the number of males and \( N_2 \) be the number of females employed by the company. Also, let \( x_1 \) and \( x_2 \) be the monthly average salaries paid to male and female employees and \( \bar{x} \) be the mean monthly salary paid to all the employees.

\[
\bar{x} = \frac{N_1 x_1 + N_2 x_2}{N_1 + N_2}
\]

or

\[
500 = \frac{520N_1 + 420N_2}{N_1 + N_2} \quad \text{or} \quad 20N_1 = 80N_2
\]

or

\[
\frac{N_1}{N_2} = \frac{80}{20} = 4
\]

Hence, the males and females are in the ratio of 4 : 1 or 80 per cent are males and 20 per cent are females in those employed by the company.

**Short-cut methods for calculating mean**

We can simplify the calculations of mean by noticing that if we subtract a constant amount \( A \) from each item \( X \) to define a new variable \( X' = X - A \), the mean \( \bar{X}' \) of \( X' \) differs from \( \bar{X} \) by \( A \). This generally simplifies the calculations and we can then add back the constant \( A \), termed as the **assumed mean**:

\[
\bar{X} = A + \bar{X}' = A + \frac{\sum f(X')}{\sum f}
\]

Table 12.1 illustrates the procedure of calculation by short-cut method using the data given in Example 12.4. The choice of \( A \) is made in such a manner as to simplify calculation the most, and is generally in the region of the concentration of data.
Statistics

Table 12.1 Short-Cut Method of Calculating Mean

<table>
<thead>
<tr>
<th>X</th>
<th>f</th>
<th>Deviation from Assumed Mean (13), X'</th>
<th>f(X')</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>1</td>
<td>-4</td>
<td>-4</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>-3</td>
<td>-6</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td>-2</td>
<td>-6</td>
</tr>
<tr>
<td>12</td>
<td>6</td>
<td>-1</td>
<td>-6</td>
</tr>
<tr>
<td>13</td>
<td>10</td>
<td>0</td>
<td>-22</td>
</tr>
<tr>
<td>14</td>
<td>11</td>
<td>+1</td>
<td>+11</td>
</tr>
<tr>
<td>15</td>
<td>7</td>
<td>+2</td>
<td>+14</td>
</tr>
<tr>
<td>16</td>
<td>3</td>
<td>+3</td>
<td>+9</td>
</tr>
<tr>
<td>17</td>
<td>2</td>
<td>+4</td>
<td>+8</td>
</tr>
<tr>
<td>18</td>
<td>1</td>
<td>+5</td>
<td>+5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>47</td>
</tr>
<tr>
<td>(\sum f)</td>
<td>46</td>
<td>(\sum fX')</td>
<td>25</td>
</tr>
</tbody>
</table>

The mean, 

\[ \bar{X} = A + \frac{\sum f(X')}{\sum f} \]

This mean is same as calculated in Example 12.5.

In the case of grouped frequency data, the variable \(X\) is replaced by midvalue \(m\), and in the short-cut technique, we subtract a constant value \(A\) from each \(m\), so that the formula becomes:

\[ \bar{X} = A + \frac{\sum f(m - A)}{\sum f} \]

In cases where the class intervals are equal, we may further simplify calculation by taking the factor \(i\) from the variable \(m - A\) defining,

\[ X' = \frac{m - A}{i} \]

where \(i\) is the class width. It can be verified that when \(X'\) is defined, then, the mean of the distribution is given by:

\[ \bar{X} = A + \frac{\sum f(X')}{{i} \sum f} \times i \]

The following examples will illustrate the use of the short-cut method.

Example 12.5: The ages of twenty husbands and wives are given in the following table. Form frequency tables showing the relationship between the ages of husbands and wives with class intervals 20–24; 25–29; etc.
Calculate the arithmetic mean of the two groups after the classification.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Age of Husband</th>
<th>Age of Wife</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28</td>
<td>23</td>
</tr>
<tr>
<td>2</td>
<td>37</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>42</td>
<td>40</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
<td>26</td>
</tr>
<tr>
<td>5</td>
<td>29</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>47</td>
<td>41</td>
</tr>
<tr>
<td>7</td>
<td>37</td>
<td>35</td>
</tr>
<tr>
<td>8</td>
<td>35</td>
<td>25</td>
</tr>
<tr>
<td>9</td>
<td>23</td>
<td>21</td>
</tr>
<tr>
<td>10</td>
<td>41</td>
<td>38</td>
</tr>
<tr>
<td>11</td>
<td>27</td>
<td>24</td>
</tr>
<tr>
<td>12</td>
<td>39</td>
<td>34</td>
</tr>
<tr>
<td>13</td>
<td>23</td>
<td>20</td>
</tr>
<tr>
<td>14</td>
<td>33</td>
<td>31</td>
</tr>
<tr>
<td>15</td>
<td>36</td>
<td>29</td>
</tr>
<tr>
<td>16</td>
<td>32</td>
<td>35</td>
</tr>
<tr>
<td>17</td>
<td>22</td>
<td>23</td>
</tr>
<tr>
<td>18</td>
<td>29</td>
<td>27</td>
</tr>
<tr>
<td>19</td>
<td>38</td>
<td>34</td>
</tr>
<tr>
<td>20</td>
<td>48</td>
<td>47</td>
</tr>
</tbody>
</table>

Solution:

**Calculation of Arithmetic Mean of Husbands’ Age**

<table>
<thead>
<tr>
<th>Class Intervals</th>
<th>Midvalues</th>
<th>Frequency ((f_j))</th>
<th>(x_j' = \frac{m - 37}{5})</th>
<th>(f_jx_j')</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–24</td>
<td>22</td>
<td>3</td>
<td>-3</td>
<td>-9</td>
</tr>
<tr>
<td>25–29</td>
<td>27</td>
<td>5</td>
<td>-2</td>
<td>-10</td>
</tr>
<tr>
<td>30–34</td>
<td>32</td>
<td>2</td>
<td>-1</td>
<td>-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-21</td>
<td></td>
</tr>
<tr>
<td>35–39</td>
<td>37</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>40–44</td>
<td>42</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>45–49</td>
<td>47</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>(\sum f_j = 20)</td>
<td></td>
<td></td>
<td>(\sum f_jx_j' = -15)</td>
<td></td>
</tr>
</tbody>
</table>

Husband age, arithmetic mean:

\[
\overline{x} = \frac{\sum f_jx_j'}{N} = \frac{-15}{20} \times 5 + 37 = 33.25
\]
Calculation of Arithmetic Mean of Wife’s Age

<table>
<thead>
<tr>
<th>Class Intervals</th>
<th>Midvalues</th>
<th>Frequency</th>
<th>$x_i' = \frac{m - 37}{5}$</th>
<th>$f_ix_i'$</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–24</td>
<td>22</td>
<td>5</td>
<td>-3</td>
<td>-15</td>
</tr>
<tr>
<td>25–29</td>
<td>27</td>
<td>5</td>
<td>-2</td>
<td>-10</td>
</tr>
<tr>
<td>30–34</td>
<td>32</td>
<td>4</td>
<td>-1</td>
<td>-4</td>
</tr>
<tr>
<td>35–39</td>
<td>37</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>40–44</td>
<td>42</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>45–49</td>
<td>47</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>$\sum f_i$ = 20</td>
<td></td>
<td></td>
<td>$\sum f_ix_i' = -25$</td>
<td></td>
</tr>
</tbody>
</table>

Wife age, arithmetic mean:

$$x = \frac{\sum f_ix_i'}{N} = \frac{-25}{20} \times 5 + 37 = 30.75$$

**Weighted arithmetic mean**

In the computation of arithmetic mean we had given equal importance to each observation in the series. This equal importance may be misleading if the individual values constituting the series have different importance as in the following example:

The Raja Toy shop sells
- Toy cars at ₹3 each
- Toy locomotives at ₹5 each
- Toy aeroplanes at ₹7 each
- Toy double decker at ₹9 each

What shall be the average price of the toys sold, if the shop sells 4 toys, one of each kind?

Mean price, i.e.,

$$x = \frac{\sum x_i}{4} = \frac{24}{4} = ₹6$$

In this case, the importance of each observation (price quotation) is equal in as much as one toy of each variety has been sold. In the above computation of the arithmetic mean, this fact has been taken care of by including ‘once only’ the price of each toy.

But if the shop sells 100 toys: 50 cars, 25 locomotives, 15 aeroplanes and 10 double deckers, the importance of the four price quotations to the dealer is **not equal** as a source of earning revenue. In fact, their respective importance is equal to the number of units of each toy sold, i.e.,

- The importance of toy car 50
- The importance of locomotive 25
- The importance of aeroplane 15
- The importance of double decker 10
It may be noted that 50, 25, 15, 10 are the quantities of the various classes of toys sold. It is for these quantities that the term ‘weights’ is used in statistical language. Weight is represented by symbol ‘w’, and \( \sum w \) represents the sum of weights.

While determining the ‘average price of toy sold’, these weights are of great importance and are taken into account in the manner illustrated as follows:

\[
\tau = \frac{50x1 + 25x2 + 15x3 + 10x4}{50 + 25 + 15 + 10} = \frac{\sum wx}{\sum w}
\]

When \( w_1, w_2, w_3, w_4 \) are the respective weights of \( x_1, x_2, x_3, x_4 \) which in turn represent the price of four varieties of toys, viz., car, locomotive, aeroplane and double decker, respectively.

\[
\tau = \frac{(50 \times 3) + (25 \times 5) + (15 \times 7) + (10 \times 9)}{50 + 25 + 15 + 10} = \frac{470}{100} = \text{₹} 4.70
\]

The table below summarizes the steps taken in the computation of the weighted arithmetic mean.

<table>
<thead>
<tr>
<th>Toys</th>
<th>Price per Toy (₹)</th>
<th>Number Sold (w)</th>
<th>Price × Weight (w × x)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>3</td>
<td>50</td>
<td>150</td>
</tr>
<tr>
<td>Locomotive</td>
<td>5</td>
<td>25</td>
<td>125</td>
</tr>
<tr>
<td>Aeroplane</td>
<td>7</td>
<td>15</td>
<td>105</td>
</tr>
<tr>
<td>Double Decked</td>
<td>9</td>
<td>10</td>
<td>90</td>
</tr>
</tbody>
</table>

\[ \sum w = 100; \quad \sum wx = 470 \]

\[
\tau = \frac{\sum wx}{\sum w} = \frac{470}{100} = \text{₹} 4.70
\]

The weighted arithmetic mean is particularly useful where we have to compute the mean of means. If we are given two arithmetic means, one for each of two different series, in respect of the same variable, and are required to find the arithmetic mean of the combined series, the weighted arithmetic mean is the only suitable method of its determination.

**Example 12.6:** The arithmetic mean of daily wages of two manufacturing concerns A Ltd. and B Ltd. is ₹ 5 and ₹ 7, respectively. Determine the average daily wages of both concerns if the number of workers employed were 2,000 and 4,000 respectively.

**Solution:** (i) Multiply each average (viz. 5 and 7), by the number of workers in the concern it represents.

(ii) Add up the two products obtained in (i) above.

(iii) Divide the total obtained in (ii) by the total number of workers.
**Weighted Mean of Mean Wages of A Ltd. and B Ltd.**

<table>
<thead>
<tr>
<th>Manufacturing Concern</th>
<th>Mean Wages ( x )</th>
<th>Workers Employed ( w )</th>
<th>Mean Wages ( \frac{wx}{w} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Ltd.</td>
<td>5</td>
<td>2,000</td>
<td>10,000</td>
</tr>
<tr>
<td>B Ltd.</td>
<td>7</td>
<td>4,000</td>
<td>28,000</td>
</tr>
</tbody>
</table>

\[ \sum w = 6,000 \quad \sum wx = 38,000 \]

\[ \tau = \frac{\sum wx}{\sum w} = \frac{38,000}{6,000} = \text{Rs. 6.33} \]

The above-mentioned examples explain that ‘Arithmetic Means and Percentage’ are not original data. They are derived figures and their importance is relative to the original data from which they are obtained. This relative importance must be taken into account by weighting while averaging them (means and percentage).

**Advantages of mean**

- Its concept is familiar to most people and is intuitively clear.
- Every data set has a mean, which is unique and describes the entire data to some degree. For example, when we say that the average salary of a professor is Rs 25,000 per month, it gives us a reasonable idea about the salaries of professors.
- It is a measure that can be easily calculated.
- It includes all values of the data set in its calculation.
- Its value varies very little from sample to sample taken from the same population.
- It is useful for performing statistical procedures such as computing and comparing the means of several data sets.

**Disadvantages of mean**

- It is affected by extreme values, and hence, are not very reliable when the data set has extreme values especially when these extreme values are on one side of the ordered data. Thus, a mean of such data is not truly a representative of such data. For example, the average age of three persons of ages 4, 6 and 80 years gives us an average of 30.
- It is tedious to compute for a large data set as every point in the data set is to be used in computations.
- We are unable to compute the mean for a data set that has open-ended classes either at the high or at the low end of the scale.
- The mean cannot be calculated for qualitative characteristics such as beauty or intelligence, unless these can be converted into quantitative figures such as intelligence into IQs.
12.3.2 Median

The second measure of central tendency that has a wide usage in statistical works is the median. Median is that value of a variable which divides the series in such a manner that the number of items below it is equal to the number of items above it. Half the total number of observations lie below the median, and half above it. The median is thus a positional average.

The median of ungrouped data is found easily if the items are first arranged in order of the magnitude. The median may then be located simply by counting, and its value can be obtained by reading the value of the middle observations. If we have five observations whose values are 8, 10, 1, 3 and 5, the values are first arrayed: 1, 3, 5, 8 and 10. It is now apparent that the value of the median is 5, since two observations are below that value and two observations are above it.

When there is an even number of cases, there is no actual middle item and the median is taken to be the average of the values of the items lying on either side of \( \frac{N+1}{2} \), where \( N \) is the total number of items. Thus, if the values of six items of a series are 1, 2, 3, 5, 8 and 10, then the median is the value of item number \( \frac{6+1}{2} = 3.5 \), which is approximated as the average of the third and the fourth items, i.e., \( \frac{3+5}{2} = 4 \).

Thus, the steps required for obtaining median are:

1. Arrange the data as an array of increasing magnitude.
2. Obtain the value of the \( \frac{N+1}{2} \)th item.

Even in the case of grouped data, the procedure for obtaining median is straightforward as long as the variable is discrete or non-continuous as is clear from the following example.

**Example 12.7:** Obtain the median size of shoes sold from the following data.

<table>
<thead>
<tr>
<th>Size</th>
<th>Number of Pairs</th>
<th>Cumulative Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>5½</td>
<td>40</td>
<td>70</td>
</tr>
<tr>
<td>6</td>
<td>50</td>
<td>120</td>
</tr>
<tr>
<td>6½</td>
<td>150</td>
<td>270</td>
</tr>
<tr>
<td>7</td>
<td>300</td>
<td>570</td>
</tr>
<tr>
<td>7½</td>
<td>600</td>
<td>1170</td>
</tr>
<tr>
<td>8</td>
<td>950</td>
<td>2120</td>
</tr>
<tr>
<td>8½</td>
<td>820</td>
<td>2940</td>
</tr>
<tr>
<td>9</td>
<td>750</td>
<td>3690</td>
</tr>
<tr>
<td>9½</td>
<td>440</td>
<td>4130</td>
</tr>
<tr>
<td>10</td>
<td>250</td>
<td>4380</td>
</tr>
<tr>
<td>10½</td>
<td>150</td>
<td>4530</td>
</tr>
<tr>
<td>11</td>
<td>40</td>
<td>4570</td>
</tr>
<tr>
<td>11½</td>
<td>39</td>
<td>4609</td>
</tr>
</tbody>
</table>

Total 4609
**Solution:** Median, is the value of \( \frac{(N + 1)}{2} = \frac{4609 + 1}{2} \) th = 2305th item. Since the items are already arranged in ascending order (size-wise), the size of 2305th item is easily determined by constructing the cumulative frequency. Thus, the median size of shoes sold is 8½, the size of 2305th item.

In the case of grouped data with continuous variable, the determination of median is a bit more involved. Consider the following table where the data relating to the distribution of male workers by average monthly earnings is given.

Clearly the median of 6291 is the earnings of \((6291 + 1)/2 = 3146\)th worker arranged in ascending order of earnings.

From the cumulative frequency, it is clear that this worker has his income in the class interval 67.5–72.5. But, it is impossible to determine his exact income. We therefore, resort to approximation by assuming that the 795 workers of this class are distributed uniformly across the interval 67.5 to 72.5. The median worker is \((3146–2713) = 433\)rd of these 795, and hence, the value corresponding to him can be approximated as,

\[
67.5 + \frac{433}{795} \times (72.5 - 67.5) = 67.5 + 2.73 = 70.23
\]

**Distribution of Male Workers by Average Monthly Earnings**

<table>
<thead>
<tr>
<th>Group No.</th>
<th>Monthly Earnings (₹)</th>
<th>No. of Workers</th>
<th>Cumulative No. of Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27.5–32.5</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>2</td>
<td>32.5–37.5</td>
<td>152</td>
<td>272</td>
</tr>
<tr>
<td>3</td>
<td>37.5–42.5</td>
<td>170</td>
<td>442</td>
</tr>
<tr>
<td>4</td>
<td>42.5–47.5</td>
<td>214</td>
<td>656</td>
</tr>
<tr>
<td>5</td>
<td>47.5–52.5</td>
<td>410</td>
<td>1066</td>
</tr>
<tr>
<td>6</td>
<td>52.5–57.5</td>
<td>429</td>
<td>1495</td>
</tr>
<tr>
<td>7</td>
<td>57.5–62.5</td>
<td>568</td>
<td>2063</td>
</tr>
<tr>
<td>8</td>
<td>62.5–67.5</td>
<td>650</td>
<td>2713</td>
</tr>
<tr>
<td>9</td>
<td>67.5–72.5</td>
<td>795</td>
<td>3508</td>
</tr>
<tr>
<td>10</td>
<td>72.5–77.5</td>
<td>915</td>
<td>4423</td>
</tr>
<tr>
<td>11</td>
<td>77.5–82.5</td>
<td>745</td>
<td>5168</td>
</tr>
<tr>
<td>12</td>
<td>82.5–87.5</td>
<td>530</td>
<td>5698</td>
</tr>
<tr>
<td>13</td>
<td>87.5–92.5</td>
<td>259</td>
<td>5957</td>
</tr>
<tr>
<td>14</td>
<td>92.5–97.5</td>
<td>152</td>
<td>6109</td>
</tr>
<tr>
<td>15</td>
<td>97.5–102.5</td>
<td>107</td>
<td>6216</td>
</tr>
<tr>
<td>16</td>
<td>102.5–107.5</td>
<td>50</td>
<td>6266</td>
</tr>
<tr>
<td>17</td>
<td>107.5–112.5</td>
<td>25</td>
<td>6291</td>
</tr>
</tbody>
</table>

Total 6291
The value of the median can thus be put in the form of the formula,

\[ Me = l + \frac{\frac{N}{2} - C}{f} \times i \]

Where \( l \) is the lower limit of the median class, \( i \) its width, \( f \) its frequency, \( C \) the cumulative frequency up to (but not including) the median class, and \( N \) is the total number of cases.

