



Research in Education and Psychology

R.P. Pathak

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R. P. Pathak

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Delhi • Chennai • Chandigarh

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Part I: Introduction to Educational and Psychological Research 1

1. Introduction to Research 3

Meaning of Research	3
Concept and Definition of Research	4
Nature and General Characteristics of Research	6
Meaning and Concept of Educational Research	8
Broad Approaches of Research	11
Pre-requisites for Research	15
Forms of Educational Research	17
Need and Importance of Research in Education	27
Role and Significance of Research in Education	29
Scientific Method	30
Summary	32
Key Words	32
References	32
Additional Readings	33

2. Selecting Research Problems 34

Identification of Research Problems	34
Selection of a Problem	35
Sources of Problems	36
Criteria for Selection of a Problem	38
Areas of Educational Research	43
Priority Areas of Educational Research in India	44
Major Areas in Educational Research	48
General Research Problems in Education	52
Summary	55
Key Words	55
References	55
Additional Readings	56

3. Preparing a Research Proposal 57

Formulation of a Research Problem	57
Illustrative Research Proposals	63

<i>Summary</i>	68
<i>Key Words</i>	69
<i>References</i>	69
<i>Additional Readings</i>	69

4. Review of Related Literature 70

Meaning of Related Literature	70
Importance of Related Literature	70
Identification of Related Literature	71
Need for Review of Related Literature	71
Review of Related Literature	72
Principle of Review of Related Literature	72
Sources of Related Literature	73
Sources for Survey of Related Literature	73
Use of Library	74
Some Important Reference Materials	76
Sources of Information	80
Card Catalogue in the Library	81
Library Classification Systems	82
Research Periodicals	86
Abstracts	87
Theses and Dissertations	88
Newspapers and Pamphlets	90
Government Documents	90
Monographs	90
Computer-generated Reference Materials	90
<i>Summary</i>	91
<i>Key Words</i>	91
<i>References</i>	91
<i>Additional Readings</i>	92

5. Research Process 93

Paradigm of Research Process	94
Identification and Definition of a Problem	95
Evaluation of the Problem	97
Survey of Relevant Information	99
Formulation of Hypotheses	102
Construction of Hypotheses	103
Sources of Hypotheses	105
Qualities of a Hypothesis	105
Importance of Hypotheses	106
Types of Hypotheses	106
Forms of Hypotheses	108
Necessity of Null Hypothesis	110
Criteria for Judging the Value of a Hypothesis	110
Criteria for a Good Hypothesis	111
Testing of Hypotheses	112

Collection of Data	114
Analysis of Data	114
Conclusion	115
<i>Summary</i>	116
<i>Key Words</i>	116
<i>References</i>	116
<i>Additional Readings</i>	117

6. Sampling 118

Purpose of Sampling Technique	118
Meaning and Concept of Sampling	118
Bases of Samplingm	119
Need for Sampling	120
Characteristics of a Good Sample	120
Uses of Sampling	120
Steps in a Sampling Procedure	121
Advantages of Sampling	121
Disadvantages of Sampling	121
Important Concepts Related to Sampling	122
Advantages of Sampling over Complete Census	124
Types of Sampling	125
Probability Sampling	126
Non-probability Sampling Procedures	132
Sample Size	135
<i>Summary</i>	136
<i>Key Words</i>	137
<i>References</i>	137
<i>Additional Readings</i>	138

7. Research Methods 139

General Methodology Classification	139
The Historical Method	140
Descriptive Research	146
Clinical Research and Case Studies	168
Genetic or Developmental Studies	171
The Experimental Method	176
Experimental Designs	180
<i>Summary</i>	185
<i>Key Words</i>	186
<i>References</i>	186
<i>Additional Readings</i>	187

8. Qualitative Research 188

Concept of Qualitative Research	188
Meaning and Definition of Qualitative Research	189
Difference Between Quantitative and Qualitative Research	189
Features of Qualitative Research	190

Themes of Qualitative Research	190
Strategies or Techniques of Qualitative Research	191
Data Collection Techniques in Qualitative Research	193
Data Analysis in Qualitative Research	195
<i>Summary</i>	196
<i>Key Words</i>	196
<i>References</i>	197
<i>Additional Readings</i>	197

9. Tools and Techniques of Research 198

Data Collection and Tools	198
Types of Research Tools	199
Tools Used in Qualitative Research	212
Computer as a Tool of Research	233
Audio Tapes	234
Video Tapes	234
Photographs	234
Artefacts	234
Diagrams	235
Drawings and Paintings	235
Cognitive Maps	235
<i>Summary</i>	236
<i>Key Words</i>	236
<i>References</i>	237
<i>Additional Readings</i>	237

10. Construction and Procedure of Research Tools 238

Planning the Construction of Tools	239
Identifying Learning Outcomes	240
Defining Objectives in Specific Terms	241
Outlining Subject Matter Content	241
Preparing a Table of Specifications	241
Using Table of Specifications	242
Preparing the Test	242
Item Analysis	243
Validity	245
Norms	247
Characteristics of Standardized Tests	247
Tools of Research	248
Questionnaire	249
Interview Method	252
Schedule Method	255
Rating Scale	260
Achievement Test	266
Checklist	275
Inventories	276
<i>Summary</i>	277

<i>Key Words</i>	277
<i>References</i>	278
<i>Additional Readings</i>	279

11. New Approaches to Educational Research 280

Heuristic Research	280
Phenomenological Research	281
Differences Between Phenomenological Research and Heuristic Research	281
Interdisciplinary Research	282
Ethnographical Studies	283
Policy Research	283
Intervention Studies	284
Baseline Studies	285
<i>Summary</i>	286
<i>Key Words</i>	286
<i>References</i>	286
<i>Additional Readings</i>	286