**Finding median by graphical analysis**

The median can quite conveniently be determined by reference to the ogive which plots the cumulative frequency against the variable. The value of the item below which half the items lie, can easily be read from the ogive.

**Example 12.8:** Obtain the median of data given in the following table.

<table>
<thead>
<tr>
<th>Monthly Earnings</th>
<th>Frequency</th>
<th>Less Than</th>
<th>More Than</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.5</td>
<td>0</td>
<td>6291</td>
<td></td>
</tr>
<tr>
<td>32.5</td>
<td>120</td>
<td>129</td>
<td></td>
</tr>
<tr>
<td>37.5</td>
<td>152</td>
<td>272</td>
<td></td>
</tr>
<tr>
<td>42.5</td>
<td>170</td>
<td>442</td>
<td></td>
</tr>
<tr>
<td>47.5</td>
<td>214</td>
<td>656</td>
<td></td>
</tr>
<tr>
<td>52.5</td>
<td>410</td>
<td>1066</td>
<td></td>
</tr>
<tr>
<td>57.5</td>
<td>429</td>
<td>1495</td>
<td></td>
</tr>
<tr>
<td>62.5</td>
<td>568</td>
<td>2063</td>
<td></td>
</tr>
<tr>
<td>67.5</td>
<td>650</td>
<td>2713</td>
<td></td>
</tr>
<tr>
<td>72.5</td>
<td>795</td>
<td>3588</td>
<td></td>
</tr>
<tr>
<td>77.5</td>
<td>915</td>
<td>4425</td>
<td></td>
</tr>
<tr>
<td>82.5</td>
<td>745</td>
<td>5168</td>
<td></td>
</tr>
<tr>
<td>87.5</td>
<td>530</td>
<td>5698</td>
<td></td>
</tr>
<tr>
<td>92.5</td>
<td>259</td>
<td>5957</td>
<td></td>
</tr>
<tr>
<td>97.5</td>
<td>152</td>
<td>6109</td>
<td></td>
</tr>
<tr>
<td>102.5</td>
<td>107</td>
<td>6216</td>
<td></td>
</tr>
<tr>
<td>107.5</td>
<td>50</td>
<td>6266</td>
<td></td>
</tr>
<tr>
<td>112.5</td>
<td>25</td>
<td>6291</td>
<td></td>
</tr>
</tbody>
</table>

**Solution:** It is clear that this is grouped data. The first class is 27.5–32.5, whose frequency is 120, and the last class is 107.5–112.5, whose frequency is 25. Figure 12.1 shows the ogive of less than cumulative frequency. The median is the value below which \( \frac{N}{2} \) items lie, is 6291/2 = 3145.5 items lie, which is read of from Figure 12.2 as about 70. More accuracy than this is unobtainable because of the space limitation on the earning scale.
The median can also be determined by plotting both ‘less than’ and ‘more than’ cumulative frequency as shown in Figure 12.1. It should be obvious that the two curves should intersect at the median of the data.
Advantages of median

- Median is a positional average and hence the extreme values in the data set do not affect it as much as they do to the mean.
- Median is easy to understand and can be calculated from any kind of data, even from grouped data with open-ended classes.
- We can find the median even when our data set is qualitative and can be arranged in the ascending or the descending order, such as average beauty or average intelligence.
- Similar to mean, median is also unique, meaning that, there is only one median in a given set of data.
- Median can be located visually when the data is in the form of ordered data.
- The sum of absolute differences of all values in the data set from the median value is minimum. This means that, it is less than any other value of central tendency in the data set, which makes it more central in certain situations.

Disadvantages of median

- The data must be arranged in order to find the median. This can be very time consuming for a large number of elements in the data set.
- The value of the median is affected more by sampling variations. Different samples from the same population may give significantly different values of the median.
- The calculation of median in case of grouped data is based on the assumption that the values of observations are evenly spaced over the entire class interval and this is usually not so.
- Median is comparatively less stable than mean, particularly for small samples, due to fluctuations in sampling.
- Median is not suitable for further mathematical treatment. For example, we cannot compute the median of the combined group from the median values of different groups.

12.3.3 Mode

The mode is that value of the variable which occurs or repeats itself the greatest number of times. The mode is the most ‘fashionable’ size in the sense that it is the most common and typical, and is defined by Zizek as ‘the value occurring most frequently in a series (or group of items) and around which the other items are distributed most densely’.

The mode of a distribution is the value at the point around which the items tend to be most heavily concentrated. It is the most frequent or the most common value, provided that a sufficiently large number of items are available, to give a
Statistics

NOTES

smooth distribution. It will correspond to the value of the maximum point (ordinate), of a frequency distribution if it is an ‘ideal’ or smooth distribution. It may be regarded as the most typical of a series of values. The modal wage, for example, is the wage received by more individuals than any other wage. The modal ‘hat’ size is that, which is worn by more persons than any other single size.

It may be noted that the occurrence of one or a few extremely high or low values has no effect upon the mode. If a series of data are unclassified, not have been either arrayed or put into a frequency distribution, the mode cannot be readily located.

Taking first an extremely simple example, if seven men are receiving daily wages of ₹5, 6, 7, 7, 8 and 10, it is clear that the modal wage is ₹7 per day. If we have a series such as 2, 3, 5, 6, 7, 10 and 11, it is apparent that there is no mode.

There are several methods of estimating the value of the mode. But, it is seldom that the different methods of ascertaining the mode give us identical results. Consequently, it becomes necessary to decide as to which method would be most suitable for the purpose in hand. In order that a choice of the method may be made, we should understand each of the methods and the differences that exist among them.

The four important methods of estimating mode of a series are: (i) Locating the most frequently repeated value in the array; (ii) Estimating the mode by interpolation; (iii) Locating the mode by graphic method; and (iv) Estimating the mode from the mean and the median. Only the last three methods are discussed in this unit.

Estimating the mode by interpolation

In the case of continuous frequency distributions, the problem of determining the value of the mode is not so simple as it might have appeared from the foregoing description. Having located the modal class of the data, the next problem in the case of continuous series is to interpolate the value of the mode within this ‘modal’ class.

The interpolation is made by the use of any one of the following formulae:

\[ Mo = l_1 + \frac{f_2}{f_0 + f_2} \times i \]

\[ Mo = l_2 - \frac{f_0}{f_0 + f_2} \times i \]

\[ Mo = l_1 + \frac{f_1 - f_0}{(f_1 - f_0) + (f_1 - f_2)} \times i \]

Where \( l_1 \) is the lower limit of the modal class, \( l_2 \) is the upper limit of the modal class, \( f_0 \) equals the frequency of the preceding class in value, \( f_1 \) equals the frequency of the modal class in value, \( f_2 \) equals the frequency of the following class (class next to modal class) in value, and \( i \) equals the interval of the modal class.
Example 12.9: Determine the mode for the data given in the following table.

<table>
<thead>
<tr>
<th>Wage Group</th>
<th>Frequency (f)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 — 18</td>
<td>6</td>
</tr>
<tr>
<td>18 — 22</td>
<td>18</td>
</tr>
<tr>
<td>22 — 26</td>
<td>19</td>
</tr>
<tr>
<td>26 — 30</td>
<td>12</td>
</tr>
<tr>
<td>30 — 34</td>
<td>5</td>
</tr>
<tr>
<td>34 — 38</td>
<td>4</td>
</tr>
<tr>
<td>38 — 42</td>
<td>3</td>
</tr>
<tr>
<td>42 — 46</td>
<td>2</td>
</tr>
<tr>
<td>46 — 50</td>
<td>1</td>
</tr>
<tr>
<td>50 — 54</td>
<td>0</td>
</tr>
<tr>
<td>54 — 58</td>
<td>1</td>
</tr>
</tbody>
</table>

Solution: In the given data, 22 – 26 is the modal class since it has the largest frequency. The lower limit of the modal class is 22, its upper limit is 26, its frequency is 19, the frequency of the preceding class is 18, and of the following class is 12. The class interval is 4. Using the various methods of determining mode, we have,

\[(i) \, Mo = 22 + \frac{12}{18 + 12} \times 4 = 22 + \frac{8}{5} = 23.6\]

\[(ii) \, Mo = 26 - \frac{18}{18 + 12} \times 4 = 26 - \frac{12}{5} = 23.6\]

\[(iii) \, Mo = 22 + \frac{19 - 18}{(19 - 18) + (19 - 12)} \times 4 = 22 + \frac{4}{8} = 22.5\]

In formulae \((i)\) and \((ii)\), the frequency of the classes adjoining the modal class is used to pull the estimate of the mode away from the midpoint towards either the upper or lower class limit. In this particular case, the frequency of the class preceding the modal class is more than the frequency of the class following and therefore, the estimated mode is less than the midvalue of the modal class. This seems quite logical. If the frequencies are more on one side of the modal class than on the other it can be reasonably concluded that the items in the modal class are concentrated more towards the class limit of the adjoining class with the larger frequency.

The formula \((iii)\) is also based on a logic similar to that of \((i)\) and \((ii)\). In this case, to interpolate the value of the mode within the modal class, the differences between the frequency of the modal class, and the respective frequencies of the classes adjoining it are used. This formula usually gives results better than the values obtained by the other and exactly equal to the results obtained by graphic method. The formulae \((i)\) and \((ii)\) give values which are different from the value obtained by formula \((iii)\) and are more close to the central point of modal class. If
the frequencies of the class adjoining the modal are equal, the mode is expected to be located at the midvalue of the modal class, but if the frequency on one of the sides is greater, the mode will be pulled away from the central point. It will be pulled more and more if the difference between the frequencies of the classes adjoining the modal class is higher and higher. In Example 6.13, the frequency of the modal class is 19 and that of preceding class is 18. So, the mode should be quite close to the lower limit of the modal class. The midpoint of the modal class is 24 and lower limit of the modal class is 22.

 Locating the mode by the graphic method

The upper corners of the rectangle over the modal class have been joined by straight lines to those of the adjoining rectangles as shown in the diagram; the right corner to the corresponding one of the adjoining rectangle on the left, etc. If a perpendicular is drawn from the point of intersection of these lines, we have a value for the mode indicated on the base line. The graphic approach is, in principle, similar to the arithmetic interpolation explained earlier.

The mode may also be determined graphically from an ogive or cumulative frequency curve. It is found by drawing a perpendicular to the base from that point on the curve where the curve is most nearly vertical, i.e., steepest (in other words, where it passes through the greatest distance vertically and smallest distance horizontal). The point where it cuts the base gives us the value of the mode. How accurately this method determines the mode is governed by: (i) The shape of the ogive, (ii) The scale on which the curve is drawn.

 Estimating the mode from the mean and the median

There usually exists a relationship among the mean, median and mode for moderately asymmetrical distributions. If the distribution is symmetrical, the mean, median and mode will have identical values, but if the distribution is skewed (moderately) the mean, median and mode will pull apart. If the distribution tails off towards higher values, the mean and the median will be greater than the mode. If it tails off towards lower values, the mode will be greater than either of the other two measures. In either case, the median will be about one-third as far away from the mean as the mode is. This means that,

\[ \text{Mode} = \text{Mean} - 3(\text{Mean} - \text{Median}) \]

\[ = 3 \text{Median} - 2 \text{Mean} \]
In the case of the average monthly earnings, the mean is 68.53 and the median is 70.2. If these values are substituted in the above formula, we get,

Mode = \( 68.5 - 3(68.5 - 70.2) \)

= 68.5 + 5.1 = 73.6

According to the formula used earlier,

Mode = \( l_1 + \frac{f_2}{f_0 + f_2} \times i \)

= \( 72.5 + \frac{745}{795 + 745} \times 5 \)

= 72.5 + 2.4 = 74.9

OR

Mode = \( l_1 + \frac{f_1 - f_0}{2f_1 - f_0 - f_2} \times i \)

= \( 72.5 + \frac{915 - 795}{2 \times 915 - 795 - 745} \times 5 \)

= 72.5 + \( \frac{120}{290} \times 5 \) = 74.57
The difference between the two estimates is due to the fact that the assumption of relationship between the mean, median and mode may not always be true which is obviously not valid in this case.

Example 12.10: (i) In a moderately symmetrical distribution, the mode and mean are 32.1 and 35.4 respectively. Calculate the median.

(ii) If the mode and median of moderately asymmetrical series are respectively 16" and 15.7", what would be its most probable median?

(iii) In a moderately skewed distribution, the mean and the median are respectively 25.6 and 26.1 inches. What is the mode of the distribution?

Solution: (i) We know,

\[
\text{Mean} - \text{Mode} = 3(\text{Mean} - \text{Median})
\]

or

\[
3\text{Median} = \text{Mode} + 2\times \text{Mean}
\]

or

\[
\text{Median} = \frac{32.1 + 2 \times 35.4}{3} = \frac{102.9}{3} = 34.3
\]

(ii) \(2\text{Mean} = 3\text{Median} - \text{Mode}\)

or

\[
\text{Mean} = \frac{1}{2}(3 \times 15.7 - 16.0) = \frac{31.1}{2} = 15.55
\]

(iii) \(\text{Mode} = 3\text{Median} - 2\text{Mean}\)

\[
= 3 \times 26.1 - 2 \times 25.6 = 78.3 - 51.2 = 27.1
\]

Advantages of mode

- Similar to median, the mode is not affected by extreme values in the data.
- Its value can be obtained in open-ended distributions without ascertaining the class limits.
- It can be easily used to describe qualitative phenomenon. For example, if most people prefer a certain brand of tea, then this will become the modal point.
- Mode is easy to calculate and understand. In some cases, it can be located simply by observation or inspection.

Disadvantages of mode

- Quite often, there is no modal value.
- It can be bi-modal or multi-modal, or it can have all modal values making its significance more difficult to measure.
- If there is more than one modal value, the data is difficult to interpret.
- A mode is not suitable for algebraic manipulations.
Since the mode is the value of maximum frequency in the data set, it cannot be rigidly defined if such frequency occurs at the beginning or at the end of the distribution.

It does not include all observations in the data set, and hence, less reliable in most of the situations.

Check Your Progress

4. List the characteristics of mean.
5. How is median calculated when the number of cases is even?
6. What are the four important methods of estimating mode of a series?

12.4 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Inferential statistics, also known as inductive statistics, goes beyond describing a given problem situation by means of collecting, summarizing, and meaningfully presenting the related data.
2. The first step in any scientific inquiry is to collect data relevant to the problem in hand.
3. The totality of observations about which an inference may be drawn, or a generalization made, is called a population or a universe.
4. The following are the characteristics of mean: the sum of the deviation of individual values of X from the mean will always add up to zero, it is very sensitive to extreme values, and the sum of the squares of the deviations about the mean is minimum.
5. When there is an even number of cases, there is no actual middle item and the median is taken to be the average of the values of the items lying on either side of \((N+1)/2\), where \(N\) is the total number of items.
6. The four important methods of estimating mode of a series are: (i) locating the most frequently repeated value in the array; (ii) estimating the mode by interpolation; (iii) locating the mode by graphic method; and (iv) estimating the mode from the mean and the median.

12.5 SUMMARY

- Descriptive statistics deals with collecting, summarizing, and simplifying data, which are otherwise quite unwieldy and voluminous. It seeks to achieve this in a manner that meaningful conclusions can be readily drawn from the data.
In contrast, inferential statistics, also known as inductive statistics, goes beyond describing a given problem situation by means of collecting, summarizing, and meaningfully presenting the related data.

In an important dimension of its role, inferential statistics helps evaluate the risks involved in reaching inferences or generalizations about an unknown population on the basis of sample information.

Apart from the methods comprising the scope of descriptive and inferential branches of statistics, statistics also consists of methods of dealing with a few other issues of specific nature.

There are several commonly used measures such as arithmetic mean, mode and median. These values are very useful not only in presenting the overall picture of the entire data but also for the purpose of making comparisons among two or more sets of data.

Arithmetic mean is also commonly known as the mean. Even though average, in general, means measure of central tendency, when we use the word average in our daily routine, we always mean the arithmetic average. The term is widely used by almost everyone in daily communication. We speak of an individual being an average student or of average intelligence. We always talk about average family size or average family income or grade point average (GPA) for students, and so on.

The second measure of central tendency that has a wide usage in statistical works is the median. Median is that value of a variable which divides the series in such a manner that the number of items below it is equal to the number of items above it. Half the total number of observations lie below the median, and half above it. The median is thus a positional average.

The mode is that value of the variable which occurs or repeats itself the greatest number of times. The mode is the most ‘fashionable’ size in the sense that it is the most common and typical, and is defined by Zizek as ‘the value occurring most frequently in a series (or group of items) and around which the other items are distributed most densely’.

The mode of a distribution is the value at the point around which the items tend to be most heavily concentrated. It is the most frequent or the most common value, provided that a sufficiently large number of items are available, to give a smooth distribution. It will correspond to the value of the maximum point (ordinate), of a frequency distribution if it is an ‘ideal’ or smooth distribution. It may be regarded as the most typical of a series of values.

### 12.6 KEY WORDS

- **Inferential statistics**: Inferential statistics makes inferences about populations using data drawn from the population. Instead of using the entire
population to gather the data, the statistician will collect a sample or samples from the millions of residents and make inferences about the entire population using the sample.

- **Mean**: It refers to the arithmetic average and measure of central location.
- **Mode**: It is a form of average that can be defined as the most frequently occurring value in the data.
- **Median**: It refers to a measure of central tendency that appears in the centre of an ordered data.

### 12.7 SELF ASSESSMENT QUESTIONS AND EXERCISES

#### Short Answer Questions

1. Define statistics as a discipline. Also bring out its scope.
2. Differentiate between a mean and a mode.
3. Write three characteristics of mean.
4. What is the importance of arithmetic mean in statistics?

#### Long Answer Questions

1. Explain the concept of inferential statistics in detail.
2. Evaluate statistics as a subject in terms of its basic use and limitations.
3. Discuss the advantages and disadvantages of various measures of central tendency.
4. How is median calculated? Explain.
5. Explain the methods of estimating mode.
6. The following table gives the heights (in inches) of 100 boys of a class. Calculate mean, mode and median of the height.

<table>
<thead>
<tr>
<th>Height (inches)</th>
<th>No. of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>60–62</td>
<td>5</td>
</tr>
<tr>
<td>62–64</td>
<td>18</td>
</tr>
<tr>
<td>64–66</td>
<td>42</td>
</tr>
<tr>
<td>66–68</td>
<td>20</td>
</tr>
<tr>
<td>68–70</td>
<td>8</td>
</tr>
<tr>
<td>70–72</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**Solution**: 65.58
12.8 FURTHER READINGS


UNIT 13 DISPERSION

Structure
13.0 Introduction
13.1 Objectives
13.2 Measures of Dispersion
  13.2.1 Range
  13.2.2 Quartile Deviation
  13.2.3 Standard Deviation and Coefficient of Variation
13.3 Test of Significance: Chi-square, T-Statistic
13.4 Correlation: Meaning, Types and Uses
  13.4.1 Different Methods of Studying Correlation
13.5 Karl Pearson’s Coefficient of Correlation
13.6 Spearman’s Rank Correlation Coefficient
13.7 Answers to Check Your Progress Questions
13.8 Summary
13.9 Key Words
13.10 Self Assessment Questions and Exercises
13.11 Further Readings

13.0 INTRODUCTION

In this unit, you will learn about the various measures of dispersion such as range, quartile deviation, standard deviation and coefficient of variation.

You will also learn about the correlation analysis techniques that analyses the indirect relationships in sample survey data and establishes the variables which are most closely associated with a given action or mindset. It is the process of finding how accurately the line fits using the observations. You will also learn about the scatter diagram, least squares method and standard error of the estimate.

13.1 OBJECTIVES

After going through this unit, you will be able to:

- Describe the various measures of dispersion
- Calculate correlation using various methods
- Describe the various tests of significance
- Discuss the meaning, types and uses of correlation

13.2 MEASURES OF DISPERSION

A measure of dispersion, or simply dispersion may be defined as statistics signifying the extent of the scatteredness of items around a measure of central tendency.
A measure of dispersion may be expressed in an ‘absolute form’, or in a ‘relative form’. It is said to be in an absolute form when it states the actual amount by which the value of an item on an average deviates from a measure of central tendency. Absolute measures are expressed in concrete units, i.e., units in terms of which the data have been expressed, e.g., rupees, centimetres, kilograms, etc., and are used to describe frequency distribution.

A relative measure of dispersion computed is a quotient by dividing the absolute measures by a quantity in respect to which absolute deviation has been computed. It is as such a pure number and is usually expressed in a percentage form. Relative measures are used for making comparisons between two or more distributions.

A measure of dispersion should possess all those characteristics which are considered essential for a measure of central tendency, viz.

- It should be based on all observations.
- It should be readily comprehensible.
- It should be fairly easily calculated.
- It should be affected as little as possible by fluctuations of sampling.
- It should be amenable to algebraic treatment.

The following are some common measures of dispersion:

(i) The range, (ii) the semi-interquartile range or the quartile deviation, (iii) the mean deviation, and (iv) the standard deviation. Of these, the standard deviation is the best measure. We describe these measures in the following sections.

13.2.1 Range

The crudest measure of dispersion is the range of the distribution. The range of any series is the difference between the highest and the lowest values in the series. If the marks received in an examination taken by 248 students are arranged in ascending order, then the range will be equal to the difference between the highest and the lowest marks.

In a frequency distribution, the range is taken to be the difference between the lower limit of the class at the lower extreme of the distribution and the upper limit of the class at the upper extreme.

**Table 13.1 Weekly Earnings of Labourers in Four Workshops of the Same Type**

<table>
<thead>
<tr>
<th>Weekly earnings</th>
<th>No. of workers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Workshop A</td>
</tr>
<tr>
<td>15–16</td>
<td>...</td>
</tr>
<tr>
<td>17–18</td>
<td>...</td>
</tr>
<tr>
<td>19–20</td>
<td>...</td>
</tr>
<tr>
<td>21–22</td>
<td>10</td>
</tr>
<tr>
<td>23–24</td>
<td>22</td>
</tr>
</tbody>
</table>
Consider the data on weekly earning of worker on four workshops given in the Table 13.1. We note the following:

<table>
<thead>
<tr>
<th>Workshop</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>D</td>
</tr>
</tbody>
</table>

From these figures, it is clear that the greater the range, the greater is the variation of the values in the group.

The range is a measure of absolute dispersion and as such cannot be usefully employed for comparing the variability of two distributions expressed in different units. The amount of dispersion measured, say, in pounds, is not comparable with dispersion measured in inches. So the need of measuring relative dispersion arises.

An absolute measure can be converted into a relative measure if we divide it by some other value regarded as standard for the purpose. We may use the mean of the distribution or any other positional average as the standard.

For Table 13.1, the relative dispersion would be:

Workshop \( A = \frac{9}{25.5} \)

Workshop \( C = \frac{23}{25.5} \)

Workshop \( B = \frac{15}{25.5} \)

Workshop \( D = \frac{15}{25.5} \)

An alternate method of converting an absolute variation into a relative one would be to use the total of the extremes as the standard. This will be equal to dividing the difference of the extreme items by the total of the extreme items. Thus,

Relative Dispersion = \( \frac{\text{Difference of extreme items, i.e., Range}}{\text{Sum of extreme items}} \)

The relative dispersion of the series is called the coefficient or ratio of dispersion. In our example of weekly earnings of workers considered earlier, the coefficients would be:

Workshop \( A = \frac{9}{21 + 30} \)

Workshop \( B = \frac{15}{17 + 32} \)
Dispersion

Workshop \( C = \frac{23}{15 + 38} \cdot \frac{23}{53} \)

Workshop \( D = \frac{15}{19 + 34} \cdot \frac{15}{53} \)

NOTES

Merits and Limitations of Range

Merits

Of the various characteristics that a good measure of dispersion should possess, the range has only two, viz (i) it is easy to understand, and (ii) its computation is simple.

Limitations

Besides the aforesaid two qualities, the range does not satisfy the other test of a good measure and hence it is often termed as a crude measure of dispersion.

The following are the limitations that are inherent in the range as a concept of variability:

(i) Since it is based upon two extreme cases in the entire distribution, the range may be considerably changed if either of the extreme cases happens to drop out, while the removal of any other case would not affect it at all.

(ii) It does not tell anything about the distribution of values in the series relative to a measure of central tendency.

(iii) It cannot be computed when distribution has open-end classes.

(iv) It does not take into account the entire data. These can be illustrated by the following illustration. Consider the data given in Table 13.2.

<table>
<thead>
<tr>
<th>Class</th>
<th>Section A</th>
<th>Section B</th>
<th>Section C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–10</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>10–20</td>
<td>1</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>20–30</td>
<td>12</td>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>30–40</td>
<td>17</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>40–50</td>
<td>29</td>
<td>35</td>
<td>16</td>
</tr>
<tr>
<td>50–60</td>
<td>18</td>
<td>25</td>
<td>18</td>
</tr>
<tr>
<td>60–70</td>
<td>16</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>70–80</td>
<td>6</td>
<td>8</td>
<td>21</td>
</tr>
<tr>
<td>80–90</td>
<td>11</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>90–100</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Total</td>
<td>110</td>
<td>110</td>
<td>110</td>
</tr>
<tr>
<td>Range</td>
<td>80</td>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>
Notes

Self-Instructional Material

Dispersion

The table is designed to illustrate three distributions with the same number of cases but different variability. The removal of two extreme students from section A would make its range equal to that of B or C.

The greater range of A is not a description of the entire group of 110 students, but of the two most extreme students only. Further, though sections B and C have the same range, the students in section B cluster more closely around the central tendency of the group than they do in section C. Thus, the range fails to reveal the greater homogeneity of B or the greater dispersion of C. Due to this defect, it is seldom used as a measure of dispersion.

Specific uses of range

In spite of the numerous limitations of the range as a measure of dispersion, there are the following circumstances when it is the most appropriate one:

(i) In situations where the extremes involve some hazard for which preparation should be made, it may be more important to know the most extreme cases to be encountered than to know anything else about the distribution. For example, an explorer would like to know the lowest and the highest temperatures on record in the region he is about to enter; or an engineer would like to know the maximum rainfall during 24 hours for the construction of a storm water drain.

(ii) In the study of prices of securities, range has a special field of activity. Thus to highlight fluctuations in the prices of shares or bullion it is a common practice to indicate the range over which the prices have moved during a certain period of time. This information, besides being of use to the operators, gives an indication of the stability of the bullion market, or that of the investment climate.

(iii) In statistical quality control the range is used as a measure of variation. We, e.g., determine the range over which variations in quality are due to random causes, which is made the basis for the fixation of control limits.

13.2.2 Quartile Deviation

Another measure of dispersion, much better than the range, is the semi-interquartile range, usually termed as ‘quartile deviation’. As stated in the previous unit, quartiles are the points which divide the array in four equal parts. More precisely, $Q_1$ gives the value of the item 1/4th the way up the distribution and $Q_3$, the value of the item 3/4th the way up the distribution. Between $Q_1$ and $Q_3$ are included half the total number of items. The difference between $Q_3$ and $Q_1$, includes only the central items but excludes the extremes. Since under most circumstances, the central half of the series tends to be fairly typical of all the items, the interquartile range $(Q_3 - Q_1)$ affords a convenient and often a good indicator of the absolute variability. The larger the interquartile range, the larger the variability.

Usually, one-half of the difference between $Q_3$ and $Q_1$, is used and to it is given the name of quartile deviation or semi-interquartile range. The interquartile range is
divided by two for the reason that half of the interquartile range will, in a normal distribution, be equal to the difference between the median and any quartile. This means that 50 per cent items of a normal distribution will lie within the interval defined by the median plus and minus the semi-interquartile range.

Symbolically:

\[ Q.D. = \frac{Q_3 - Q_1}{2} \]  

...(13.1)

Let us find quartile deviations for the weekly earnings of labour in the four workshop whose data is given in Table 13.1. The computations are as shown in Table 13.3.

As shown in the table, Q.D. of workshop A is 2.12 and median value in 25.3. This means that if the distribution is symmetrical the number of workers whose wages vary between (25.3–2.1) = 23.2 and (25.3 + 2.1) = 27.4, shall be just half of the total cases. The other half of the workers will be more than 2.1 removed from the median wage. As this distribution is not symmetrical, the distance between \( Q_1 \) and the median \( Q_2 \) is not the same as between \( Q_3 \) and the median. Hence the interval defined by median plus and minus semi inter-quartile range will not be exactly the same as given by the value of the two quartiles. Under such conditions the range between 23.2 and 27.4 will not include precisely 50 per cent of the workers.

If quartile deviation is to be used for comparing the variability of any two series, it is necessary to convert the absolute measure to a coefficient of quartile deviation. To do this the absolute measure is divided by the average size of the two quartile.

Symbolically:

\[ \text{Coefficient of quartile deviation} = \frac{Q_3 - Q_1}{Q_3 + Q_1} \]  

...(13.2)

Applying this to our illustration of four workshops, the coefficients of Q.D. are as given below.

<table>
<thead>
<tr>
<th>Workshop</th>
<th>Workshop</th>
<th>Workshop</th>
<th>Workshop</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Location of ( Q_2 )</td>
<td>( \frac{N}{2} )</td>
<td>80 ( \frac{2}{4} )</td>
<td>40</td>
</tr>
<tr>
<td>( Q_2 )</td>
<td>24.5 + 0.9 = 25.4</td>
<td>24.5 + 1.1 = 25.6</td>
<td>24.5 + 0.75 = 25.25</td>
</tr>
<tr>
<td>Location of ( Q_1 )</td>
<td>( \frac{N}{4} )</td>
<td>80 ( \frac{4}{4} )</td>
<td>20</td>
</tr>
<tr>
<td>( Q_1 )</td>
<td>22.5 + 9.1 = 23.41</td>
<td>22.5 + 5.7 = 23.07</td>
<td>22.5 + 2 = 22.5</td>
</tr>
</tbody>
</table>
Characteristics of quartile deviation

- The size of the quartile deviation gives an indication about the uniformity or otherwise of the size of the items of a distribution. If the quartile deviation is small it denotes large uniformity. Thus, a coefficient of quartile deviation may be used for comparing uniformity or variation in different distributions.
- Quartile deviation is not a measure of dispersion in the sense that it does not show the scatter around an average, but only a distance on scale. Consequently, quartile deviation is regarded as a measure of partition.
- It can be computed when the distribution has open-end classes.

Limitations of quartile deviation

Except for the fact that its computation is simple and it is easy to understand, a quartile deviation does not satisfy any other test of a good measure of variation.

13.2.3 Standard Deviation and Coefficient of Variation

By far the most universally used and the most useful measure of dispersion is the standard deviation or root mean square deviation about the mean. We have seen that all the methods of measuring dispersion so far discussed are not universally adopted for want of adequacy and accuracy. The range is not satisfactory as its magnitude is determined by most extreme cases in the entire group. Further, the range is notable because it is dependent on the item whose size is largely matter of chance. Mean deviation method is also an unsatisfactory measure of scatter, as it ignores the algebraic signs of deviation. We desire a measure of scatter which is free from these shortcomings. To some extent standard deviation is one such measure.

The calculation of standard deviation differs in the following respects from that of mean deviation. First, in calculating standard deviation, the deviations are
Dispersion

NOTES

Self-Instructional

Material

squared. This is done so as to get rid of negative signs without committing algebraic violence. Further, the squaring of deviations provides added weight to the extreme items, a desirable feature for certain types of series.

Secondly, the deviations are always recorded from the arithmetic mean, because although the sum of deviations is the minimum from the median, the sum of squares of deviations is minimum when deviations are measured from the arithmetic average. The deviation from \( \tau \) is represented by \( d \).

Thus, standard deviation, \( \sigma \) (sigma) is defined as the square root of the mean of the squares of the deviations of individual items from their arithmetic mean.

\[
\sigma = \sqrt{\frac{\sum (x - \tau)^2}{N}} \quad \ldots (13.3)
\]

For grouped data (discrete variables)

\[
\sigma = \sqrt{\frac{\sum f (x - \tau)^2}{\Sigma f}} \quad \ldots (13.4)
\]

and, for grouped data (continuous variables)

\[
\sigma = \sqrt{\frac{\sum f (M - \tau)^2}{\Sigma f}} \quad \ldots (13.5)
\]

where \( M \) is the mid-value of the group.

The use of these formulae is illustrated by the following examples.

**Example 13.1:** Compute the standard deviation for the following data:

11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21.

**Solution:**

Here formula (6.7) is appropriate. We first calculate the mean as \( \tau = \frac{\sum x}{N} = 176/11 = 16 \), and then calculate the deviation as follows:

<table>
<thead>
<tr>
<th>( x )</th>
<th>( x - \tau )</th>
<th>((x - \tau)^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>-5</td>
<td>25</td>
</tr>
<tr>
<td>12</td>
<td>-4</td>
<td>16</td>
</tr>
<tr>
<td>13</td>
<td>-3</td>
<td>9</td>
</tr>
<tr>
<td>14</td>
<td>-2</td>
<td>4</td>
</tr>
<tr>
<td>15</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>19</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>20</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>21</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>176</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

Thus by formula (7).

\[
\sigma = \sqrt{\frac{110}{11}} = \sqrt{10} = 3.16
\]
Example 13.2: Find the standard deviation of the data in the following distributions:

<table>
<thead>
<tr>
<th>x</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>f</td>
<td>4</td>
<td>11</td>
<td>32</td>
<td>21</td>
<td>15</td>
<td>8</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

Solution:

For this discrete variable grouped data, we use formula 6.8. Since for calculation of \( \bar{x} \), we need \( \sum f \) and then for \( \sigma \) we need \( \sum f(x - \bar{x})^2 \), the calculations are conveniently made in the following format.

\[
\begin{array}{cccccc}
 x & f & fx & d = x - \bar{x} & d^2 & fd^2 \\
12 & 4 & 48 & -3 & 9 & 36 \\
13 & 11 & 143 & -2 & 4 & 44 \\
14 & 32 & 448 & -1 & 1 & 32 \\
15 & 21 & 315 & 0 & 0 & 0 \\
16 & 15 & 240 & 1 & 1 & 15 \\
17 & 8 & 136 & 2 & 4 & 32 \\
18 & 5 & 90 & 3 & 9 & 45 \\
20 & 4 & 80 & 5 & 25 & 100 \\
\end{array}
\]

\[
\sum fx = 100 \\
\sum f = 150 \\
\sum fd^2 = 304
\]

Here \( \bar{x} = \frac{\sum f x}{\sum f} = \frac{1500}{100} = 15 \)

and

\[
\sigma = \sqrt{\frac{\sum fd^2}{\sum f}} = \sqrt{\frac{304}{100}} = 1.74
\]

Example 13.3: Calculate the standard deviation of the following data.

<table>
<thead>
<tr>
<th>Class</th>
<th>1–3</th>
<th>3–5</th>
<th>5–7</th>
<th>7–9</th>
<th>9–11</th>
<th>11–13</th>
<th>13–15</th>
</tr>
</thead>
<tbody>
<tr>
<td>frequency</td>
<td>1</td>
<td>9</td>
<td>25</td>
<td>35</td>
<td>17</td>
<td>10</td>
<td>3</td>
</tr>
</tbody>
</table>

Solution: This is an example of continuous frequency series and formula 6.9 seems appropriate.

\[
\begin{array}{ccccccc}
 Class & Mid-point & Frequency & Deviation of mid-point from mean (x) & Squared deviation & Squared deviation times frequency \\
 x & f & fx & d & d^2 & fd^2 \\
1–3 & 2 & 1 & 2 & -6 & 36 & 36 \\
3–5 & 4 & 9 & 36 & -4 & 16 & 144 \\
5–7 & 6 & 25 & 150 & -2 & 4 & 100 \\
7–9 & 8 & 35 & 280 & 0 & 0 & 0 \\
9–11 & 10 & 17 & 170 & 2 & 4 & 68 \\
11–13 & 12 & 10 & 120 & 4 & 16 & 160 \\
13–15 & 14 & 3 & 42 & 6 & 36 & 108 \\
\end{array}
\]

\[
\sum fx = 100 \\
\sum f = 800 \\
\sum fd^2 = 616
\]
First the mean is calculated as
\[ \bar{x} = \frac{\sum fx}{\sum f} = \frac{800}{100} = 8.0 \]

Then the deviations are obtained from 8.0. The standard deviation,
\[ \sigma = \sqrt{\frac{\sum fd^2}{\sum f} - \left(\frac{\sum fx}{\sum f}\right)^2} \]
\[ \sigma = \sqrt{\frac{616}{100} - \left(\frac{800}{100}\right)^2} = 2.48 \]

**Calculation of Standard Deviation by Short-cut Method**

The three examples worked out above have one common simplifying feature, namely \( \bar{x} \) in each, turned out to be an integer, thus, simplifying calculations. In most cases, it is very unlikely that it will turn out to be so. In such cases, the calculation of \( d \) and \( d^2 \) becomes quite time-consuming. Short-cut methods have consequently been developed. These are on the same lines as those for calculation of mean itself.

In the short-cut method, we calculate deviations \( x' \) from an assumed mean \( A \). Then,

- for ungrouped data
  \[ \sigma = \sqrt{\frac{\sum x'^2}{N} - \left(\frac{\sum x'}{N}\right)^2} \] ...

and for grouped data

\[ \sigma = \sqrt{\frac{\sum fx'^2}{\sum f} - \left(\frac{\sum fx'}{\sum f}\right)^2} \] ...

This formula is valid for both discrete and continuous variables. In case of continuous variables, \( x \) in the equation \( x' = x - A \) stands for the mid-value of the class in question.

Note that the second term in each of the formulae is a correction term because of the difference in the values of \( A \) and \( \bar{x} \). When \( A \) is taken as \( \bar{x} \) itself, this correction is automatically reduced to zero.

**Example 13.4:** Compute the standard deviation by the short-cut method for the following data:

\[ 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 \]
Solution: Let us assume that $A = 15$.