12. Research Report 288

Meaning of Research Report	288
Steps of Writing a Research Report	288
Style and Format of Writing Research Report	293
Typing of Research Report	295
Proofreading of Final Draft of Research Report	300
Binding and Submission of Research Report	300
Evaluation of Research Report	301
Brief Summary of Research Report	301
Format	301
Executive Summary	302
Style and Language	302
Mechanics	303
<i>Summary</i>	304
<i>Key Words</i>	304
<i>References</i>	305
<i>Additional Readings</i>	305

Part II: Data Analysis 307

13. Descriptive Data Analysis 309

Statistical Analysis	310
Normal Distribution	325
Measures of Relationship	333
List of Factorial Studies	370
Evaluation of Factor Analytical Approach	370
<i>Summary</i>	371
<i>Key Words</i>	372

References 372
Additional Readings 372

14. Inferential Data Analysis 374

Parametric Treatment of Data 374
Analysis of Variance 387
Non-parametric Tests 411
Correlational Analysis 416
Chi-square Test χ^2 427
Summary 431
Key Words 432
References 432
Additional Readings 432

15. Computer Data Analysis 434

Data Organization in Computer System 434
Computer Data Analysis 436
Summary 446
Key Words 446
References 447
Additional Readings 447

Appendix A 448
Appendix B 450
Appendix C 452
Appendix D 454
Appendix E 457
Bibliography 459

Preface

Progress and development in any field is linked with research and innovation. Research in every sphere, especially in the field of education, is imperative. It involves application of scientific methods to problem solving. The problems in the field of education necessitate a purposeful and sustained research effort.

This textbook approaches research from a perspective different from that taken in other educational research textbooks. The main aim is to show educationists that the application of research principles can make teaching and learning more effective. Using a non-technical and simple language, numerous examples and illustrations have been drawn from the field of education to enhance the reader's understanding of the essential principles, concepts and techniques of research. The book is divided into two parts. The first part introduces educational and psychological research and the second part throws light on data analysis. There are fifteen chapters which comprehensively explain the background, needs, significance and relevance of educational research. All aspects like creation of a proposal, review of related literatures, sampling, construction and presentation are explained in detail. This textbook will cater to B.Ed., M.Ed., M.Phil. and Ph.D. students. It will also be useful to teacher educators who are enrolled in research.

I wish to express my thanks to Pearson Education India and its team for publishing this book. I am also thankful to those authors and educationists whose books I have consulted. I am grateful to my wife Smt. Manoj Pathak and daughter Abhilasha for their encouragement and support. Any suggestion for the modification and further improvement in the contents of this book will be gratefully acknowledged.

R. P. Pathak

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Part I

Introduction to Educational and Psychological Research

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Introduction to Research

1

Research is the application of scientific methods to problem solving. It has not always been evident to teachers and other educators that scientific methodology is important in education. Very likely, this neglect of scientific methodology has occurred because research has been considered irrelevant to educators. Teachers have too many practical problems to worry about ivory tower research, or at least the belief goes thus. During this era, research has moved from the periphery to the centre of our social and economic life. Most of us recognize that the progress in our society has largely been a result of research. The terms 'research' and 'scientific method' are sometimes used synonymously in educational discussions. Application of scientific methods in problem solving may be through the use of informal tools such as problem identification, hypothesis formulation, observation, analysis and conclusion. Research is a more systematic activity directed towards the discovery and development of an organized body of knowledge.

▲ Meaning of Research

Let us first consider the meaning of the word 'research'. If we ask laymen, their answer will be, 'to search for a new thing' or 'to see the phenomenon or thing in a new context which is already known'. The 'Oxford' *Advanced Learner's Dictionary* of current English lays down the meaning of research thus: 'a careful investigation or inquiry specially to search for new facts in any branch of knowledge'. So, research is a purposeful investigation. There are three parts involved in any investigation:

- (i) The implicit question posed
- (ii) The explicit answer proposed
- (iii) Collection, analysis and interpretation of information leading from the question to the answer

The third part is viewed as research.

The term 'research' consists of two parts: 're' and 'search'. 'Re' means again and again, and 'search' means trying to find out. It is a process by which a person observes a phenomenon again and again and collects the data. The data may be both of numerical and non-numerical nature. On the basis of the collected data, they draw some conclusions. Such an art of scientific investigation is known as research. Generally, researchers confuse the term 'research' with 'common sense'. They take both the words synonymously, but 'research' is different from a commonsensical approach for solving a problem, both in terms of procedure and method. The difference revolves around the words 'systematic', 'objective' and 'reproducible'.

▲ Concept and Definition of Research

Research is considered to be a formal, systematic and intensive process of carrying out a scientific method of analysis. Application of scientific methods in problem solving may be through the use of informal tools such as problem identification, hypothesis formulation, observation, analysis and conclusion. One could reach a conclusion as to why a car would not start or why a fire occurred in an unoccupied house by employing a scientific method, but the processes involved would probably not be as much structured as those of research. Research is a more systematic activity that is directed towards the discovery and development of an organized body of knowledge.

Research may be defined as the systematic and objective analysis and recording of controlled observations that may lead to the development of generalizations, principles or theories, resulting in prediction and, possibly, ultimate control of events.

According to Rusk, '*research is a point of view, an attitude of inquiry*'. He writes: 'Research is a point of view, an attitude of inquiry or a frame of mind. It asks questions which have not been asked, and it seeks answers to them by following fairly definite procedure. It is not a mere theorizing but rather an attempt to elicit facts and to face them once they have been assembled.'

Research is, likewise, not an attempt to bolster preconceived opinions, but implies a readiness to accept the conclusions to which an inquiry leads, no matter how much unwelcome they may prove to be. When successful, research adds to the scientific knowledge of the subject.