$\begin{array}{c|c|c}
  x' &=& (x - A) \\
  x^2 &=& \hline
  11 & 4 & 16 \\
  12 & -3 & 9 \\
  13 & -2 & 4 \\
  14 & -1 & 1 \\
  15 & 0 & 0 \\
  16 & 1 & 1 \\
  17 & 2 & 4 \\
  18 & 3 & 9 \\
  19 & 4 & 16 \\
  20 & 5 & 25 \\
  21 & 6 & 36 \\
\end{array}$

$N = 11 \quad \sum x' = 11 \quad \sum x'^2 = 121$

$\sigma = \sqrt{\frac{\sum x'^2}{N} - \left(\frac{\sum x'}{N}\right)^2}$

$= \sqrt{\frac{121}{11} - \left(\frac{11}{11}\right)^2}$

$= \sqrt{10}$

$= 3.16.$

Another method

If we assumed $A$ as zero, then the deviation of each item from the assumed mean is the same as the value of item itself. Thus, 11 deviates from the assumed mean of zero by 11, 12 deviates by 12, and so on. As such, we work with deviations without having to compute them, and the formula takes the following shape:

$\begin{array}{c|c|c}
  x &=& x^2 \\
  11 & 121 \\
  12 & 144 \\
  13 & 169 \\
  14 & 196 \\
  15 & 225 \\
  16 & 256 \\
  17 & 289 \\
  18 & 324 \\
  19 & 361 \\
  20 & 400 \\
  21 & 441 \\
\end{array}$

$\sum x = 176 \quad \sum x^2 = 2,926$
Dispersion

\[ \sigma = \sqrt{\frac{\sum x^2}{N} - \left(\frac{\sum x}{N}\right)^2} \]

\[ = \sqrt{\frac{2926}{11} - \left(\frac{176}{11}\right)^2} = \sqrt{256 - 256} = 3.16 \]

**Example 13.5:** Calculate the standard deviation of the following data by short method.

<table>
<thead>
<tr>
<th>Person</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly income (Rupees)</td>
<td>300</td>
<td>400</td>
<td>420</td>
<td>440</td>
<td>460</td>
<td>480</td>
<td>580</td>
</tr>
</tbody>
</table>

**Solution:** In this data, the values of the variable are very large making calculations cumbersome. It is advantageous to take a common factor out. Thus, we use \( x' = \frac{x - A}{C} \). The standard deviation is calculated using \( x' \) and then the true value of \( \sigma \) is obtained by multiplying back by \( C \). The effective formula then is

\[ \sigma = C \times \sqrt{\frac{\sum x'^2}{N} - \left(\frac{\sum x'}{N}\right)^2} \]

where \( C \) represents the common factor.

Using \( x' = (x - 420)/20 \).

<table>
<thead>
<tr>
<th>( x )</th>
<th>Deviation from Assumed mean ( x' = (x - 420) )</th>
<th>( x' )</th>
<th>( x'^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>-120</td>
<td>-6</td>
<td>36</td>
</tr>
<tr>
<td>400</td>
<td>-20</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>420</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>440</td>
<td>20</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>460</td>
<td>40</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>480</td>
<td>60</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>580</td>
<td>160</td>
<td>8</td>
<td>64</td>
</tr>
</tbody>
</table>

\[ N = 7 \]

\[ \sigma = 20 \times \sqrt{\frac{\sum x'^2}{N} - \left(\frac{\sum x'}{N}\right)^2} \]

\[ = 20 \times \sqrt{\frac{115 - 7}{7}} \]

\[ = 78.56 \]
Example 13.6: Calculate the standard deviation from the following data:

<table>
<thead>
<tr>
<th>Size</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>18</td>
<td>2</td>
</tr>
</tbody>
</table>

**Solution:**

<table>
<thead>
<tr>
<th>$x$</th>
<th>Frequency</th>
<th>Deviation from assumed mean 12</th>
<th>Deviation divided by common factor 3 $f'x'$</th>
<th>$x'$ times frequency $fx'$</th>
<th>$x'^2$ times frequency $fx'^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>7</td>
<td>-6</td>
<td>-2</td>
<td>-14</td>
<td>28</td>
</tr>
<tr>
<td>9</td>
<td>12</td>
<td>-3</td>
<td>-1</td>
<td>-12</td>
<td>12</td>
</tr>
<tr>
<td>12</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>18</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

$N = 50$  
$\sum fx' = -12$  
$\sum fx'^2 = 58$

Since deviations have been divided by a common factor, we use

$$\sigma = C \sqrt{\frac{\sum fx'^2}{N}} - \left(\frac{\sum fx'}{N}\right)^2$$

$$= \sqrt{\frac{58}{50}} - \left(\frac{-12}{50}\right)^2$$

$$= 3 \sqrt{1.1600 - 0.0576} = 3 \times 1.05 = 3.15.$$

**Example 13.7:** Obtain the mean and standard deviation of the first $N$ natural numbers, i.e., of 1, 2, 3, ..., $N-1$, $N$.

**Solution:** Let $x$ denote the variable which assumes the values of the first $N$ natural numbers.

Then

$$\bar{x} = \frac{\sum x}{N} = \frac{N(N+1)}{2} \cdot \frac{N+1}{2}$$

because

$$\sum x = 1 + 2 + 3 + ... + (N-1) + N = \frac{N(N+1)}{2}$$

To calculate the standard deviation $\sigma$, we use 0 as the assumed mean. Then

$$\sigma = \sqrt{\frac{\sum x^2}{N} - \left(\frac{\sum x}{N}\right)^2}$$

But

$$\sum x^2 = 1^2 + 2^2 + 3^2 + ... + (N-1)^2 + N^2 = \frac{N(N+1)(2N+1)}{6}$$

Therefore
Dispersion

\[ \sigma = \sqrt{\frac{N(N+1)(2N+1)}{6N} - \frac{N^2(N+1)^2}{4N^2}} \]

\[ = \sqrt{\frac{(N+1)2N+1}{3} - \frac{N+1}{2}} = \sqrt{\frac{N(N+1)(N-1)}{12}} \]

Thus for first 11 natural numbers

\[ \tau = \frac{11 + 1}{2} = 6 \]

and

\[ \sigma = \sqrt{\frac{11(11+1)(11-1)}{12}} = 3.16 \]

Example 13.8:

<table>
<thead>
<tr>
<th>Mid-point ( s )</th>
<th>Frequency ( f )</th>
<th>Deviation from class of assumed mean ( x' )</th>
<th>Deviation time frequency ( fx' )</th>
<th>Squared deviation times frequency ( fx'^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–10</td>
<td>5</td>
<td>18</td>
<td>-2</td>
<td>-36</td>
</tr>
<tr>
<td>10–20</td>
<td>15</td>
<td>16</td>
<td>-1</td>
<td>-16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-52</td>
</tr>
<tr>
<td>20–30</td>
<td>25</td>
<td>15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>30–40</td>
<td>35</td>
<td>12</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>40–50</td>
<td>45</td>
<td>10</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>50–60</td>
<td>55</td>
<td>5</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>60–70</td>
<td>65</td>
<td>2</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>70–80</td>
<td>75</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( \sum fx'^2 = 8 )</td>
</tr>
</tbody>
</table>

Solution: Since the deviations are from assumed mean and expressed in terms of class-interval units,

\[ \sigma = 10 \times \sqrt{\frac{\sum fx'^2}{N} - \left( \frac{\sum fx'}{N} \right)^2} \]

\[ = 10 \times \sqrt{\frac{242}{79} - \left( \frac{8}{79} \right)^2} \]

\[ = 10 \times 1.75 = 17.5. \]

Combining Standard Deviations of Two Distributions

If we were given two sets of data of \( N_1 \) and \( N_2 \) items with means \( \tau_1 \) and \( \tau_2 \) and standard deviations \( \sigma_1 \) and \( \sigma_2 \), respectively, we can obtain the mean and standard deviation \( \tau \) and \( \sigma \) of the combined distribution by the following formulae:
\[ \tau = \frac{N_1 \bar{x}_1 + N_2 \bar{x}_2}{N_1 + N_2} \quad \text{...(13.8)} \]

and

\[ \sigma = \sqrt{\frac{N_1 \sigma_1^2 + N_2 \sigma_2^2 + N_1(\tau - \bar{x}_1)^2 + N_2(\tau - \bar{x}_2)^2}{N_1 + N_2}} \quad \text{...(13.9)} \]

**Example 13.9:** The mean and standard deviations of two distributions of 100 and 150 items are 50, 5 and 40, 6 respectively. Find the standard deviation of all taken together.

**Solution:** Combined mean

\[ \tau = \frac{N_1 \tau_1 + N_2 \tau_2}{N_1 + N_2} = \frac{100 \times 50 + 150 \times 40}{100 + 150} = 44 \]

Combined standard deviation

\[ \sigma = \sqrt{\frac{N_1 \sigma_1^2 + N_2 \sigma_2^2 + N_1(\tau - \bar{x}_1)^2 + N_2(\tau - \bar{x}_2)^2}{N_1 + N_2}} = \sqrt{\frac{100 \times (5)^2 + 150 \times (6)^2 + 100(44 - 50)^2 + 150(44 - 40)^2}{100 + 150}} = 7.46. \]

**Example 13.10:** A distribution consists of three components with 200, 250, 300 items having mean 25, 10 and 15 and standard deviation 3, 4 and 5, respectively. Find the standard deviation of the combined distribution.

**Solution:** In the usual notations, we are given here

\[ N_1 = 200, \quad N_2 = 250, \quad N_3 = 300 \]

\[ \tau_1 = 25, \quad \tau_2 = 10, \quad \tau_3 = 15 \]

The formulae (12) and (13) can easily be extended for combination of three series as

\[ \tau = \frac{N_1 \tau_1 + N_2 \tau_2 + N_3 \tau_3}{N_1 + N_2 + N_3} = \frac{200 \times 25 + 250 \times 10 + 300 \times 15}{200 + 250 + 300} = \frac{12000}{750} = 16 \]

and

\[ \sigma = \sqrt{\frac{N_1 \sigma_1^2 + N_2 \sigma_2^2 + N_3 \sigma_3^2 + N_1(\tau - \bar{x}_1)^2 + N_2(\tau - \bar{x}_2)^2 + N_3(\tau - \bar{x}_3)^2}{N_1 + N_2 + N_3}} = \sqrt{\frac{200 \times 9 + 250 \times 16 + 300 \times 25 + 200 \times 81 + 250 \times 36 + 300 \times 1}{200 + 250 + 300}} = \sqrt{57.73} = 7.19. \]
Dispersion

Comparison of Various Measures of Dispersion

The range is the easiest to calculate the measure of dispersion, but since it depends on extreme values, it is extremely sensitive to the size of the sample, and to the sample variability. In fact, as the sample size increases the range increases dramatically, because the more the items one considers, the more likely it is that some item will turn up which is larger than the previous maximum or smaller than the previous minimum. So, it is, in general, impossible to interpret properly the significance of a given range unless the sample size is constant. It is for this reason that there appears to be only one valid application of the range, namely in statistical quality control where the same sample size is repeatedly used, so that comparison of ranges are not distorted by differences in sample size.

The quartile deviations and other such positional measures of dispersions are also easy to calculate but suffer from the disadvantage that they are not amenable to algebraic treatment. Similarly, the mean deviation is not suitable because we cannot obtain the mean deviation of a combined series from the deviations of component series. However, it is easy to interpret and easier to calculate than the standard deviation.

The standard deviation of a set of data, on the other hand, is one of the most important statistics describing it. It lends itself to rigorous algebraic treatment, is rigidly defined and is based on all observations. It is, therefore, quite insensitive to sample size (provided the size is ‘large enough’) and is least affected by sampling variations.

It is used extensively in testing of hypothesis about population parameters based on sampling statistics.

In fact, the standard deviations has such stable mathematical properties that it is used as a standard scale for measuring deviations from the mean. If we are told that the performance of an individual is 10 points better than the mean, it really does not tell us enough, for 10 points may or may not be a large enough difference to be of significance. But if we know that the s for the score is only 4 points, so that on this scale, the performance is 2.5s better than the mean, the statement becomes meaningful. This indicates an extremely good performance. This sigma scale is a very commonly used scale for measuring and specifying deviations which immediately suggest the significance of the deviation.

The only disadvantages of the standard deviation lies in the amount of work involved in its calculation, and the large weight it attaches to extreme values because of the process of squaring involved in its calculations.

Check Your Progress

1. How can you define a measure of dispersion?
2. State the common measures of dispersion.
13.3 TEST OF SIGNIFICANCE: CHI-SQUARE, T-STATISTIC

Chi-square test is a non-parametric test of statistical significance for bivariate tabular analysis (also known as cross-breaks). Any appropriate test of statistical significance lets you know the degree of confidence you can have in accepting or rejecting a hypothesis. Typically, the Chi-square test is any statistical hypothesis test in which the test statistics has a chi-square distribution when the null hypothesis is true. It is performed on different samples (of people) who are different enough in some characteristic or aspect of their behaviour that we can generalize from the samples selected. The population from which our samples are drawn should also be different in the behaviour or characteristic. Amongst the several tests used in statistics for judging the significance of the sampling data, Chi-square test, developed by Prof. Fisher, is considered as an important test. Chi-square, symbolically written as $\chi^2$ (pronounced as Ki-square), is a statistical measure with the help of which, it is possible to assess the significance of the difference between the observed frequencies and the expected frequencies obtained from some hypothetical universe. Chi-square tests enable us to test whether more than two population proportions can be considered equal. In order that Chi-square test may be applicable, both the frequencies must be grouped in the same way and the theoretical distribution must be adjusted to give the same total frequency which is equal to that of observed frequencies. $\chi^2$ is calculated with the help of the following formula:

$$\chi^2 = \sum \frac{(o_i - e_i)^2}{e_i}$$

Where, $o_i$ means the observed frequency; and $e_i$ means the expected frequency.

Whether or not a calculated value of $\chi^2$ is significant, it can be ascertained by looking at the tabulated values of $\chi^2$ for given degrees of freedom at a certain level of confidence (generally a 5 per cent level is taken). If the calculated value of $\chi^2$ exceeds the table value, the difference between the observed and expected frequencies is taken as significant, but if the table value is more than the calculated value of $\chi^2$, then the difference between the observed and expected frequencies is considered as insignificant, i.e., considered to have arisen as a result of chance and as such can be ignored.

Degrees of Freedom

The number of independent constraints determines the number of degrees of freedom (or df). If there are 10 frequency classes and there is one independent constraint, then there are $(10 - 1) = 9$ degrees of freedom. Thus, if $n$ is the number of groups and one constraint is placed by making the totals of observed and expected frequencies equal, $df = (n - 1)$; when two constraints are placed
by making the totals as well as the arithmetic means equal then $df = (n - 2)$, and so on. In the case of a contingency table (i.e., a table with two columns and more than two rows or table with two rows but more than two columns or a table with more than two rows and more than two columns) or in the case of a $2 \times 2$ table, the degrees of freedom is worked out as follows:

$$df = (c - 1)(r - 1)$$

Where,

$c = \text{Number of columns}$

$r = \text{Number of rows}$

**Conditions for the Application of Test**

The following conditions should be satisfied before the test can be applied:

(i) Observations recorded and used are collected on a random basis.

(ii) All the members (or items) in the sample must be independent.

(iii) No group should contain very few items, say less than 10. In cases where the frequencies are less than 10, regrouping is done by combining the frequencies of adjoining groups so that the new frequencies become greater than 10. Some statisticians take this number as 5, but 10 is regarded as better by most of the statisticians.

(iv) The overall number of items (i.e., $N$) must be reasonably large. It should at least be 50, however small the number of groups may be.

(v) The constraints must be linear. Constraints which involve linear equations in the cell frequencies of a contingency table (i.e., equations containing no squares or higher powers of the frequencies) are known as linear constraints.

**Areas of Application of Chi-Square Test**

Chi-square test is applicable in a large number of problems. The test is, in fact, a technique through the use of which it is possible for us to (a) Test the goodness of fit; (b) Test the homogeneity of a number of frequency distributions; and (c) Test the significance of association between two attributes. In other words, Chi-square test is a test of independence, goodness of fit and homogeneity. At times, Chi-square test is used as a test of population variance also.

As a test of goodness of fit, $\chi^2$ test enables us to see how well the distribution of observed data fits the assumed theoretical distribution, such as Binomial distribution, Poisson distribution or the Normal distribution.

As a test of independence, $\chi^2$ test helps explain whether or not two attributes are associated. For instance, we may be interested in knowing whether a new medicine is effective in controlling fever or not and $\chi^2$ test will help us in deciding this issue. In such a situation, we proceed on the null hypothesis that the two attributes (viz., new medicine and control of fever) are independent. Which means that the new medicine is not effective in controlling
fever. It may, however, be stated here that $\chi^2$ is not a measure of the degree of relationship or the form of relationship between two attributes but it simply is a technique of judging the significance of such association or relationship between two attributes.

As a test of homogeneity, $\chi^2$ test helps us in stating whether different samples come from the same universe. Through this test, we can also explain whether the results worked out on the basis of sample/samples are in conformity with well-defined hypothesis or the results fail to support the given hypothesis. As such, the test can be taken as an important decision-making technique.

As a test of population variance, Chi-square is also used to test the significance of population variance through confidence intervals, especially in case of small samples.

**Additive Property of Chi-Square ($\chi^2$)**

An important property of $\chi^2$ is its additive nature. This means that several values of $\chi^2$ can be added together and if the degrees of freedom are also added, this number gives the degrees of freedom of the total value of $\chi^2$. Thus, if a number of $\chi^2$ values have been obtained from a number of samples of similar data, then, because of the additive nature of $\chi^2$, we can combine the various values of $\chi^2$ by just simply adding them. Such addition of various values of $\chi^2$ gives one value of $\chi^2$ which helps in forming a better idea about the significance of the problem under consideration. The following example illustrates the additive property of the $\chi^2$ (refer Example 13.11).

**Example 13.11**: The following values of $\chi^2$ are obtained from different investigations carried out to examine the effectiveness of a recently invented medicine for checking malaria.

<table>
<thead>
<tr>
<th>Investigation</th>
<th>$\chi^2$</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.5</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>3.2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>4.1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>3.7</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>4.5</td>
<td>1</td>
</tr>
</tbody>
</table>

What conclusion would you draw about the effectiveness of the new medicine on the basis of the five investigations taken together?

**Solution:**

By adding all the values of $\chi^2$, we obtain a value equal to 18.0. Also, by adding the various d.f. as given in the question, we obtain a figure 5. We can now state that the value of $\chi^2$ for 5 degrees of freedom (when all the five investigations are taken together) is 18.0.

Let us take the hypothesis that the new medicine is not effective. The table value of $\chi^2$ for 5 degrees of freedom at 5% level of significance is 11.070. But our
calculated value is higher than this table value which means that the difference is significant and is not due to chance. As such the hypothesis is wrong and it can be concluded that the new medicine is effective in checking malaria.

**Important Characteristics of Chi-Square ($\chi^2$) Test**

The following are the important characteristics of chi-square test:

(i) This test is based on frequencies and not on the parameters like mean and standard deviation.

(ii) This test is used for testing the hypothesis and is not useful for estimation.

(iii) This test possesses the additive property.

(iv) This test can also be applied to a complex contingency table with several classes and as such is a very useful test in research work.

(v) This test is an important non-parametric (or a distribution free) test as no rigid assumptions are necessary in regard to the type of population and no need of the parameter values. It involves less mathematical details.

**A Word of Caution in Using $\chi^2$ Test**

Chi-square test is no doubt a most frequently used test, but its correct application is equally an uphill task. It should be borne in mind that the test is to be applied only when the individual observations of sample are independent which means that the occurrence of one individual observation (event) has no effect upon the occurrence of any other observation (event) in the sample under consideration.

The researcher, while applying this test, must remain careful about all these things and must thoroughly understand the rationale of this important test before using it and drawing inferences concerning his hypothesis.

**t-Statistic**

Sir William S. Gosset (pen name Student) developed a significance test and through it made significant contribution to the theory of sampling applicable in case of small samples. When population variance is not known, the test is commonly known as Student’s $t$-test and is based on the $t$ distribution.

Like the normal distribution, $t$ distribution is also symmetrical but happens to be flatter than the normal distribution. Moreover, there is a different $t$ distribution for every possible sample size. As the sample size gets larger, the shape of the $t$ distribution loses its flatness and becomes approximately equal to the normal distribution. In fact, for sample sizes of more than 30, the $t$ distribution is so close to the normal distribution that we will use the normal to approximate the $t$ distribution. Thus, when $n$ is small, the $t$ distribution is far from normal, but when $n$ is infinite, it is identical to normal distribution.

For applying $t$-test in context of small samples, the $t$ value is calculated first of all and, then the calculated value is compared with the table value of $t$ at certain level of significance for given degrees of freedom. If the calculated value of $t$
If the calculated value is $t_c$ is less than its concerning table value, the difference is not treated as significant.

The $t$-test is used when the following two conditions are fulfilled:

(i) The sample size is less than 30, i.e., when $n \leq 30$.

(ii) The population standard deviation ($\sigma_p$) must be unknown.

In using the $t$-test, we assume the following:

(i) The population is normal or approximately normal.

(ii) The observations are independent and the samples are randomly drawn samples.

(iii) There is no measurement error.

(iv) In the case of two samples, population variances are regarded as equal if equality of the two population means is to be tested.

The following formulae are commonly used to calculate the $t$ value:

(i) To Test the Significance of the Mean of a Random Sample

$$ t = \frac{|\bar{x} - \mu|}{SE_{\bar{x}}} $$

Where,

$\bar{x}$ = Mean of the sample

$\mu$ = Mean of the universe

$SE_{\bar{x}}$ = S.E. of mean in case of small sample and is worked out as,

$$ SE_{\bar{x}} = \frac{\sigma_p}{\sqrt{n}} \times \frac{\sqrt{n}}{\sqrt{n}} $$

and the degrees of freedom = ($n - 1$)

The above stated formula for $t$ can as well be stated as,

$$ t = \frac{|\bar{x} - \mu|}{SE_{\bar{x}}} $$

$$ = \frac{\sqrt{n}}{\sqrt{n}} \times \frac{\sqrt{n}}{\sqrt{n}} $$

If we want to work out the probable or fiducial limits of population mean ($\mu$) in case of small samples, we can use either of the following:
Dispersion

\( (a) \) Probable limits with 95 per cent confidence level:
\[ \mu = \bar{X} \pm SE_\mu (t_{0.05}) \]

\( (b) \) Probable limits with 99 per cent confidence level:
\[ \mu = \bar{X} \pm SE_\mu (t_{0.01}) \]

At other confidence levels, the limits can be worked out in a similar manner, taking the concerning table value of \( t \) just as we have taken \( t_{0.05} \) in (a) and \( t_{0.01} \) in (b) above.

\( (ii) \) To Test the Difference between the Means of Two Samples

\[ t = \frac{|\bar{X}_1 - \bar{X}_2|}{SE_{\bar{X}_1 - \bar{X}_2}} \]

Where, \( \bar{X}_1 \) = Mean of the sample 1
\( \bar{X}_2 \) = Mean of the sample 2
\( SE_{\bar{X}_1 - \bar{X}_2} \) = Standard error of difference between two sample means and
is worked out as follows:

\[ SE_{\bar{X}_1 - \bar{X}_2} = \sqrt{\frac{\sum (x_{1i} - \bar{X}_1)^2 + \sum (x_{2i} - \bar{X}_2)^2}{n_1 + n_2 - 2}} \]
\[ \times \sqrt{\frac{1}{n_1} + \frac{1}{n_2}} \]

and the degrees of freedom = \((n_1 + n_2 - 2)\).

When the actual means are in fraction, then use of assumed means is convenient.

In such a case, the standard deviation of difference, i.e.,
\[ \sqrt{\frac{\Sigma (x_{1i} - x_{1A})^2 + \Sigma (x_{2i} - x_{2A})^2}{n_1 + n_2 - 2}} \]

can be worked out by the following short-cut formula:

\[ = \sqrt{\frac{\Sigma (x_{1i} - A_1)^2 + \Sigma (x_{2i} - A_2)^2 - n_1 (x_{1i} - A_1)^2 - n_2 (x_{2i} - A_2)^2}{n_1 + n_2 - 2}} \]

Where,
\( A_1 \) = Assumed mean of sample 1
\( A_2 \) = Assumed mean of sample 2
\( \bar{X}_1' \) = Assumed mean of sample 1
\( \bar{X}_2' \) = True mean of sample 1
\( \bar{X}_2' \) = True mean of sample 2
(iii) To Test the Significance of an Observed Correlation Coefficient

$$t = \frac{r}{\sqrt{1-r^2}} \times \sqrt{n-2}$$

Here, $t$ is based on $(n - 2)$ degrees of freedom.

(iv) In Context of the ‘Difference Test’

Difference test is applied in the case of paired data and in this context $t$ is calculated as,

$$t = \frac{\bar{X}_{diff} - 0}{\sigma_{diff}} \times \sqrt{n}$$

Where, $\bar{X}_{diff}$ or $\bar{D} = \text{Mean of the differences of sample items.}$

$0 = \text{the value zero on the hypothesis that there is no difference}$

$\sigma_{diff} = \text{standard deviation of difference and is worked out as}$

$$\sqrt{\frac{\sum (D - \bar{X}_{diff})^2}{n-1}}$$

or

$$\sqrt{\frac{\sum D^2 - (\bar{D})^2 \cdot n}{n-1}}$$

$D = \text{differences}$

$n = \text{number of pairs in two samples and is based on (n – 1)}$

$\text{degrees of freedom}$

$F$-Statistic

In business decisions, we are often involved in determining if there are significant differences among various sample means, from which conclusions can be drawn about the differences among various population means. What if we have to compare more than two sample means? For example, we may be interested to find out if there are any significant differences in the average sales figures of four different salesmen employed by the same company, or we may be interested to find out if the average monthly expenditures of a family of 4 in 5 different localities are similar or not, or the telephone company may be interested in checking, whether there are any significant differences in the average number of requests for information received in a given day among the five areas of New York City, and so on. The methodology used for such types of determinations is known as Analysis of Variance.

This technique is one of the most powerful techniques in statistical analysis and was developed by R.A. Fisher. It is also called the $F$-Test.
There are two types of classifications involved in the analysis of variance. The one-way analysis of variance refers to the situations when only one fact or variable is considered. For example, in testing for differences in sales for three salesmen, we are considering only one factor, which is the salesman’s selling ability.

In the second type of classification, the response variable of interest may be affected by more than one factor. For example, the sales may be affected not only by the salesman’s selling ability, but also by the price charged or the extent of advertising in a given area.

For the sake of simplicity and necessity, our discussion will be limited to One-way Analysis of Variance (ANOVA).

The null hypothesis, that we are going to test, is based upon the assumption that there is no significant difference among the means of different populations. For example, if we are testing for differences in the means of \( k \) populations, then,

\[
H_0: \mu_1 = \mu_2 = \mu_3 = \ldots = \mu_k
\]

The alternate hypothesis \((H_1)\) will state that at least two means are different from each other. In order to accept the null hypothesis, all means must be equal. Even if one mean is not equal to the others, then we cannot accept the null hypothesis. The simultaneous comparison of several population means is called Analysis of Variance or ANOVA.

**Assumptions**

The methodology of ANOVA is based on the following assumptions:

(i) Each sample of size \( n \) is drawn randomly and each sample is independent of the other samples.

(ii) The populations are normally distributed.

(iii) The populations from which the samples are drawn have equal variances. This means that:

\[
\sigma_1^2 = \sigma_2^2 = \sigma_3^2 = \ldots = \sigma_k^2
\]

for \( k \) populations.

**The Rationale Behind Analysis of Variance**

Why do we call it the Analysis of Variance, even though we are testing for means? Why not simply call it the Analysis of Means? How do we test for means by analysing the variances? As a matter of fact, in order to determine if the means of several populations are equal, we do consider the measure of variance, \( \sigma^2 \).

The estimate of population variance, \( \sigma^2 \), is computed by two different estimates of \( \sigma^2 \), each one by a different method. One approach is to compute an estimator of \( \sigma^2 \) in such a manner that even if the population means are not equal, it will have no effect on the value of this estimator. This means that, the differences in the values of the population means do not alter the value of \( \sigma^2 \) as calculated by a given method. This estimator of \( \sigma^2 \) is the average of the variances found within
each of the samples. For example, if we take 10 samples of size \( n \), then each sample will have a mean and a variance. Then, the mean of these 10 variances would be considered as an unbiased estimator of \( \sigma^2 \), the population variance, and its value remains appropriate irrespective of whether the population means are equal or not. This is really done by pooling all the sample variances to estimate a common population variance, which is the average of all sample variances. This common variance is known as variance within samples or \( \sigma^2_{within} \).

The second approach to calculate the estimate of \( \sigma^2 \) is based upon the Central Limit Theorem and is valid only under the null hypothesis assumption that all the population means are equal. This means that in fact, if there are no differences among the population means, then the computed value of \( \sigma^2 \) by the second approach should not differ significantly from the computed value of \( \sigma^2 \) by the first approach. Hence,

If these two values of \( \sigma^2 \) are approximately the same, then we can decide to accept the null hypothesis.

The second approach results in the following computation:

Based upon the Central Limit Theorem, we have previously found that the standard error of the sample means is calculated by,

\[
\sigma_s = \frac{\sigma}{\sqrt{n}}
\]

or, the variance would be:

\[
\sigma_s^2 = \frac{\sigma^2}{n}
\]

or,

\[
\sigma^2 = n\sigma_s^2
\]

Thus, by knowing the square of the standard error of the mean \((\sigma_s)^2\), we could multiply it by \( n \) and obtain a precise estimate of \( \sigma^2 \). This approach of estimating \( \sigma^2 \) is known as \( \sigma^2_{between} \). Now, if the null hypothesis is true, that is if all population means are equal then, \( \sigma^2_{between} \) value should be approximately the same as \( \sigma^2_{within} \) value. A significant difference between these two values would lead us to conclude that this difference is the result of differences between the population means.

But, how do we know that any difference between these two values is significant or not? How do we know whether this difference, if any, is simply due to random sampling error or due to actual differences among the population means?

R.A. Fisher developed a Fisher test or \( F \)-test to answer the above question. He determined that the difference between \( \sigma^2_{between} \) and \( \sigma^2_{within} \) values could be expressed as a ratio to be designated as the \( F \)-value, so that,

\[
F = \frac{\sigma^2_{between}}{\sigma^2_{within}}
\]
In the minter case, if the population means are exactly the same, then $\sigma^2_{\text{between}}$ will be equal to the $\sigma^2_{\text{within}}$ and the value of $F$ will be equal to 1.

However, because of sampling errors and other variations, some disparity between these two values will be there, even when the null hypothesis is true, meaning that all population means are equal. The extent of disparity between the two variances and consequently, the value of $F$, will influence our decision on whether to accept or reject the null hypothesis. It is logical to conclude that, if the population means are not equal, then their sample means will also vary greatly from one another, resulting in a larger value of $\sigma^2_{\text{between}}$ and hence a larger value of $F$ ($\sigma^2_{\text{within}}$ is based only on sample variances and not on sample means and hence, is not affected by differences in sample means). Accordingly, the larger the value of $F$, the more likely the decision to reject the null hypothesis. But, how large the value of $F$ be so as to reject the null hypothesis? The answer is that the computed value of $F$ must be larger than the critical value of $F$, given in the table for a given level of significance and calculated number of degrees of freedom. (The $F$ distribution is a family of curves, so that there are different curves for different degrees of freedom).

**Degrees of Freedom**

We have talked about the $F$-distribution being a family of curves, each curve reflecting the degrees of freedom relative to both $\sigma^2_{\text{between}}$ and $\sigma^2_{\text{within}}$. This means that, the degrees of freedom are associated both with the numerator as well as with the denominator of the $F$-ratio.

(i) **The numerator.** Since the variance between samples, $\sigma^2_{\text{between}}$ comes from many samples and if there are $k$ number of samples, then the degrees of freedom, associated with the numerator would be $(k-1)$.

(ii) **The denominator** is the mean variance of the variances of $k$ samples and since, each variance in each sample is associated with the size of the sample ($n$), then the degrees of freedom associated with each sample would be $(n-1)$. Hence, the total degrees of freedom would be the sum of the degrees of freedom of $k$ samples or $df = k(n-1)$, when each sample is of size $n$.

**The $F$-Distribution**

The major characteristics of the $F$-distribution are as follows:

(i) Unlike normal distribution, which is only one type of curve irrespective of the value of the mean and the standard deviation, the $F$-distribution is a *family* of curves. A particular curve is determined by two parameters. These are the degrees of freedom in the numerator and the degrees of freedom in the denominator. The shape of the curve changes as the number of degrees of freedom changes.

(ii) It is a continuous distribution and the value of $F$ cannot be negative.
(iii) The curve representing the $F$ distribution is positively skewed.

(iv) The values of $F$ theoretically range from zero to infinity.

A diagram of $F$ distribution curve is shown in Figure 13.1.

![Fig. 13.1 F-Distribution on Curve](image)

The rejection region is only in the right end tail of the curve because unlike $Z$ distribution and $t$ distribution which had negative values for areas below the mean, $F$ distribution has only positive values by definition and only positive values of $F$ that are larger than the critical values of $F$, will lead to a decision to reject the null hypothesis.

**Computation of $F$**

$F$ ratio contains only two elements, which are the variance between the samples and the variance within the samples.

If all the means of samples were exactly equal and all samples were exactly representative of their respective populations so that all the sample means were exactly equal to each other and to the population mean, then there will be no variance. However, this can never be the case. We always have variation, both between samples and within samples, even if we take these samples randomly and from the same population. This variation is known as the total variation.

The total variation designated by $\sum (X - \bar{X})^2$, where $X$ represents individual observations for all samples and $\bar{X}$ is the grand mean of all sample means and equals ($\mu$), the population mean, is also known as the total sum of squares or $SST$, and is simply the sum of squared differences between each observation and the overall mean. This total variation represents the contribution of two elements. These elements are:

(i) **Variance between Samples:** The variance between samples may be due to the effect of different treatments, meaning that the population means may be affected by the factor under consideration, thus making the population means actually different, and some variance may be due to the inter-sample variability. This variance is also known as the sum of squares between samples. Let this sum of squares be designated as $SSB$. 

$$SSB = \sum (X - \bar{X})^2$$
Then, SSB is calculated by the following steps:

(a) Take \( k \) samples of size \( n \) each and calculate the mean of each sample, i.e.,
\[
\bar{X}_1, \bar{X}_2, \bar{X}_3, \ldots, \bar{X}_k.
\]

(b) Calculate the grand mean \( \bar{X} \) of the distribution of these sample means, so that,
\[
\bar{X} = \frac{\sum \bar{X}_i}{k}.
\]

(c) Take the difference between the means of the various samples and the grand mean, i.e.,
\[
(\bar{X}_1 - \bar{X}), (\bar{X}_2 - \bar{X}), (\bar{X}_3 - \bar{X}), \ldots, (\bar{X}_k - \bar{X}).
\]

(d) Square these deviations or differences individually, multiply each of these squared deviations by its respective sample size and sum up all these products, so that we get;
\[
\sum_{i=1}^{k} n_i (\bar{X}_i - \bar{X})^2,
\]
where \( n_i \) = size of the \( i \)th sample.

This will be the value of the SSB.

However, if the individual observations of all samples are not available, and only the various means of these samples are available, where the samples are either of the same size \( n \) or different sizes, \( n_1, n_2, n_3, \ldots, n_k \), then the value of SSB can be calculated as:
\[
SSB = n_1 (\bar{X}_1 - \bar{X})^2 + n_2 (\bar{X}_2 - \bar{X})^2 + \ldots + n_k (\bar{X}_k - \bar{X})^2
\]

Where,
- \( n_1 = \) Number of items in sample 1
- \( n_2 = \) Number of items in sample 2
- \( n_k = \) Number of items in sample \( k \)
- \( \bar{X}_1 = \) Mean of sample 1
- \( \bar{X}_2 = \) Mean of sample 2
- \( \bar{X}_k = \) Mean of sample \( k \)
- \( \bar{X} = \) Grand mean or average of all items in all samples.

(e) Divide SSB by the degrees of freedom, which are \( (k - 1) \), where \( k \) is the number of samples and this would give us the value of \( \sigma_{\text{between}}^2 \) so that,
\[
\sigma_{\text{between}}^2 = \frac{SSB}{(k - 1)}.
**Dispersion**

**(ii) Variance within Samples:** Even though each observation in a given sample comes from the same population and is subjected to the same treatment, some chance variation can still occur. This variance may be due to sampling errors or other natural causes. This variance or sum of squares is calculated by the following steps:

(a) Calculate the mean value of each sample, i.e., \( \bar{x}_1, \bar{x}_2, \bar{x}_3, \ldots, \bar{x}_k \).

(b) Take one sample at a time and take the deviation of each item in the sample from its mean. Do this for all the samples, so that we would have a difference between each value in each sample and their respective means for all values in all samples.

(c) Square these differences and take the total of all these squared differences (or deviations). This sum is also known as \( SSW \) or sum of squares within samples.

(d) Divide this \( SSW \) by the corresponding degrees of freedom. The degrees of freedom are obtained by subtracting the total number of samples from the total number of items. Thus, if \( N \) is the total number of items or observations, and \( k \) is the number of samples, then,

\[
df = (N - k)
\]

These are the degrees of freedom within samples. (If all samples are of equal size \( n \), then \( df = k(n - 1) \), since \((n - 1)\) are the degrees of freedom for each sample and there are \( k \) samples).

(e) This figure \( SSW/df \) is also known as \( \sigma^2_{\text{within}} \) or MSW (mean of sum of squares within samples).

Now, the value of \( F \) can be computed as:

\[
F = \frac{\sigma^2_{\text{between}}}{\sigma^2_{\text{within}}} = \frac{SSB/df}{SSW/df} = \frac{SSB/(k - 1)}{SSW/(N - k)} = \frac{MSB}{MSW}
\]

This value of \( F \) is then compared with the critical value of \( F \) from the table and a decision is made about the validity of null hypothesis.

### 13.4 CORRELATION: MEANING, TYPES AND USES

Correlation analysis is the statistical tool generally used to describe the degree to which one variable is related to another. The relationship, if any, is usually assumed to be a linear one. This analysis is used quite frequently in conjunction with regression analysis to measure how well the regression line explains the variations of the
dependent variable. In fact, the word correlation refers to the relationship or interdependence between two variables. There are various phenomena which have relation to each other. When, for instance, demand of a certain commodity increases, then its price goes up and when its demand decreases then its price comes down. Similarly, with age the height of the children, with height the weight of the children, with money supply the general level of prices go up. Such sort of relationship can as well be noticed for several other phenomena. The theory by means of which quantitative connections between two sets of phenomena are determined is called the Theory of Correlation.