According to George J. Mouly, '*research is a systematic and scholarly application of the scientific method*'. He defines educational research as: 'The systematic and scholarly application of the scientific method interpreted in its broader sense, to the solution of educational problems; conversely, any systematic study designed to promote the development of education as a science can be considered educational research.'

According to Francis G. Cornell, '*research is information in which we have confidence*'.

To be sure the best research is that which is reliable, verifiable and exhaustive, so that it provides information in which we have confidence. The main point here is that research is, literally speaking, a kind of human behaviour, an activity in which people engage. By this definition intelligent human behaviour involves some research.

In education, teachers, administrators or others engage in 'educational research' when they systematically and propose fully assemble information about schools, school children, the social matrix in which a school or school system is determined, the characteristic of the learner or the interaction between the school and pupil.

Clifford Woody of the University of Michigan, *research is a careful inquiry*. In an article of the *Journal of Education Research* (1927), Woody writes:

Research is careful inquiry or examination in seeking facts or principles; a diligent investigation to ascertain something according to Webster's *New International Dictionary*. This definition makes clear the fact that research is not merely a search for truth, but a prolonged, intensive, purposeful search. In the last analysis, research constitutes a method for the discovery of truth, which is really a method of critical thinking. It comprises defining and redefining problems, formulating hypotheses or suggested solutions; collection organizing and evaluating data; making deductions and reaching conclusions; and at last, carefully testing the conclusions to determine whether they lift the formulating hypotheses.

According to C.C. Crawford, '*research is a systematic and refined technique for obtaining a more adequate solution to a problem*'. He writes: 'Research is simply a systematic and refined technique of thinking, employing specialized tools, instruments and procedures in order to obtain a more adequate solution of a problem than would be possible under ordinary means. It starts with a problem, collects data or facts; analyses these critically and reaches decisions based on the actual evidence. It evolves original work instead of mere exercise of personal. It evolves from a genuine desire to know rather a desire to prove something. It is quantitative, seeking to know not only what but how much, and measurement is therefore, a central feature of it.'

John W. Best thinks: 'Research is considered to be the more formal, systematic, intensive process of carrying on the scientific methods of analysis. It involves a more systematic structure of investigation, usually resulting in some sort of formal record of procedures and a report of results of conclusions.'

Research is just diligent search which enjoys the high flavour of primitive hunting.

—James Harvey Robinson

Research is the manipulation of things, concepts of symbols for the purpose of generalizing to extend, correct or verify knowledge, whether that knowledge aids in the practice of an art.

—Encyclopaedia of Social Science

Research is a systematized effort to gain new knowledge.

—I.V. Redmand and A.V. H. Mory

According to H.C. Sinha, 'research is an endeavour to discover, develop and verify knowledge. It is an intellectual process that has developed over hundreds of years, ever changing in purpose and form and always searching for truth.'

P. M. Cook has given a very comprehensive and functional definition of the term research:

Research is an honest, exhaustive, intelligent searching for facts and their meanings or implications with reference to a given problem. The product or findings of a given piece of research should be an authentic, verifiable and contribution to knowledge in the field studied.

He emphasized the following characteristics of research in his definition:

- It is an honest and exhaustive process.
- The facts are studied with understanding.
- The facts are discovered in the light of problem. Research is problem centred.
- The findings are valid and verifiable.
- Research work should contribute new knowledge in that field.

According to W.S. Monroe, *research is a process of ascertaining principles*. Monroe, University of Illinois, states:

Research may be defined as a method of studying problems whose solutions are to be derived partly or wholly from facts. The facts dealt within research may be statements of opinion, historical facts, those contained in records and reports, the results of tests, answers to questionnaires, experimental data of any sorts and so forth. The final purpose of educational research is to ascertain principles and develop procedures for use in the field of education; therefore, it should conclude by formulating principles or procedures. The mere collection and tabulation of facts is not research, though it may be preliminary to it or even a part thereof.

On examining the preceding definitions, the following characteristics of research emerge:

- Research is an inquiry or investigation.
- It has clearly defined parameters.
- It describes the problem.
- It explains the problem.
- It generalizes the findings.
- It predicts the phenomena.
- It is a critical inquiry.
- It is a systematic inquiry.
- It is a controlled inquiry.
- It is an empirical inquiry.

▲ Nature and General Characteristics of Research

Research may be defined as the application of scientific methods in the study of problems. At times, the terms research and scientific method are used interchangeably.

Research is a systematic attempt to obtain answers to meaningful questions about phenomena or events through the application of scientific procedures. It is an objective, impartial, empirical and logical analysis and recording of controlled observations that may lead to the development of generalizations, principles or theories, resulting, to some extent, in the prediction and control of events that may be consequences or causes of specific phenomena. Research is scientific and is as such not satisfied with isolated facts, but seeks to integrate and systematize its findings. It is concerned with the objective verification of generalizations. Such a verification requires logical analyses of problems and devising of appropriate methodologies for obtaining evidence.

Best and Kahn (1992: 18–20) have summarized the main characteristics of research as follows:

- Research is directed towards the solution of a problem. It may attempt to answer a question or to determine the relation between two or more variables.
- Research emphasizes the development of generalizations, principles or theories that will be helpful in the prediction of future occurrences. Research usually goes beyond the specific objects, groups or situations investigated, and infers characteristics of a target population from the sample observed. Research is more than information retrieval, the simple gathering of information. Although many school research departments gather and tabulate statistical information that may be useful in decision-making, these activities are not properly termed as research.
- Research is based upon observable experience or empirical evidence. Certain interesting questions do not lend themselves to research procedures because they cannot be observed. Research rejects revelation and dogma as methods of establishing knowledge and accepts only what can be verified by observation.
- Research demands accurate observation and description. The researcher uses quantitative, numerical measuring devices, the most precise means of description. The researcher selects or devises valid data-gathering instruments or procedures and employs appropriate mechanical, electronic or psychometric devices to refine human observation, recording, computation and analysis of data.
- Research involves gathering new data from primary or first-hand sources or using existing data for a new purpose. Teachers frequently assign a so-called research project that may involve writing a paper dealing with the life of a prominent person. The students are expected to read a number of

encyclopaedias, books or periodical references and synthesize the information in a written report. This is not research, for the data are not new. Merely reorganizing or restating what is already known and has already been written, valuable as it may be as learning experience, is not research. It adds nothing to what is known.