On the basis of the theory of correlation, one can study the comparative changes occurring in two related phenomena and their cause-effect relation can be examined. It should, however, be borne in mind that relationship like 'black cat causes bad luck', 'filled-up pitchers result in good fortune' and similar other beliefs of the people cannot be explained by the theory of correlation since they are all imaginary and are incapable of being justified mathematically. Thus, correlation is concerned with the relationship between two related and quantifiable variables. If two quantities vary in sympathy so that a movement (an increase or decrease) in the one tends to be accompanied by a movement in the same or opposite direction in the other and the greater the change in the one, the greater is the change in the other, the quantities are said to be correlated. This type of relationship is known as correlation or what is sometimes called, in statistics, as co-variation.

For correlation, it is essential that the two phenomena should have a cause-effect relationship. If such relationship does not exist then there can be no correlation. If, for example, the height of the students as well as the height of the trees increases, then one should not call it a case of correlation because the two phenomena, viz. the height of students and the height of trees are not even causally related. However, the relationship between the price of a commodity and its demand, the price of a commodity and its supply, the rate of interest and savings, etc., are examples of correlation since in all such cases the change in one phenomenon is explained by a change in other phenomenon.

It is appropriate here to mention that correlation in case of phenomena pertaining to natural sciences can be reduced to absolute mathematical terms, e.g., heat always increases with light. But in phenomena pertaining to social sciences it is often difficult to establish any absolute relationship between two phenomena. Hence, in social sciences we must take the fact of correlation being established if in a large number of cases, two variables always tend to move in the same or opposite direction.

Correlation can either be positive or it can be negative. Whether correlation is positive or negative would depend upon the direction in which the variables are moving. If both variables are changing in the same direction, then correlation is said to be positive but when the variations in the two variables take place in opposite direction, the correlation is termed as negative. This can be explained as follows:
Correlation can either be linear or it can be non-linear. The non-linear correlation is also known as curvilinear correlation. The distinction is based upon the constancy of the ratio of change between the variables. When the amount of change in one variable tends to bear a constant ratio to the amount of change in the other variable, then the correlation is said to be linear. In such a case if the values of the variables are plotted on a graph paper, then a straight line is obtained. This is why the correlation is known as linear correlation. But when the amount of change in one variable does not bear a constant ratio to the amount of change in the other variable, i.e., the ratio happens to be a variable instead of a constant, then the correlation is said to be non-linear or curvilinear. In such a situation, we shall obtain a curve if the values of the variables are plotted on a graph paper.

Correlation can either be simple correlation or it can be partial correlation or multiple correlation. The study of correlation for two variables (of which one is independent and the other is dependent) involves application of simple correlation. When more than two variables are involved in a study relating to correlation, then it can either be a multiple correlation or a partial correlation. Multiple correlation studies the relationship between a dependent variable and two or more independent variables. In partial correlation, we measure the correlation between a dependent variable and one particular independent variable assuming that all other independent variables remain constant.

Statisticians have developed two measures for describing the correlation between two variables, viz. the coefficient of determination and the coefficient of correlation.

### 13.4.1 Different Methods of Studying Correlation

The following are the different methods of studying correlation and analysing the effects.

#### A. The Scatter Diagram

The scatter diagram is a graph of observed plotted points where each point represents the values of X and Y as a coordinate. It portrays the relationship between these two variables graphically. By looking at the scatter of the various points on the chart, it is possible to determine the extent of association between these two variables. The wider the scatter on the chart, the less close is the relationship. On the other hand, the closer the points and the closer they come to falling on a line passing through them, the higher the degree of relationship. If all the points fall on a line, the relationship is perfect. If this line goes up from the lower left-hand corner to the upper right-hand corner, the relationship is perfect.

<table>
<thead>
<tr>
<th>Changes in Independent Variable</th>
<th>Changes in Dependent Variable</th>
<th>Nature of Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase (+)↑</td>
<td>Increase (+)↑</td>
<td>Positive (+)</td>
</tr>
<tr>
<td>Decrease (-)↓</td>
<td>Decrease (-)↓</td>
<td>Positive (+)</td>
</tr>
<tr>
<td>Increase (+)↑</td>
<td>Decrease (-)↓</td>
<td>Negative (–)</td>
</tr>
<tr>
<td>Decrease (-)↓</td>
<td>Increase (+)↑</td>
<td>Negative (–)</td>
</tr>
</tbody>
</table>
corner, i.e., if the slope of the line is positive, then the correlation between the two variables is considered to be perfect positive. Similarly, if this line starts at the upper left-hand corner and comes down to the lower right-hand corner of the diagram, i.e., if the slope is negative, and also all points fall on the line, then their correlation is said to be perfect negative.

**Example 13.12:** The following data represents the money spent on advertising of a product and the respective profits realized from each advertising period for the given product. The amounts are in thousands of dollars. Assume profit to be a dependent variable and advertising as an independent variable.

<table>
<thead>
<tr>
<th>Advertising ($X$)</th>
<th>Profit ($Y$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>11</td>
<td>13</td>
</tr>
</tbody>
</table>

**Solution:** We shall draw a scatter diagram for this data.

We can see that the trend in the relationship is increasing and even though this relationship is not perfect, i.e., all the points do not lie in a straight line, the profits in general do increase as the advertising budget increases. This gives us a reasonable visual idea about the relationship between $X$ and $Y$.

**B. The Linear Regression Equation**

The pattern of the scatter diagram shown above indicates a linear relationship between $X$ and $Y$, and this relationship can be described by a straight line through these points. This line is known as the *line of regression*. This line should be the most representative of the data. There are infinite number of lines that can approximately pass through this pattern, and we are looking for one line out of these, that is most suitable as representative of all the data. This line is known as the *line of best fit*. But, how do we find this regression line or the line of best fit?
The best line would be the one that passes through all the points. Since that is not possible, we must find a line which is closest to all the points. A line will be closest to all these points if the total distance between the line and all the points is minimum. However, the same points will be above the line, so that the difference between the line and the points above the line would be positive and some points will be below the line, so that these differences would be negative. Accordingly, for the best line through this data, these differences will cancel each other, and the total sum of differences as a measure of best fit would not be valid. However, if we took these differences individually and squared them, this would eliminate the problem of positive and negative differences. Since the square of negative differences would also be positive, the total sum of squares would be positive.

Now, we are looking for a line which is closest to all the points. Hence, for such a line the absolute sum of differences between the points would be minimum and so would the sum of squares of these differences. Hence, this method of finding the line of best fit is known as the method of least squares.

This line of best fit is known as the regression line and the algebraic expression that identifies this line is a general straight line equation and is given as,

\[ Y_c = b_0 + b_1 X \]

where \( b_0 \) and \( b_1 \) are the two pieces of information called parameters which determine the position of the line completely. Parameter \( b_0 \) is known as the \( Y \)-intercept (or the value of \( Y \) at \( X = 0 \)) and parameter \( b_1 \) determines the slope of the regression line which is the change in \( Y \) for each unit change in \( X \).

Also, \( X \) represents a given value of the independent variable, and \( Y_c \) represents the computed value of the dependent variable based upon the above relationship.

This regression would have the following properties:

(a) \( \Sigma (Y - Y_c) = 0 \).  
(b) \( \Sigma (Y - Y_c)^2 = \text{Minimum} \).

where \( Y \) is the observed value of the dependent variable for a given value of \( X \) and \( Y_c \) is the computed value of the dependent variable for the same value of \( X \). This relation between \( Y \) and \( Y_c \) is shown in Figure 13.2.

\[ \text{Fig. 13.2 Observed and Computed Value of Dependent Variable} \]
The line $AB$ is the line of best fit when,

(a) $\sum (Y - Y_c) = 0$.

(b) $\sum (Y - Y_c)^2 = \text{Minimum}$.

**NOTES**

Here, $Y$ is the actual observation and $Y_c$ is the corresponding computed value, based upon the method of least squares.

Now, since $Y_c = b_0 + b_1X$ is the algebraic equation for any line, we must find the unique values of $b_0$ and $b_1$, which would automatically give us the regression line. These unique values of $b_0$ and $b_1$ based upon the least squares principle are calculated according to the following formulae:

$$b_0 = \frac{(\sum Y)(\sum X^2) - (\sum X)(\sum XY)}{n(\sum X^2) - (\sum X)^2}$$

and

$$b_1 = \frac{n(\sum XY) - (\sum X)(\sum Y)}{n(\sum X^2) - (\sum X)^2}$$

The value of $b_0$ can also be calculated easily, once the value of $b_1$ has been calculated as follows:

$$b_0 = \overline{Y} - b_1\overline{X}$$

where $\overline{Y}$ and $\overline{X}$ are simple arithmetic means of the $Y$ data and $X$ data respectively, and $n$ represents the number of paired observations.

We can illustrate these calculations by an example.

**Example 13.13:** A researcher wants to find out if there is a relationship between the heights of the sons and the heights of their fathers. In other words, do tall fathers have tall sons? He took a random sample of 6 fathers and their 6 sons. Their heights in inches are given in an ordered array as follows.

<table>
<thead>
<tr>
<th>Father ($X$)</th>
<th>Son ($Y$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>66</td>
</tr>
<tr>
<td>65</td>
<td>68</td>
</tr>
<tr>
<td>66</td>
<td>65</td>
</tr>
<tr>
<td>67</td>
<td>67</td>
</tr>
<tr>
<td>67</td>
<td>69</td>
</tr>
<tr>
<td>68</td>
<td>70</td>
</tr>
</tbody>
</table>

(a) For this data, compute the regression line.

(b) Based upon the relationship between the heights, what would be the estimate of the height of the son, if the father’s height is 70 inches?

**Solution:** (a) We can start with showing the scatter diagram for this data.
The scatter diagram shows an increasing trend through which the line of the best fit \( AB \) can be established. This line is identified by:

\[
Y_c = b_0 + b_1 X
\]

Where,

\[
b_1 = \frac{n(\Sigma XY) - (\Sigma X)(\Sigma Y)}{n(\Sigma X^2) - (\Sigma X)^2}
\]

And,

\[
b_0 = \bar{Y} - b_1 \bar{X}
\]

Let us make a table to calculate all these values.

<table>
<thead>
<tr>
<th>( X )</th>
<th>( Y )</th>
<th>( X^2 )</th>
<th>( X \bar{Y} )</th>
<th>( Y^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>66</td>
<td>3969</td>
<td>4158</td>
<td>4356</td>
</tr>
<tr>
<td>65</td>
<td>68</td>
<td>4225</td>
<td>4420</td>
<td>4624</td>
</tr>
<tr>
<td>66</td>
<td>65</td>
<td>4356</td>
<td>4290</td>
<td>4225</td>
</tr>
<tr>
<td>67</td>
<td>67</td>
<td>4489</td>
<td>4489</td>
<td>4489</td>
</tr>
<tr>
<td>67</td>
<td>69</td>
<td>4489</td>
<td>4623</td>
<td>4761</td>
</tr>
<tr>
<td>68</td>
<td>70</td>
<td>4624</td>
<td>4760</td>
<td>4900</td>
</tr>
</tbody>
</table>

\[
\Sigma X = 396 \quad \Sigma Y = 405 \quad \Sigma X^2 = 26152 \quad \Sigma XY = 26740 \quad \Sigma Y^2 = 27355
\]

Then,

\[
b_1 = \frac{6(26740) - (396)(405)}{6(26152) - (396)(396)} = \frac{60}{96} = 0.625
\]

and,

\[
b_0 = \frac{405}{6} - 0.625(396/6)
\]

\[
= 62.5 - 41.25 = 26.25
\]

Hence, the line of regression equation would be:

\[
Y_c = b_0 + b_1 X
\]

\[
= 26.25 + 0.625X
\]
(b) If the father’s height is 70 inches, i.e., if \( X = 70 \), then the computed height of the son or \( Y_c \) would be:

\[
Y_c = 26.25 + 0.625 (70) \\
= 26.25 + 43.75 = 70
\]

**Standard Error of the Estimate**

We have found a line through the scatter points which best fits the data. But how good is this fit? How reliable is the estimated value of \( Y \)? How close are the values of \( Y_c \) to the observed values of \( Y \)? The closer these values are to each other, the better the fit. This means that if the points in the scatter diagram are closely spaced around the regression line, then the estimated value \( Y_c \) will be close to the observed value of \( Y \) and hence, this estimate can be considered as highly reliable. Accordingly, a measure of variability of scatter around the regression line would determine the reliability of this estimate \( Y_c \). The smaller this estimate, the more dependable the prediction will be. This measure is similar in nature to standard deviation which is also a measure of scattered data around the mean.

This measure is known as *standard error of the estimate* and is used to determine the dispersion of observed values of \( Y \) about the regression line. This measure is designated by \( S_{y.x} \) and is given by:

\[
S_{y.x} = \sqrt{\frac{\sum (Y - Y_c)^2}{n - 2}}
\]

Where

- \( Y \) = Observed value of the dependent variable.
- \( Y_c \) = Corresponding computed value of the dependent variable.
- \( n \) = Sample size.

And,

\( (n - 2) \) = Degrees of freedom.

Based upon this relationship, a simpler formula for calculating \( S_{y.x} \) would be:

\[
S_{y.x} = \sqrt{\frac{\sum (Y - \hat{b}_0 \hat{b}_1 X)^2}{n - 2}}
\]

**Example 13.14:** Considering Example 13.16, regarding the relationship of heights between sons and their fathers, calculate the standard error of the estimate \( S_{y.x} \).

**Solution:** Now,

\[
S_{y.x} = \sqrt{\frac{\sum (Y - \hat{b}_0 \hat{b}_1 X)^2}{n - 2}}
\]

\[
= \sqrt{\frac{27355 - 26.25(405) - 0.625(26740)}{4}}
\]

\[
= \frac{0.125}{4} = 0.8125 = 1.678
\]
Correlation Coefficient

The coefficient of correlation symbolically denoted by ‘r’ is another important measure to describe how well one variable is explained by another. It measures the degree of relationship between the two causally-related variables. The value of this coefficient can never be more than +1 or less than –1. Thus +1 and –1 are the limits of this coefficient. For a unit change in independent variable, if there happens to be a constant change in the dependent variable in the same direction, then the value of the coefficient will be +1 indicative of the perfect positive correlation; but if such a change occurs in the opposite direction, the value of the coefficient will be –1, indicating the perfect negative correlation. In practical life the possibility of obtaining either a perfect positive or perfect negative correlation is very remote particularly in respect of phenomena concerning social sciences. If the coefficient of correlation has a zero value then it means that there exists no correlation between the variables under study.

There are several methods of finding the coefficient of correlation but the following ones are considered important:

(i) Coefficient of Correlation by the Method of Least Squares.
(ii) Coefficient of Correlation using Simple Regression Coefficients.
(iii) Coefficient of Correlation through Product Moment Method or Karl Pearson’s Coefficient of Correlation.

Whichever of these above-mentioned three methods we adopt, we get the same value of r.

C. Coefficient of Correlation by the Method of Least Squares

Under this method, first of all the estimating equation is obtained using the least square method of simple regression analysis. The equation is worked out as:

\[ \hat{Y} = a + bX \]

Total variation \[ = \sum (Y - \bar{Y})^2 \]
Unexplained variation \[ = \sum (\hat{Y} - \bar{Y})^2 \]
Explained variation \[ = \sum (\hat{Y} - \bar{Y})^2 \]

Then, by applying the following formulae we can find the value of the coefficient of correlation.

\[ r = \sqrt{\frac{\text{Explained variation}}{\text{Total variation}}} = \sqrt{1 - \frac{\text{Unexplained variation}}{\text{Total variation}}} = \sqrt{1 - \frac{\sum (Y - \hat{Y})^2}{\sum (Y - \bar{Y})^2}} \]
This clearly shows that coefficient of correlation happens to be the square root of the coefficient of determination.

Short-cut formula for finding the value of \( r \) by the method of least squares can be repeated and readily written as follows:

\[
    r = \frac{\sqrt{\sum Y + b \sum XY - n \bar{Y}^2}}{\sqrt{\Sigma Y^2 - n \bar{Y}^2}}
\]

Where
- \( a \) = \( Y \)-intercept
- \( b \) = Slope of the estimating equation
- \( X \) = Values of the independent variable
- \( Y \) = Values of dependent variable
- \( \bar{Y} \) = Mean of the observed values of \( Y \)
- \( n \) = Number of items in the sample
  (i.e., pairs of observed data)

The plus (+) or the minus (–) sign of the coefficient of correlation worked out by the method of least squares is related to the sign of \( b \) in the estimating equation, viz., \( \hat{Y} = a + bX \). If \( b \) has a minus sign, the sign of \( r \) will also be minus but if \( b \) has a plus sign, then the sign of \( r \) will also be plus. The value of \( r \) indicates the degree along with the direction of the relationship between the two variables \( X \) and \( Y \).

**Coefficient of Correlation using Simple Regression Coefficient**

Under this method, the estimating equation of \( Y \) and the estimating equation of \( X \) is worked out using the method of least squares. From these estimating equations we find the regression coefficient of \( X \) on \( Y \), i.e., the slope of the estimating equation of \( X \) (symbolically written as \( b_{XY} \)) and this is equal to \( \frac{\sigma_X}{\sigma_Y} \) and similarly, we find the regression coefficient of \( Y \) on \( X \), i.e., the slope of the estimating equation of \( Y \) (symbolically written as \( b_{YX} \)) and this is equal to \( \frac{\sigma_Y}{\sigma_X} \). For finding \( r \), the square root of the product of these two regression coefficients are worked out as stated below:

\[
    r = \sqrt{b_{XY} \cdot b_{YX}} = \sqrt{\frac{\sigma_X}{\sigma_Y} \cdot \frac{\sigma_Y}{\sigma_X}} = \sqrt{r^2} = r
\]

As stated earlier, the sign of \( r \) will depend upon the sign of the regression coefficients. If they have minus sign, then \( r \) will take minus sign but the sign of \( |r| \) will be plus if regression coefficients have plus sign.
13.5 KARL PEARSON’S COEFFICIENT OF CORRELATION

Karl Pearson’s method is the most widely-used method of measuring the relationship between two variables. This coefficient is based on the following assumptions:
(a) There is a linear relationship between the two variables which means that straight line would be obtained if the observed data are plotted on a graph.
(b) The two variables are causally related which means that one of the variables is independent and the other one is dependent.
(c) A large number of independent causes are operating in both the variables so as to produce a normal distribution.

According to Karl Pearson, \( r \) can be worked out as under:

\[
r = \frac{\sum XY}{\sigma_x \sigma_y}
\]

Where

\[
X = (X - \bar{X})
\]

\[
Y = (Y - \bar{Y})
\]

\( \sigma_x \) = Standard deviation of

\( \bar{X} \) series and is equal to \( \sqrt{\frac{\sum X^2}{n}} \)

\( \sigma_y \) = Standard deviation of

\( \bar{Y} \) series and is equal to \( \sqrt{\frac{\sum Y^2}{n}} \)

\( n \) = Number of pairs of \( X \) and \( Y \) observed.

A short-cut formula known as the Product Moment Formula (PMF) can be derived from the above-stated formula as under:

\[
r = \frac{\sum XY}{\sigma_x \sigma_y} = \frac{\sum XY}{\sqrt{\sum X^2 \sum Y^2}}
\]

\[
= \frac{\sum XY}{\sqrt{\sum X^2 \sum Y^2}}
\]

The above formulae are based on obtaining true means (viz., \( \bar{X} \) and \( \bar{Y} \)) first and then doing all other calculations. This happens to be a tedious task particularly if...
the true means are in fractions. To avoid difficult calculations, we make use of the assumed means in taking out deviations and doing the related calculations. In such a situation, we can use the following formula for finding the value of ‘r’:

\[ r = \frac{\sum dX \cdot dY}{\sqrt{\left(\frac{\sum dX^2}{n}\right) \left(\frac{\sum dY^2}{n}\right)}} \]

\[ = \frac{\sum fdX \cdot fdY}{\sqrt{\left(\frac{\sum fdX^2}{n}\right) \left(\frac{\sum fdY^2}{n}\right)}} \]

Where:
- \( \sum dX = \sum (X - X_a) \)  
  \( X_a = \) Assumed average of \( X \)
- \( \sum dY = \sum (Y - Y_a) \)  
  \( Y_a = \) Assumed average of \( Y \)
- \( \sum dX^2 = \sum (X - X_a)^2 \)
- \( \sum dY^2 = \sum (Y - Y_a)^2 \)
- \( \sum dX \cdot dY = \sum (X - X_a) (Y - Y_a) \)
- \( n = \) Number of pairs of observations of \( X \) and \( Y \)

(b) In Case of Grouped Data:

\[ r = \frac{\sum fdX \cdot fdY}{\sqrt{\left(\frac{\sum fdX^2}{n}\right) \left(\frac{\sum fdY^2}{n}\right)}} \]

Or

\[ r = \frac{\sum fdX \cdot fdY}{\sqrt{\left(\frac{\sum fdX^2}{n}\right) \left(\frac{\sum fdY^2}{n}\right)}} \]

Where:
- \( \sum fdX \cdot fdY = \sum (X - X_a) (Y - Y_a) \)
- \( \sum fdX = \sum (X - X_a) \)
- \( \sum fdY = \sum (Y - Y_a) \)
- \( \sum fdX^2 = \sum (X - X_a)^2 \)
- \( \sum fdY^2 = \sum (Y - Y_a)^2 \)
- \( n = \) Number of pairs of observations of \( X \) and \( Y \)

Probable Error of the Coefficient of Correlation

Probable Error (PE) of \( r \) is very useful in interpreting the value of \( r \) and is worked out as under for Karl Pearson’s coefficient of correlation:

\[ PE = 0.6745 \frac{1 - r^2}{\sqrt{n}} \]
If $r$ is less than its PE, it is not at all significant. If $r$ is more than PE, there is correlation. If $r$ is more than 6 times its PE and greater than $\pm 0.5$, then it is considered significant.

**Example 13.15:** From the following data calculate 'r' between $X$ and $Y$ applying the following three methods:

(a) The method of least squares.
(b) The method based on regression coefficients.
(c) The product moment method of Karl Pearson.

Verify the obtained result of any one method with that of another.

<table>
<thead>
<tr>
<th>$X$</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y$</td>
<td>9</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>11</td>
<td>13</td>
<td>14</td>
<td>16</td>
<td>15</td>
</tr>
</tbody>
</table>

**Solution:** Let us develop the following table for calculating the value of 'r':

<table>
<thead>
<tr>
<th>$X$</th>
<th>$Y$</th>
<th>$X^2$</th>
<th>$Y^2$</th>
<th>$XY$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
<td>1</td>
<td>81</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>4</td>
<td>64</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>9</td>
<td>100</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>16</td>
<td>144</td>
<td>48</td>
</tr>
<tr>
<td>5</td>
<td>11</td>
<td>25</td>
<td>121</td>
<td>55</td>
</tr>
<tr>
<td>6</td>
<td>13</td>
<td>36</td>
<td>169</td>
<td>78</td>
</tr>
<tr>
<td>7</td>
<td>14</td>
<td>49</td>
<td>196</td>
<td>98</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
<td>64</td>
<td>256</td>
<td>128</td>
</tr>
<tr>
<td>9</td>
<td>15</td>
<td>81</td>
<td>225</td>
<td>135</td>
</tr>
</tbody>
</table>

$n = 9$

$\sum X = 45$  $\sum Y = 108$  $\sum X^2 = 285$  $\sum Y^2 = 1356$  $\sum XY = 597$

$\therefore \quad X = 5; \quad Y = 12$

(i) **Coefficient of correlation by the method of least squares is worked out as under:**

First of all find out the estimating equation

$$\hat{Y} = a + bX_i$$

Where,

$$b = \frac{\sum XY - n\bar{X}\bar{Y}}{\sum X^2 - n\bar{X}^2} = \frac{597 - 9(5)(12)}{285 - 9(25)} = \frac{597 - 540}{285 - 225} = \frac{57}{60} = 0.95$$

And,

$$a = \bar{Y} - b\bar{X} = 12 - 0.95(5) = 12 - 4.75 = 7.25$$

Hence,

$$\hat{r} = 7.25 + 0.95X_i$$

Now, 'r' can be worked out as under by the method of least squares:
$r = \sqrt{\frac{\text{Unexplained variation}}{\text{Total variation}}}$

$= \sqrt{\frac{\sum (Y - \bar{Y})^2}{\sum (Y - \bar{Y})^2}} = \sqrt{\frac{\sum (Y - \bar{Y})^2}{\sum (Y - \bar{Y})^2}}$

$= \sqrt{\frac{a \sum Y + b \sum XY - nY^2}{\sum Y^2 - nY^2}}$

As per the short-cut formula,

$r = \sqrt{\frac{7.25(108) + 0.95(597) - 9(12)^2}{1356 - 9(12)^2}} = \sqrt{\frac{783 + 540 - 1296}{1356 - 1296}} = \sqrt{\frac{54.15}{60}} = 0.95$

(ii) Coefficient of correlation by the method based on regression coefficients is worked out as under:

Regression coefficients of $Y$ on $X$:

$b_{YX} = \frac{\sum XY - n\bar{X}\bar{Y}}{\sum X^2 - n\bar{X}^2} = \frac{597 - 9 \times 5 \times 12}{285 - 9(5)^2} = \frac{597 - 540}{285 - 225} = \frac{57}{60} = 0.95$

Regression coefficient of $X$ on $Y$:

$b_{XY} = \frac{\sum XY - n\bar{X}\bar{Y}}{\sum Y^2 - n\bar{Y}^2} = \frac{597 - 9 \times 5 \times 12}{1356 - 9(12)^2} = \frac{597 - 540}{1356 - 1296} = \frac{57}{60} = 0.95$

Hence,

$r = \sqrt{b_{YX} \times b_{XY}} = \sqrt{0.95 \times 0.95} = 0.95$

(iii) Coefficient of correlation by the product moment method of Karl Pearson is worked out as under:

$r = \frac{\sum XY - n\bar{X}\bar{Y}}{\sqrt{\sum X^2 - n\bar{X}^2} \sqrt{\sum Y^2 - n\bar{Y}^2}} = \frac{597 - 9(5)(12)}{\sqrt{285 - 9(5)^2} \sqrt{1356 - 9(12)^2}} = 0.95$
Dispersion

\[
\sigma = \sqrt{\frac{597 - 540}{\sqrt{285 - 225\sqrt{1356 - 1296}}} = \frac{57}{60} = 0.95}
\]

Hence, we get the value of \(r = 0.95\). We get the same value applying the other two methods also. Therefore, whichever method we apply, the results will be the same.

**Example 13.16:** Calculate the coefficient of correlation and lines of regression from the following data.

### Solution:
Since the given information is a case of bivariate grouped data we shall extend the given table rightwards and downwards to obtain various values for finding \(r\) as stated below:

<table>
<thead>
<tr>
<th>(X)</th>
<th>(Y)</th>
<th>Advertising Expenditure (Rs '00)</th>
<th>Midpoint (\bar{X} = 200)</th>
<th>(\bar{Y} = 50)</th>
<th>(\bar{X}^2)</th>
<th>(\bar{X}Y)</th>
<th>(\sum\bar{X}Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-15</td>
<td>75-125</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td></td>
<td>125-175</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td></td>
<td>175-225</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>225-275</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>15</td>
<td>15</td>
<td>14</td>
<td>21</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(n = 65\)

\(\sum\bar{X}Y = 111\)

Midpoint of \(X\): 10 20 30 40

If \(\bar{X} = 30\)

\(i=10\)

\(\bar{X} = -2\)

\(\bar{X}Y = 1\)

\(\sum\bar{X}Y = -24\)

\(\sum\bar{X}^2 = 96\)

\(\sum\bar{X}\bar{Y} = -14\)
Dispersion

\[ r = \frac{\sum fdX \cdot fdY}{\sqrt{\left(\frac{\sum fdX^2}{n}\right) \cdot \left(\frac{\sum fdY^2}{n}\right)}} \]

\[ \therefore \]

Putting the calculated values in the above equation we have:

\[ r = \frac{14}{\sqrt{\frac{96}{65} \cdot \frac{111}{65} \cdot \frac{157.70}{65}}} \]

\[ = \frac{0.2154 - (0.3124)}{\sqrt{1.48 - 0.14 \cdot 1.71 - 0.72}} \]

\[ = \frac{0.0970 - 0.00970}{0.0970} = (-0.0843) \]

Hence,

\[ r = (-0.0843) \]

This shows a poor negative correlation between the two variables. Since only 0.64% \((r^2) = (0.08)^2 = 0.0064)\) variation in \(Y\) (Sales revenue) is explained by variation in \(X\) (Advertising expenditure).

The two lines of regression are as under:

Regression line of \(X\) on \(Y\):

\[ (X - \bar{X}) = r \frac{\sigma_X}{\sigma_Y} (Y - \bar{Y}) \]

Regression line of \(Y\) on \(X\):

\[ (Y - \bar{Y}) = r \frac{\sigma_Y}{\sigma_X} (X - \bar{X}) \]

First obtain the following values:

\[ \bar{X} = A + \frac{\sum fdX}{n} \times i = 30 + \frac{(-24)}{65} \times 10 = 26.30 \]

\[ \bar{Y} = A + \frac{\sum fdY}{n} \times i = 200 + \frac{(-55)}{65} \times 10 = 157.70 \]

\[ \sigma^2_X = \frac{\sum fdX^2}{n} \times i - \left(\frac{\sum fdX}{n}\right)^2 \times i = \frac{96}{65} \times \frac{(-24)}{65} \times 10 = 11.60 \]

\[ \sigma^2_Y = \frac{\sum fdY^2}{n} \times i - \left(\frac{\sum fdY}{n}\right)^2 \times i = \frac{111}{65} \times \frac{(-55)}{65} \times 50 = 49.50 \]

Therefore, the regression line of \(X\) on \(Y\):

\[ (X - 26.30) = \frac{11.6}{49.5} (Y - 157.70) \]

Or,

\[ X = -0.02Y + 3.15 + 26.30 \]

\[ \therefore X = -0.02Y + 29.45 \]
Regression line of \( Y \) on \( X \):

\[
(Y - 157.70) = 49.5 + 0.084(X - 26.30)
\]

Or,

\[
\hat{Y} = 0.36X + 9.47 + 157.70
\]

\[
\hat{Y} = 0.36X + 167.17
\]

### 13.6 Spearman’s Rank Correlation Coefficient

If observations on two variables are given in the form of ranks and not numerical values, it is possible to compute what is known as rank correlation between the two series.

The rank correlation, written as \( \rho \), is a descriptive index of agreement between ranks over individuals. It is the same as the ordinary coefficient of correlation computed on ranks, but its formula is simpler.

\[
\rho = 1 - \frac{6 \Sigma D^2}{n(n^2 - 1)}
\]

where \( n \) is the number of observations and \( D \), the positive difference between ranks associated with the individuals \( i \).

Like \( r \), the rank correlation lies between \(-1\) and \(+1\).

**Example 13.17:** The ranks given by two judges to 10 individuals are as follows:

<table>
<thead>
<tr>
<th>Individual</th>
<th>Rank given by Judge I ( x )</th>
<th>Rank given by Judge II ( y )</th>
<th>( D = x - y )</th>
<th>( D^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>7</td>
<td>6</td>
<td>36</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>8</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>10</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>9</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>3</td>
<td>7</td>
<td>49</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>9</td>
</tr>
</tbody>
</table>

\[ \Sigma D^2 = 128 \]

**Solution:** The Rank Correlation is given by,

\[
\rho = 1 - \frac{6 \Sigma D^2}{n(n^2 - 1)} = 1 - \frac{6 \times 128}{10 \times (10^2 - 10)} = 1 - 0.776 = 0.224
\]

The value of \( \rho = 0.224 \) shows that the agreement between the judges is not high.

**Example 13.18:** Referring to the previous case, compute \( r \) and compare.

**Solution:** The simple coefficient of correlation \( r \) for the previous data is calculated...
as follows:

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
<th>x^2</th>
<th>y^2</th>
<th>xy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>1</td>
<td>49</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>4</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>49</td>
<td>64</td>
<td>56</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>81</td>
<td>100</td>
<td>90</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>64</td>
<td>81</td>
<td>72</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>36</td>
<td>16</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>16</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>9</td>
<td>36</td>
<td>18</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>100</td>
<td>9</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>25</td>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>

\[ \Sigma x = 55 \quad \Sigma y = 55 \quad \Sigma x^2 = 385 \quad \Sigma y^2 = 385 \quad \Sigma xy = 321 \]

\[ r = \frac{321 - 10 \times \frac{55}{10} \times \frac{55}{10}}{\sqrt{385 - 10 \times \frac{55}{10} \times \frac{55}{10}}} \]

\[ = \frac{18.5}{82.5} = 0.224 \]

This shows that the Spearman \( \rho \) for any two sets of ranks is the same as the Pearson \( r \) for the set of ranks. But it is much easier to compute \( r \).

Often, the ranks are not given. Instead, the numerical values of observations are given. In such a case, we must attach the ranks to these values to calculate \( \rho \).

**Example 13.19:** On the basis of the table given below, analyse the type of correlation and calculate the group of equal ranks.

<table>
<thead>
<tr>
<th>Marks in Maths</th>
<th>Marks in Stats</th>
<th>Rank in Maths</th>
<th>Rank in Stats</th>
<th>D</th>
<th>D^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>60</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>47</td>
<td>61</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>60</td>
<td>58</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>38</td>
<td>48</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>50</td>
<td>46</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>9</td>
</tr>
</tbody>
</table>

\[ \Sigma D^2 = 22 \]

**Solution:** The correlation can be analysed as,

\[ \rho = 1 - \frac{6 \Sigma D^2}{n^3 - n} = 1 - \frac{6 \times 22}{125 - 5} = -0.1 \]

This shows a negative, though small, correlation between the ranks.

If two or more observations have the same value, their ranks are equal and obtained by calculating the means of the various ranks.
If in this data, marks in maths is 45 for each of the first two students, the rank of each would be \( \frac{3+4}{2} = 3.5 \). Similarly, if the marks of each of the last two students in statistics is 48, their ranks would be \( \frac{4+5}{2} = 4.5 \).

The problem takes the following shape:

<table>
<thead>
<tr>
<th>Marks in Maths</th>
<th>Marks in Stats</th>
<th>x</th>
<th>y</th>
<th>D</th>
<th>D^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>60</td>
<td>3.5</td>
<td>2</td>
<td>1.5</td>
<td>2.25</td>
</tr>
<tr>
<td>45</td>
<td>61</td>
<td>3.5</td>
<td>1</td>
<td>2.5</td>
<td>6.25</td>
</tr>
<tr>
<td>60</td>
<td>58</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4.00</td>
</tr>
<tr>
<td>38</td>
<td>48</td>
<td>5</td>
<td>4.5</td>
<td>1.5</td>
<td>2.25</td>
</tr>
<tr>
<td>50</td>
<td>48</td>
<td>2</td>
<td>4.5</td>
<td>2.5</td>
<td>6.25</td>
</tr>
</tbody>
</table>

\[
\rho = 1 - \frac{6\Sigma D^2}{n(n-1)} = 1 - \frac{6 \times 21}{120} = -0.05
\]

The formula which can be used in cases of equal ranks is,

\[
\rho = 1 - \frac{6}{n(n-1)} \left[ \Sigma D^2 + \frac{1}{12} \left( \Sigma (m^3 - m) \right) \right]
\]

where \( \frac{1}{12} \Sigma (m^3 - m) \) is to be added to \( \Sigma D^2 \) for each group of equal ranks, \( m \) being the number of equal ranks each time.

For the given data, we have for \( x \) series, number of equal ranks \( m = 2 \)

For \( y \) series also, \( m = 2 \), so that,

\[
\rho = 1 - \frac{6}{5(5-1)} \left[ 21 + \frac{1}{12} (2^3 - 2) + \frac{1}{12} (2^3 - 2) \right]
\]

\[
= 1 - \frac{6}{120} \left[ 21 + \frac{6}{12} + \frac{6}{12} \right] = 1 - \frac{6 \times 22}{120} = -0.1
\]

---

### Check Your Progress

6. Define rank correlation method.
7. What is the line of best fit?

### 13.7 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. A measure of dispersion, or simply dispersion may be defined as statistics signifying the extent of the scatteredness of items around a measure of central tendency.
2. The following are some common measures of dispersion:
   (i) The range, (ii) the semi-interquartile range or the quartile deviation, (iii) the mean deviation, and (iv) the standard deviation. Of these, the standard deviation is the best measure.

3. Chi-square test is a non-parametric test of statistical significance for bivariate tabular analysis (also known as cross-breaks). Any appropriate test of statistical significance lets you know the degree of confidence you can have in accepting or rejecting a hypothesis.

4. F-statistic technique is one of the most powerful techniques in statistical analysis and was developed by R.A. Fisher. It is also called the F-Test.

5. The coefficient of correlation symbolically denoted by ‘r’ is another important measure to describe how well one variable is explained by another. It measures the degree of relationship between the two causally-related variables.

6. If observations on two variables are given in the form of ranks and not numerical values, it is possible to compute what is known as rank correlation between the two series.

   The rank correlation, written as ρ, is a descriptive index of agreement between ranks over individuals.

7. There are infinite number of lines that can approximately pass through the pattern of scatter diagram, and we need one line out of these, that is most suitable as representative of all the data. This line is known as the line of best fit.

13.8 SUMMARY

- A measure of dispersion, or simply dispersion may be defined as statistics signifying the extent of the scatteredness of items around a measure of central tendency. A measure of dispersion may be expressed in an ‘absolute form’, or in a ‘relative form’.

- A relative measure of dispersion computed is a quotient by dividing the absolute measures by a quantity in respect to which absolute deviation has been computed. It is as such a pure number and is usually expressed in a percentage form. Relative measures are used for making comparisons between two or more distributions.

- The following are some common measures of dispersion: (i) The range, (ii) the semi-interquartile range or the quartile deviation, (iii) the mean deviation, and (iv) the standard deviation. Of these, the standard deviation is the best measure.
The crudest measure of dispersion is the range of the distribution. The range of any series is the difference between the highest and the lowest values in the series.

The range is a measure of absolute dispersion and as such cannot be usefully employed for comparing the variability of two distributions expressed in different units. The amount of dispersion measured, say, in pounds, is not comparable with dispersion measured in inches.

Another measure of dispersion, much better than the range, is the semi-interquartile range, usually termed as ‘quartile deviation’. Quartiles are the points which divide the array in four equal parts.