- Although research activity may at times be somewhat random and unsystematic, it is more often characterized by carefully designed procedures, always applying rigorous analysis. Although trial and error is often involved, research is rarely a blind, shotgun investigation—trying something to see what happens.
- Research requires expertise. The researchers know what is already known about the problems and how others have investigated it. They search the related literature carefully and are also thoroughly conversant in the terminology, the concepts and the technical skills necessary to understand and analyse the data that they have gathered.
- Research strives to be objective and logical, applying every possible test to validate the procedures employed, the data collected and the conclusions reached. The researcher attempts to eliminate personal bias. There is no attempt to persuade or to prove an emotionally held conviction. The emphasis is on testing rather than on proving the hypothesis. Although absolute objectivity is as elusive as pure righteousness, researchers try to suppress bias and emotion in their analyses.
- Research involves the quest for answers to unsolved problems. Pushing back the frontiers of ignorance is its goal, and originality is frequently the quality of a good research project. However, previous important studies are deliberately repeated, using identical or similar procedures, with different subjects, different settings and at a different time. Replication is always desirable to confirm or to raise questions about the conclusions of a previous study.
- Research is characterized by patient and unhurried activity. It is rarely spectacular and the researchers must accept disappointment and discouragement as they pursue answers to difficult questions.
- Research is carefully recorded and reported. Each important term is defined, limiting factors are recognized, procedures are described in detail, references are carefully documented, results are objectively recorded and conclusions are presented with scholarly caution and restraint. The written report and accompanying data are made available for the scrutiny of associates or others scholars. Any competent scholar will have the information necessary to analyse, evaluate and even replicate the study.

Main Characteristics of Research

The following are the main characteristics of research:

- Systematic approach
- Objectivity
- Reproducible
- Relevancy
- Control

A *systematic approach* is essential in a good research. All the steps must be in hierarchical order, that is, each step must lead to its next step. There should be planning with regard to data collection and their analyses. Such planning and organization play an important role in a systematic approach.

Objectivity is another important characteristic of research. In an objective approach, researcher's personal views about an answer to a problem do not find any place.

A *reproducible research* procedure is one which an equally competent researcher could duplicate and obtain approximately the same results from it. It is only possible when the data are not subjective but objective, and the measurements and observations are definite and flawless. Can we imagine what poor and vague sampling procedures (i.e., methods of selecting sample from population) can lead to? It can result in non-reproducibility.

In other words, we can say that if our procedures are vague, it will be foolishness to expect consistency even from the same person. After discussing the primary characteristics, let us now consider some secondary characteristics which may be called 'relevance' and 'control'. In fact, research cannot address itself to the complete information to a particular subject.

Relevancy accomplishes two important tasks. First, it avoids the collection of unnecessary information and, second, it forces the comparison of the data collected with the researcher's criteria for action.

Is *control* the other aspect which is pertinent in research? It is impossible to have control in all those factors which play an important part in research. The best we can do is to have a control on those which may cause difficulty. Control must consider two aspects. First, those variables that are truly within our control must be varied or dealt with the nature of our investigation. Second, those variables beyond our control must be properly recorded and controlled either administratively or statistically.

After going through the preceding discussion, we can finally arrive at our definition of research—the search for knowledge through objective and systematic methods of finding is called 'research'. This implies that research is a systematic, objective, reproducible and deliberate attempt which is made to answer meaningful questions pertaining to a field of study or about phenomenon or events in a given situation. The word research identifies a process which helps in seeking answers of certain questions through planned and systematic collection, analysis and interpretation of data.

Evaluate Yourself

- (i) Define research.
- (ii) Enumerate the two important characteristics of research.

▲ Meaning and Concept of Educational Research

According to Cornell:

Research is, literally speaking, a kind of human behaviour, an activity in which people engage. In education teachers, administrators, scholars or others engaged in educational research when they systematically assemble information about school, school children, the social matrix or the interaction between the school and the pupils.

In other words, educational research refers to a systematic attempt to gain a better understanding of the educational process, with a view to improve its efficiency. Educational research is nothing but an application of scientific methods to the study of educational problems or educational thoughts. It means that its scope is limited only to educational practices/issues. Since education is a behavioural science, the major concern of educational research is to understand, explain and, to some extent, predict and control human behaviour. It is an activity directed towards the development of an organized body of scientific knowledge about the events with which educators are concerned.

In a nutshell, educational research is a systematic, objective and a deliberate attempt to answer meaningful questions, pertaining to educational processes, forms, organizations and thoughts. The goal

of educational research is to discover laws or generalizations concerning educational issues in order to make predictions and control educational events, and improve the quality of teaching and learning by taking effective decisions and proper utilization of resources.

Definitions of Educational Research

Here are a few definitions of educational research.

Research is an inquiry process that has clearly defined parameters and has as its aim the discovery or creation of knowledge of knowledge, or theory building, testing, confirmation, revision, refutation of knowledge and theory and/or investigation of a problem for local decision-making.

—C. R. McClure and P. Hersson (1991: 3)

Scientific research is a systematic, controlled empirical and critical investigation of hypothetical propositions about the presumed relations among natural phenomena.

—F. N. Kerlinger (1978: 11)

Aims of Educational Research

The following are the aims of educational research:

- To identify important variables, *exploratory researches* are undertaken.
- To identify causal factors and explain a phenomenon, *explanatory researches* are undertaken.
- To describe a relationship, a phenomenon, a situation, an effect, an event, etc., *descriptive researches* are undertaken.
- To forecast outcomes, behaviours, events, *predictive researches* are undertaken.

The aims of research studies can also be explicitly expressed as follows:

- *Finding truth*: Research is a search for truth.
- *Testing hypothesis(/es)*: Whenever research workers are confronted with any probable relations known as hypothesis(/es), they test the hypothesis(/es) through scientific process.
- *Establishing relationship(s)*: Many a time, researches are undertaken to study the relationship between some variables, for example, relationship between the socio-economic status of parents and the achievements of their offsprings.
- *Arriving at generalization of theory building*: On the basis of research findings, generalizations are arrived at or theories are built, like the theories of learning.
- *Verification and testing of existing facts, theories, generalizations, etc. (improvement of knowledge)*: Research findings also help in verifying the existing theories of generalization arrived at by other researchers.
- *Revision of existing theories*: The existing theories undergo revision whenever contradictory evidences come to light.
- *Finding solutions to problems or questions*: Research is also a problem-solving activity in a systematic way.
- *Providing a scientific basis for planning, decision-making, policy formulation, policy revision*: The database generated through research activity is helpful in decision-making and planning process.
- *Predicting several characteristics such as behaviour, forecasting outcomes, events*: It is possible to forecast or predict the outcomes or events on the basis of research, viz. population projections, number of teacher and schools needed in the next decade, etc.

Factors like self, environment and educational literature generate the research problems which lead to specific research questions (many a time called hypotheses). Keeping research question in view, appropriate sample, research design, tools and techniques are identified and developed. Then is the stage of analysis, interpretation and reporting. Completion of these activities leads to the answers to research questions, which build a new body of knowledge generating further research areas and questions.

Keeping in view a specific research problem, a preliminary line of action is drawn and a pilot study is undertaken. This leads to redefining the problem and revision of the earlier preliminary plan. The final plan is, thus, launched and the relevant data collected. The subsequent are data analyses, conclusions and reporting. These steps can be elaborated as given in Figure 1.1.

- (i) Research workers come across some problem. They specifically formulate their research problem. The problem occurs to the research workers either from their own experiences/armchair thinking or after going through the literature on education or by observing the happenings in the environment in which they live.

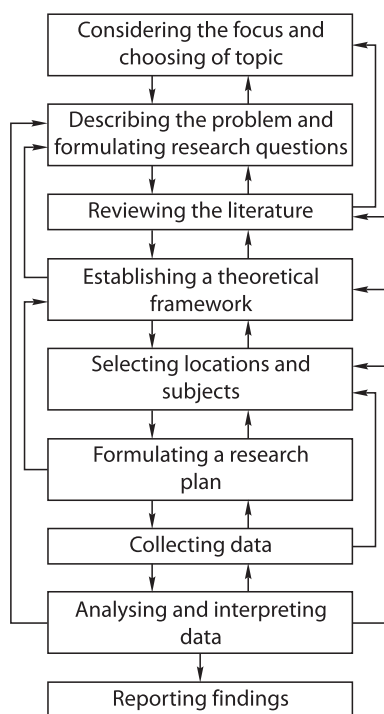


Figure 1.1 Recursive research process

Source: *Qualitative Research for the Information Professional: A Practical Handbook*, G. E. Gorman and Peter Clayton (1997), London: Library Association.

- (ii) Often, the research workers in the initial stage formulate their problem in a broad manner. They prepare a preliminary plan of investigation and undertake a pilot study on a small sample. The results of the pilot study help in developing insight, which in turn helps them to redefine the problem specifically and also to revise their preliminary plan of investigation.

- (iii) In some cases, the problem and the plan of investigation are very clear to the research worker, which obviates the necessity of a pilot study.
- (iv) Research questions are formulated, the answers for which have to be sought on the basis of the findings of the research.
- (v) The sample is selected and appropriate methods, tools and techniques are also selected.
- (vi) After completing the spadework, the researcher reaches the launching stage.
- (vii) Collection of data is done using appropriate tools and techniques.
- (viii) The data collected are analysed and interpreted.
- (ix) The conclusions are drawn and research questions answered.
- (x) The research process gives rise to new questions which can be answered by undertaking new researches following the cycle just mentioned.
- (xi) After completing the research, a research report is prepared for disseminating the findings among interested persons or groups.

Activities

- (i) Write two important characteristics of educational research.
- (ii) Why do we undertake exploratory research?
- (iii) Clarify the aims of educational research.

■ Broad Approaches of Research

The broad approaches of research are as follows:

- Qualitative research
- Quantitative research

Qualitative Research

Characteristics

The following are the characteristics of a qualitative research:

- The approach is inductive.
- Its focus is on various areas such as specific situations, institutions, communities or groups of people.
- Its emphasis is on causes, interpretations and implications rather than on quantitative scores, measurement and statistical analysis.
- Its emphasis is on personalized experiences rather than on structured tools.
- It is based on a smaller number of cases.

Purposes

The purpose of qualitative research is as follows:

- Understanding the meaning of broad terms like attitude, prejudice, organizational climate
- Understanding the context in which some behaviour finds expression or some phenomenon takes place
- Identifying an anticipated phenomenon

- Understanding the process
- Developing causal explanations
- In-depth study to find out the constellation of factors that determine a particular type of behaviour or lead to a particular phenomenon
- Studying inter-relationships between various factors responsible for a phenomenon or a behaviour. Freud developed his theory of psychoanalysis through qualitative research. Piaget developed his theory of cognitive development by initially starting the study of language development in his own children.