By far the most universally used and the most useful measure of dispersion is the standard deviation or root mean square deviation about the mean.

The calculation of standard deviation differs in the following respects from that of mean deviation. First, in calculating standard deviation, the deviations are squared. This is done so as to get rid of negative signs without committing algebraic violence.

Secondly, the deviations are always recorded from the arithmetic mean, because although the sum of deviations is the minimum from the median, the sum of squares of deviations is minimum when deviations are measured from the arithmetic average.

Chi-square test is a non-parametric test of statistical significance for bivariate tabular analysis (also known as cross-breaks). Any appropriate test of statistical significance lets you know the degree of confidence you can have in accepting or rejecting a hypothesis.

Chi-square test is applicable in a large number of problems. The test is, in fact, a technique through the use of which it is possible for us to (a) Test the goodness of fit; (b) Test the homogeneity of a number of frequency distributions; and (c) Test the significance of association between two attributes.

In business decisions, we are often involved in determining if there are significant differences among various sample means, from which conclusions can be drawn about the differences among various population means.

Correlation analysis is the statistical tool generally used to describe the degree to which one variable is related to another. The relationship, if any, is usually assumed to be a linear one. This analysis is used quite frequently in conjunction with regression analysis to measure how well the regression line explains the variations of the dependent variable.

The coefficient of correlation symbolically denoted by ‘$r$’ is another important measure to describe how well one variable is explained by another. It measures the degree of relationship between the two causally-related variables.
Karl Pearson’s method is the most widely-used method of measuring the relationship between two variables. This coefficient is based on the following assumptions:

(a) There is a linear relationship between the two variables which means that a straight line would be obtained if the observed data are plotted on a graph.
(b) The two variables are causally related which means that one of the variables is independent and the other one is dependent.
(c) A large number of independent causes are operating in both the variables so as to produce a normal distribution.

If observations on two variables are given in the form of ranks and not numerical values, it is possible to compute what is known as rank correlation between the two series.

### 13.9 KEY WORDS

- **Coefficient of variation**: In probability theory and statistics, the coefficient of variation, also known as relative standard deviation, is a standardized measure of dispersion of a probability distribution or frequency distribution. It is often expressed as a percentage, and is defined as the ratio of the standard deviation to the mean.
- **Quartile Deviation**: It is a simple way to estimate the spread of a distribution about a measure of its central tendency (usually the mean).
- **Chi square test**: A chi-squared test, also written as \( \chi^2 \) test, is any statistical hypothesis test where the sampling distribution of the test statistic is a chi-squared distribution when the null hypothesis is true.

### 13.10 SELF ASSESSMENT QUESTIONS AND EXERCISES

#### Short Answer Questions

1. What are some of the specific uses of range?
2. Write a short note on quartile deviation.
3. Define standard deviation. Why is it used in statistical evaluation of data?
4. What is a linear regression equation? State some of its properties.

#### Long-Answer Questions

1. Describe the different measures of dispersion with the help of illustrations.
2. Discuss the significance of diagrammatic representation of data.
3. What is a ‘Scatter diagram’? How does it help in studying correlation between two variables? Explain with the help of examples.

4. Analyse Karl Pearson’s Coefficient of Correlation method.

13.11 FURTHER READINGS


UNIT 14 COMPUTER APPLICATIONS

14.0 INTRODUCTION

In any technological development that has contributed gigantically towards the social work research and practice, it is that of evolution and development of computers. The first ever mention of technology and social work can be traced as early as 1917 in the work of Mary Richmond, who noted the importance of using the telephone in social work practice. Earlier the social work practitioner and researchers were fearful of the telephone technology. However, eventually the use of telephone as an important practice tool became highly acceptable. Today, social work practitioners and researchers have discovered and embraced computers and other technological advancements for effective and efficient research work and practice.

Historically, three important developments promoted the successful use of computers in social work practice and research. First, military applications were the impetus for computers and second the Internet. During the early days the use of computer and other technological advancements in academic domain was not user friendly and therefore witnessed problems towards successful applications in social work research and practice. It was only because of third important development which was commercialization of technology that an effective and efficient integration of computers and social work could take shape. Redin observes, “Technology entrepreneurs were motivated by profit to reduce costs and to make technology user friendly”.

Huff and Edwards and Lamb documented that despite rapid advances in reducing cost and increasing their user friendliness, resistance among social workers
to use computer technology as a tool for daily practice was evident. With his 1981 inaugural issue of a newsletter entitled Computer Use in Social Services Network Newsletter, Dick Schoech advocated for the integration of technology in social work practice. In 1985, Schoech’s newsletter evolved into a practice journal, the Journal of Technology in Human Services, and laid a greater impact on use of computer in social work. However, the period still saw confusion on use of computers as social work practices and research was clearly different than that of military and business use of technology.

14.1 OBJECTIVES

After going through this unit, you will be able to:

- Understand the role and importance of computers in social work research
- Identify various applications which are significantly used in social work research and practice
- Understand the usefulness of internet in social work research
- Identify newer technological trends or applications reshaping social work research

14.2 SOCIAL WORK RESEARCH BEFORE THE EVOLUTION OF COMPUTERS

The limitations and hardships of social work research before the evolution and commercial use of computers can now easily be envisioned. One of the most significant and herculean limitations was engaging into calculating research results with huge data. It is very much clear that in the absence of computers, creating and calculating a simple frequency distribution table could have been cumbersome, leave aside the complex calculations. For examples in early 1968 Myron Weiner and his associates at the Massachusetts Institute of Technology undertook the enormous task of compiling the electoral statistics of 3000 assembly constituencies in India. (The fast PC’s or main frames had not arrived then, and the scholars used the slow and punched card reading mainframes.) The statistics included the variables like the size of the electorate, votes polled, valid votes, votes and seats won by the different political parties, for all the elections till 1967. A four-volume series came out of this data base.⁷

Dasgupta and Morris-Jones sought to explain political participation, part competition for the general elections from 1952 to 1967 with the help of indices of socio-economic development and cultural pluralism. Their units of analysis are 294 districts in India.⁸

Other than calculations, computers have also streamlined the typing, designing and printing of the research ideas and models. Earlier, all of the work involved laborious commitment in terms of their time and energy.
Yet another significant and recent contribution of technological advancements and computers in the field of social work research is that of Internet. With internet, emails, search engines and several others tasks have become all the easier and have streamlined tasks in social work practice and research.

The evolution and widespread acceptance of information technology including computers and Internet has changed the ways in which social workers provide services to clients, manage tasks, educate social work practitioners and conduct social work research.

With the advent and commercialization of improved interactive technology dealing with clients in need has changed dramatically. Today, with such technologies social work practice is possible on a global scale and with all sizes of systems.

The computers aided with several useful applications has simplified clerical work, fiscal planning, scheduling, reporting and several other similar administrative tasks that have been in the past very time consuming.

Use of computers and internet has also facilitated improved changes in the social work education. Online and continuing education programs are now possible and have offered a realistic alternative to traditional programs.

Similarly in terms of conducting social work research the advancements have offered number of applications to undertake the most complex statistical calculations.

In lieu of the rapidly changing field of technology several professions have changed course over the time and social work is not exception to this rapidly changing environment. The integration of technology and the discipline/profession is the need of the hour but at the same time it is equally important to uphold the social work values and ethics that are the essential principles of the profession.

14.3 USE OF COMPUTER APPLICATIONS AND SOCIAL WORK RESEARCH

Over the years several computer applications have assisted academic and research domains. Overcoming initial hesitation and resistance towards advancements in information technology, social research now seem to have embraced the integration of the two. Today, we witness a large number of applications assisting social work research in one way or the other.

14.3.1 MS Word

One of the most significant and widely used applications in any research work is Microsoft Word. Today, MS Word is one of the most used typing or text composing applications in the world that has removed the sweat and hardships of composing manuscripts over a manual or electronic typewriter.

Word processing since the development of WordStar, a word processing program, has changed the way documents were prepared, edited, stored and
printed. Unlike typewriter, either manual or electronic the word processing applications like MS Word have transformed the secretarial work like preparing perfect letters, memos and reports.

The word processing applications like MS Word have clearly provided an edge over the traditional typewriter based text typing. The advantages of the same are discussed as under:

1. **Word Processing – A Workspace**

   Unlike typewriter, one of the most significant capabilities of a word processor is that it provides a space in which documents can be created and saved for future use. It is entirely different from the typewriter where a document is filed or torn or crumbled.

   An ideal text or word processing application assists the workspace by letting the writer:
   - work on documents of any length;
   - save multiple versions of a file;
   - save part of the buffer into a file for later use;
   - switch easily between multiple files;
   - insert the contents of an existing file into the buffer;
   - summarize the differences between two versions of a document

2. **Editing Tools**

   Yet another striking feature of any word processing application including MS Word is its ability to retrieve the document and edit the same. The same privilege was never a possibility in case of a typewriter. Various editing tools included with the word processing applications make it very easy to sift within the largest of the documents possible and make changes wherever and whenever required. At a minimum any word processing application will assist a writer to:
   - move to a particular position in the document;
   - insert new text;
   - find, change or replace text;
   - delete text;
   - copy or move text

3. **Text Formatting and Printing**

   Yet another striking feature that makes the word processing applications all the more popular over typewriters is their ability to format text. Gone are the days where only one kind of alphabetical representation was possible through typewriter based printing. The word processing applications have made designing and printing possible. The various formatting options in word processing applications including MS Word have made it possible to:
NOTES

- Change the text style,
- Change the font colour of the text,
- Highlight text including bold, underline and italics,
- Manage spacing,
- Manage text alignment,
- Inserting tables or special characters,
- Draw models or insert diagrams or charts and sever other formatting features.

Most word processing applications have several such or even more inbuilt formatting features that make it a popular tool in any kind of word processing. Finally a neatly formatted document can be printed for further documentation and presentation.

14.3.2 MS Power Point

Microsoft Power Point is an important application that is used a lot these days for presentations of the research work. With several options to apply creativity to the research results power point assists researchers in designing and delivering engaging presentations before the audience.

14.3.3 MS Excel

If any application has gained significant success and acceptance in social work research it is undoubtedly Microsoft Excel. With several other spreadsheets and statistical packages like SPSS available in the market, MS Excel tops the tally for three very important reasons. The first and foremost is the convenience as the application is easily available. Almost all of us have access to Excel on our own computers and therefore do not need to source and invest in other software. Second, the application is not too costly but is affordable. Finally, Excel easily integrates with other Microsoft applications and facilitates reporting.

Excel which is a spreadsheet, can be used in social work research in many ways. For instance it can be used for data entry, manipulation and presentation. The application also offers a collection of various statistical analysis functions and other tools that can be used to run descriptive statistics and to perform several different and useful inferential statistical tests that are widely used in research. In addition, it provides all of the standard spreadsheet functionality, which makes it useful for other analysis and data manipulation tasks, including generating graphical and other presentation formats. Despite so many functionalities Excel does have limitations for statistical analysis and it does not cover many of the more advanced statistical techniques that are used in research.

As an application Excel includes a large number of tools that used for general data analysis in any research. Here a set of four tools are particularly useful in any kind of research for quantitative data presentation and analysis.
• **Statistical Functions**: Excel offers a broad range of built-in statistical functions. These are used to carry out specific data manipulation tasks, including statistical tests. An example is the AVERAGE function that calculates the arithmetic mean of the cells in a specified range. Similarly, the other functions include ABS, COUNT, COUNTA, MAX, MEDIAN, MIN, MODE, PRODUCT, SQRT, STDEV.S, SUM, and many more.

• **Data Analysis ToolPak**: The Data Analysis ToolPak is an Excel add-in. It contains more extensive functions, including some useful inferential statistical tests. An example is the Descriptive Statistics routine that will generate a whole range of useful statistics in one go.

• **Charts**: Excel’s in-built charts or graphs cover most of the chart types and are invaluable in data exploration and presentation.

• **Pivot Tables**: Pivot tables provide a way of generating summaries of your data and organising data in ways that are more useful for particular tasks. They are extremely useful for creating contingency tables, cross-tabulations, and tables of means or other summary statistics.

### 14.3.4 Statistical Packages for Social Sciences

In recent times another software made its way to tackle the complex problems in social work research. A few scholars, who dealt with complex and higher level statistical analysis in research worked to develop sophisticated packages, which enable you to perform the required operations. The most popular one is Statistical Package for Social Sciences (SPSS), which is very user friendly. Unlike Excel that pushes a research to insert a formula or equation, SPSS avoids the same. While using SPSS, it is expected to have an understanding of the fundamental statistical concepts like mean, standard deviation, variance, sampling error, confidence intervals, parametric and non-parametric tests, correlation, regression, etc. The package automatically processes the data which is manually entered or imported from Excel or other spreadsheet. Today, SPSS has taken an upsurge to have been included in most of the social and business research across the world.

### 14.4 WEBSITES AND ONLINE ENCYCLOPEDIA

Undoubtedly one of the very important developments in the history of technological advancements is that of Internet. With the emergence of Internet came the websites. The first web page went live on August 6, 1991. It was dedicated to information on the World Wide Web project and was made by Tim Berners-Lee. It ran on a NeXT computer at the European Organization for Nuclear Research, CERN. Today, when we look around almost all public and private organizations are live on World Wide Web (www). The one of the most striking support that these websites have provided in social research is the availability of data with much
ease. Earlier, when these websites did not exist the researchers used to spend most of their times visiting and sitting in libraries or visiting concerned offices for first hand data collection. This is has surely made life of a researcher easy and saved on lot of time, energy and money. Alike websites several online encyclopaedia have made it easier for researchers to search and gather information on a particular topic. Wikipedia the world’s fifth-most visited website was launched on 15 January 2001, two days after the domain was registered by Jimmy Wales and Larry Sanger. Since its launch the website has assisted several people’s quest for information.

Search Engines

Similar to websites search engines also play a very important role in social work research today. As we talk today the search engine like Google has moved miles ahead and become smarter than ever. Today, several search engines including Google use machine learning to help process and rank information, and can understand natural human speech. However, as it seems today, the internet wasn’t always so easy to navigate! There was a time when you had to know the exact wording of a website’s title to find it. Search results were riddled with spam. Getting new content indexed by the search engines could take weeks to complete.

The first tool used for searching content (as opposed to users) on the Internet was Archie. The name stands for “archive” without the “v”. It was created by Alan Emtage, Bill Heelan and J. Peter Deutsch, computer science students at McGill University in Montreal, Quebec, Canada in 1990. In 1994 YAHOO was created by David Filo and Jerry Yang, beginning as a collection of favorable web pages that included a man-made description with each URL. Later in 1998 GOOGLE was launched that changed the discourse of search engine operations.

Today, a social work researcher within a flash of light can search anything related to the research. Research papers including research conceptualization and execution can be searched and even downloaded. Literature review on a particular topic can be undertaken very easily. Theories and models on a particular topic can be searched and referred.

Check Your Progress

1. What was the most significant limitation of social work research?
2. What are the various features of Word formatting options?
3. What is MS PowerPoint?
4. What is a pivot table?
5. What was the first tool used for searching content?
14.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. One of the most significant and herculean limitations was engaging into calculating research results with huge data. It is very much clear that in the absence of computers, creating and calculating a simple frequency distribution table could have been cumbersome, leave aside the complex calculations.

2. The various formatting options in word processing applications including MS Word have made it possible to:
   - Change the text style,
   - Change the font colour of the text,
   - Highlight text including bold, underline and italics,
   - Manage spacing,
   - Manage test alignment,
   - Inserting tables or special characters,
   - Draw models or insert diagrams or charts and sever other formatting features.

3. Microsoft Power Point is an important application that is used a lot these days for presentations of the research work. With several options to apply creativity to the research results power point assists researchers in designing and delivering engaging presentations before the audience.

4. Pivot tables provide a way of generating summaries of your data and organising data in ways that are more useful for particular tasks. They are extremely useful for creating contingency tables, cross-tabulations and tables of means or other summary statistics.

5. The first tool used for searching content (as opposed to users) on the Internet was Archie.

14.6 SUMMARY

- The limitations and hardships of social work research before the evolution and commercial use of computers can now easily be envisioned. One of the most significant and herculean limitations was engaging into calculating research results with huge data.

- The evolution and widespread acceptance of information technology including computers and Internet has changed the ways in which social workers provide services to clients, manage tasks, educate social work practitioners and conduct social work research.
• Use of computers and internet has also facilitated improved changes in the social work education. Online and continuing education programs are now possible and have offered a realistic alternative to traditional programs.

• One of the most significant and widely used applications in any research work is Microsoft Word. Today, MS Word is one of the most used typing or text composing applications in the world that has removed the sweat and hardships of composing manuscripts over a manual or electronic typewriter.

• Word processing since the development of WordStar, a word processing program, has changed the way documents were prepared, edited, stored and printed. Unlike typewriter, either manual or electronic the word processing applications like MS Word have transformed the secretarial work like preparing perfect letters, memos and reports.

• If any application has gained significant success and acceptance in social work research it is undoubtedly Microsoft Excel. With several other spreadsheets and statistical packages like SPSS available in the market, MS Excel tops the tally for three very important reasons.

• Excel which is a spreadsheet, can be used in social work research in many ways. For instance it can be used for data entry, manipulation and presentation. The application also offers a collection of various statistical analysis functions and other tools that can be used to run descriptive statistics and to perform several different and useful inferential statistical tests that are widely used in research.

• In recent times another software made its way to tackle the complex problems in social work research. A few scholars, who dealt with complex and higher level statistical analysis in research worked to develop sophisticated packages, which enable you to perform the required operations.

• Undoubtedly one of the very important developments in the history of technological advancements is that of Internet. With the emergence of Internet came the websites. The first web page went live on August 6, 1991. It was dedicated to information on the World Wide Web project and was made by Tim Berners-Lee.

• Similar to websites search engines also play a very important role in social work research today. As we talk today the search engine like Google has moved miles ahead and become smarter than ever.

• The first tool used for searching content (as opposed to users) on the Internet was Archie. The name stands for “archive” without the “v”. It was created by Alan Emtage, Bill Heelan and J. Peter Deutsch, computer science students at McGill University in Montreal, Quebec, Canada in 1990.

• In 1994 YAHOO was created by David Filo and Jerry Yang, beginning as a collection of favorable web pages that included a man-made description with each URL. Later in 1998 GOOGLE was launched that changed the discourse of search engine operations.
14.7 KEY WORDS

- **Data Analysis ToolPak**: The Data Analysis ToolPak is an Excel add-in. It contains more extensive functions, including some useful inferential statistical tests.
- **Statistical Functions**: Excel offers a broad range of built-in statistical functions. These are used to carry out specific data manipulation tasks, including statistical tests. An example is the AVERAGE function that calculates the arithmetic mean of the cells in a specified range.

14.8 SELF-ASSESSMENT QUESTIONS AND EXERCISES

**Short Answer Questions**
1. State one of the recent contributions of technological advancements.
2. Write a short note on MS PowerPoint.
3. What are some of the statistical packages for social sciences?

**Long Answer Questions**
1. How was social work research conducted before the evolution of computers.
2. Describe the advantages of MS Word.
3. Discuss the use of websites and online encyclopaedia in the contemporary scenario.

14.9 FURTHER READINGS


Footnotes

7. Myron Weiner, and J Osgood Field., Electoral Politics in the Indian States, Manohar, Delhi, 1975