Practical Uses

The following are the practical uses of qualitative research:

- Generating theories that are understandable
- Conducting formative evaluation intended to improve the existing practices rather than to simply assess the value of programme or product being evaluated
- Engaging in collaborative research with practitioners

Types

The following are the main types of qualitative research:

- Phenomenological
- Ethnographical
- Heuristic
- Case studies
- Historical studies
- Philosophical studies

Case studies: In qualitative approach, in order to understand a phenomenon, some cases are selected and an in-depth study of these cases is undertaken. A case or unit may be a person or an institution, a social group, a community or a village. The case study unfolds the interaction between the various factors influencing the phenomena. Case studies of some juvenile delinquents can be undertaken for gaining an understanding of the phenomenon of delinquency. Jean Piaget conducted case studies of some children in order to propound his theory of cognitive development. Since the case study involves deeper study over a longer span of time involving personalized techniques of data collection such as observation interview, the sample in this approach has to be kept small. The researcher has to be very cautious to avoid bias in favour or against the subjects studied.

Historical studies: Historical research is undertaken to understand the present in the light of past events. Such investigations aim at studying the growth and development of educational institutions, rise of educational movements and may be their decline, evolution of new techniques and methods in the field of education, and contributions of educators and other thinkers to varying fields of education. Some of the problems for historical studies could be education of women in post-independent India, rise and fall of basic education.

The data for historical studies are collected from the following two sources:

- (i) *Primary sources:* These are actual witness to several events, such as objects of the past, relics, photographs, artefacts, original letters, parliamentary proceedings documents.
- (ii) *Secondary sources:* These are the sources which are not actual witness to the event but are the reports of the person observing the event, for example, books on history, description of accounts, statements made by a witness.

As far as possible, primary sources should be used because they are more reliable. In the circumstances when primary sources are not available, the researcher can make use of secondary sources.

Internal and external evaluation: Before making use of any historical source, it should be subjected to internal and external criticism in order to establish its authenticity, genuineness, accuracy and worthiness. The first two characteristics are established by external criticism and the other two by internal criticism.

Difficulties

Historical research has its own difficulties because it involves locating the authentic sources and their scrutiny and study, which is a time-consuming process. This research may include visiting distant places involving a lot of time and heavy financial implications.

Philosophical studies: In educational research, philosophical studies occupy an important place. These studies are important as they seek to examine the basic assumptions about human life and the world around them. Philosophy influences the policies related to education and also to educational practices. Individuals have their own philosophies which influence their views about education and formulation of policies and practices related to education. Similarly, a nation believing in democratic philosophy will lay great emphasis on universalization of education, human right in education, rights of students, freedom and autonomy in education, equality of educational opportunity and so on.

Since philosophical studies are based on reasoned analytical thinking about the relationship between mind and reality, a philosophical research worker has to have an analytical insight and the ability to synthesize ideas. The research worker has to bank heavily on a library, which provides an understanding of what eminent philosophers have to say about educational reality. The method of a philosopher is not totally different from that of a scientist. Although the philosophers do not use the tools commonly used in scientific studies, they do tests and verify the logical consistency of their hypothesis and draw a conclusion after a careful scrutiny of the ideas.

Quantitative Research

Characteristics

The following are the characteristics of quantitative research:

- The approach is deductive.
- The sample studied is larger.
- The emphasis is on precision in describing events.
- The emphasis is on numbers rather than on words.
- A relationship between variables is anticipated (hypothesis), which is tested on the basis of the data collected.
- An attempt is made to convert the data into a mathematical form.
- Tools used are to be such as to yield data in a numerical form.
- The conclusions drawn from the sample are applicable to the total population which the sample represents.
- It helps in the objective study of phenomena.
- Data are available for analyses on a computer and hence inferences can be easily drawn.
- Demand on personalized ingenuity and skill is less for data collection.
- These can be easily replicated and the results verified.

Purposes

The purposes of quantitative research are as follows:

- Standardization of tests

- Identifying the characteristics of a group in quantitative terms
- Measurement of the effect of the experimental variable
- Comparison of the characteristics of groups
- Studying the relationship between the variables

Types

Under quantitative research, the following are the main types:

- (i) *Experimental research*: A hypothesis is propounded stating a relationship between the dependent and the independent variables. Then the relationship is verified by making observations under controlled conditions. The control over intervening variables is exercised either by physical manipulations or through statistical methods.
- (ii) *Quasi-experimental research*: These studies do not apply to vigorous criteria of pure experiments. In these studies, the experimental and control groups are not exactly equivalent and control over all the intervening variables is sometimes not possible. Such designs are generally used in educational experiments conducted in the classrooms. The class groups are kept intact presuming that they are similar. One group is taken as the control group and the experimental variable is introduced in the other group; which will be the experimental group. Pre- and post-test scores of both the groups are used for studying the differences. Since the design does not have a full check over all the intervening variables, the results of such studies need to be accepted cautiously. In some quasi-experimental studies, only one group is taken. In this group, an experimental variable is introduced and its effect is observed by comparing the pre- and post-test results.

In the less refined form of quasi-experimental study, no pre-test is conducted. The experimental variable is introduced in a group and the post-test is administered. If the results in the post-test are positive, the experimenter attributes it to the experimental variable.

- (iii) *Surveys*: Some trends in the field of education are studied quantitatively, such as the drop-out rate, enrolment rates, literacy percentage and unit cost of higher education.
- (iv) *Correlational studies*: A complex phenomenon is analysed into its components and each component is defined in measurable terms. Then instruments are developed to measure each component. The relationship between the components and other variables can be studied. For example, classroom interaction can be separated into teacher and student's behaviour. Each behaviour is specifically defined. In a given time, the interval frequencies of occurrence of these behaviours can be plotted. The relationship between teachers' behaviour or the personality traits with other variables such as students' achievements or classroom climate can be determined.

Activities

- (i) Read the following two observations, with which do you agree most; record your observations.
Research is not all mysterious and is carried out by thousands of quite normal individuals, more often in teams than alone, very often in the factory, the school or the community, as well as in the laboratory. Its importance is attested by the tremendous amounts of time, manpower and money spent on it. We recognize the fruits of research as better consumer products, better ways of preventing and treating diseases, better understanding of the world in which we live. In the field of education, we identify research with a better understanding of the individual and of the teaching-learning process and the conditions under which it is most successfully carried on.

Research is often tedious, painfully slow and rarely spectacular. The search for truth and solutions to important problems take a great deal of time and energy and intensive application of logical thinking. Research makes its contribution to human welfare by countless small additions to knowledge. The researcher has some of the characteristics of an ant, which brings its single grain of sand to the anthill.

- (ii) Give two examples of research problems each from the area of qualitative and quantitative studies.
- (iii) Some research problems are given below. Write A against the problems which fall under the category of qualitative research and B against the problems which fall under the category of quantitative research.
 - Relationship between the teacher's behaviour, age of teachers and their academic qualification. ☐
 - A study of the role of teachers' organization in policy formulation. ☐
 - Intelligence, socio-economic status and personality traits of low achievers. ☐
 - Causes of juvenile delinquency. ☐
 - A study of innovative practices in the teachers' colleges in the state. ☐

▲ Pre-requisites for Research

A particular mindset predisposes an individual towards research activities. That mindset, its propensities and pre-requisites are curiosity, inquisitiveness, a questioning mind, high level of sensitivity, a burning desire to know more, a desire to explore alternatives, willingness to bring about a change, a sense of commitment and responsibility, and a desire for theory building and application.

Curiosity

Inquisitiveness and a questioning mind go a long way in the process of research. A research worker, working in the field of education while observing varied phenomena in the educational world, should ask questions like, Why do students fail? What characteristics make a successful teacher? Which classroom climate is more congenial for learning? and so on. This questioning mind will lead the research worker to undertake significant research studies. Whenever questions arise in our mind, there is an attempt to seek answers which will lead to research.

Sensitivity

Problem sensitivity is the keynote to success in research. A research worker has to develop this sensitivity. Often, we are not able to feel a problem that impinges on our work. This is due to lack of sensitivity. Even when a large number of students fail we do not feel concerned and do not try to analyse the reasons for this catastrophe. For developing sensitivity, research workers must be able to perceive the smallest happening around them, however trivial it might be. It was Newton's sensitive mind which led him to ponder why the apple fell down. There were many people before Newton who had observed the phenomenon of an apple falling from a tree, but the question did not strike their mind.

Desire to Improve the Existing Situation

Those who believe in status quo cannot take up research work. Research is meaningless for those who believe that everything is all right and nothing more needs to be done. The need for research will only arise when one has a strong feeling that there is a considerable scope for improvement in the existing practices or situations. Even a good performance can be made better and there is no limit to improvement. When this attitude exists, there is a lot of scope for research.

Belief That Change Can Be Brought About

If one goes on enumerating the constraints due to which no change is possible, then there can be little scope and motivation for research. If one believes that some changes can be brought about in spite of all the odds, then there is a possibility for undertaking meaningful and worthwhile research.

Preparedness to Accept the Responsibility of Bringing About a Change

There are many people who are convinced that a change must be brought about. But they feel that it is not they themselves but someone else who should take up the responsibility of bringing about a change. They themselves cannot do anything. Such an attitude is not congenial for research work. A person who is bold enough to accept the challenges of changing the existing situations is most suited for research work.

Belief in the Scientific Way of Problem Solving

Ad hoc solutions to problems cannot give reliable answers. Hence a scientific method should be followed for finding out answers to problems. This mainly involves collecting evidence and evaluating whether the proposed solution is appropriate or not.

Facilitative Climate

Research activity can go on in a climate which fosters experimentation, raising doubts and attempting new thinking. A restrictive, inhibited academic and administrative climate retards the pace of research activities and de-motivates the researcher. Research activities go into high gear in an academic climate where new issues are raised, unpalatable questions are asked and divergent thinking is encouraged.

Activities

- (i) While supervising the practice of teaching, what questions come to your mind, the answers to which you would like to look for? Write any two.
- (ii) Which of the following situations are not congenial for research? Write 'NC' against such situations and 'C' against the situations which are congenial for research.
 - Head of an institution ensures that their views prevail. ☐
 - One is not satisfied with the existing situations. ☐
 - One feels an urgent need of bringing about change. ☐
 - One feels that the government alone can solve problems. ☐
 - One feels what he/she thinks is correct. ☐
 - One likes to try out new ideas. ☐

▲ Forms of Educational Research

There are various forms of educational research. Research is conducted at different levels for different purposes. On the basis of our problems or purposes, we may categorize research into the following three forms:

- (i) Fundamental, basic or pure research
- (ii) Applied research
- (iii) Action research

Fundamental Research

The purpose of this research is to contribute new knowledge in the form of new theory, facts and truth. For conducting fundamental research, sophisticated procedures, tools and techniques are employed, controls exercised and the generalizations arrived at which have a wide application. It is primarily concerned with the formulation of a theory and is not hampered by considerations of immediate utility.

Discovery of such useful concepts as motivation, reinforcement, concept formation and social environment in learning are a result of fundamental educational research.

Applied Research

In this type of research, this knowledge produced, the concept discovered, the theory constructed and the laws established are put to application in specific educational situations. The researcher in such a frame of reference works out the strategy for applying the already discovered facts, principles and truths. The applied research also takes into consideration the scientific method of inquiry but its methodology is not as rigorous as that of basic research. Its findings are to be evaluated in terms of local applicability and not in terms of universal validity.

This type of research is concrete by its very nature and requires understanding of the practical situation encountered by the practitioners.

Action Research

Action research is a research conducted in informal contexts and hence is flexible. The approach of action research emphasizes the practitioners to do research in order to improve themselves. The objective of such research, by teacher for example, will be to improve classroom practices. The goal of research, in terms of adding to scientific knowledge by arriving at sound generalization, takes a backseat.

This research places importance on a specific problem which is present here and now. As the methodology is not rigorous as that of fundamental research, the persons facing the problem, that is, the teachers or the administrators, can undertake it themselves.

We are living in a democratic country where we talk of equality of opportunity. This right can be provided by spreading education at the grass-root level. Therefore, the future of democracy depends upon the students and the type of education they are getting. It means that the responsibility of educating the youth depends mainly on the educational institutions and the teachers who are directly concerned with the teaching-learning process.

In recent times, we have witnessed the development of educational technology. Educational technology has contributed a great deal towards the improvement of formal as well as informal streams of

education with the primary objective of improving the teaching–learning process. But, at the same time, these rapid technological changes have also brought about some practical problems. These problems are related to the areas of discipline in classroom, copying, system of examination, curriculum, textbooks, co-curricular activities, backwardness, delinquency and individual learning difficulties.

That is why, our teachers, administrators and other workers engaged in this process must concentrate and try to find some amicable solution to their classroom problems. They should evolve suitable techniques and procedures through scientific approach. ‘Action research’ is an attempt in this direction. Hence, at this stage, before going into the details of processes in action research, it will be worthwhile to acquaint ourselves with the concept of action research.

Meaning and Concept of Action Research

Action research is a new innovation in the field of education. It helps in evolving suitable measures and programmes through scientific approach. These measures and programmes, in turn, help the practitioners in analysing their problems, in finding effective solutions, in improving their own work and in smooth functioning of educational institutions. Alternatively, it helps the practitioners to work on constructive lines by analysing their problems. Thus, we can say that the type of research used to solve various problems of educational institutions through scientific approach is known as action research.

Action research is a concept which was first used by Stephen M. Corey in the field of education. Corey (1953) held the opinion that if teachers are to make an active contribution towards effective learning, better achievement of learners and resolving their problems, it will probably be in the area of action research. Studies can be undertaken for the purpose of improving local school practices and teacher’s professional growth, teaching strategies/techniques and classroom management, professional improvement, preparation of textbooks and the development of curriculum.

Introductory remarks about the basic concept of action research, its main characteristics and elaborated specific themes are described here and two illustrations on how to develop an action research project are touched upon.

The Present Shift

With the concerted efforts of Corey and his colleagues (1953), action research was brought to the forefront of educational research in early 1950s. In India, enthusiasm towards action research was palpable in 1960s and 1970s. However, the boost to this movement had come with the establishment of District Institutes of Education and Training (DIETs).

IASEs and CTEs

Believing in the ideology that teaching and research should go hand-in-hand, DIETs were advised to train teachers in action research so that teachers become reflective practitioners. Colleges of Teacher Education (CTEs) and Institutes of Advanced Studies in Education (IASEs) have also been advised to orient teachers and teacher education in action research.

According to S.M. Corey: ‘The process by which practitioners attempt to study their problems scientifically in order to guide, correct and evaluate their decisions and actions is, what a number of people have called, action research.’ In fact, it is the type of research which people conduct in order to enable them to achieve their purposes effectively, e.g. teachers conduct action research to improve their own teaching.

In the words of Blackwell: ‘Action research is the research concerned with school problems carried on by school personnel to improve school practices.’ In other words, action research inspires everybody engaged in the work of education to work collectively for the total good and it is the medium for strengthening the practical side of research.

Goode (1959) has appropriately summed up the nature and goal of action research in his definition: 'Action research is research used by teachers, supervisors, administrators to improve the quality of their decisions and action.'

Action researches are small-scale and narrowly focused researches undertaken by teachers in a given context. It has also been referred to as 'research into practice by practitioners, for practitioners.'

—*Hammersley (1993: 237)*

Theory building is not the major concern of action research. It emphasizes more on understanding and solving the problem rather than theory building. The felt problem is contextual and the researcher examines the problem within the existing context (social, administrative, technological, ethical and others). It aims at improving personal or institutional efficiency.

Main Features

In action research, teachers, the classroom practitioners, feel and solve the problem. A practitioner undertakes both the functions of diagnosis and therapeutic treatment

- to remedy problems diagnosed in specific situations;
- to heighten the self-awareness, self-criticality and analytical abilities of teachers and teacher educators and
- to inject innovative approaches to teaching.

—*L. Cohen and L. Manion (1994: 188)*

This action research movement in education has as its goal of involving classroom teachers in the study and application of research to the educational problems in educational setting. Action research focuses on immediate application and not on the development of theory or on general application. Its findings are to be evaluated in terms of local applicability and not universal validity. The main purpose in this kind of research is to improve school practices and to improve those who try to improve the practices.

—*J.W. Best and J.V. Kahn (1986: 21)*

In a nutshell, we can say that action research is a process for studying adopted by practitioners to scientifically take decisions for improving their current practices. Therefore, action research is the research by the practitioner (teacher/administrators/examiners), of the practitioner and for the practitioner.

Difference Between Action Research and Pure Research

The following are the differences between action research and pure research:

- The purpose of pure research is to evolve a theory whereas the purpose of action research is to solve a specific problem felt by a person working in the field.
- The solution of action research is applicable to a particular situation for which the solution has been found. The generalizations of pure research have wider applicability.
- The sample of pure research is large and that of action research is small and restricted to the situation for which a solution has to be found.
- The research design for pure research is very rigorous and rigid whereas the design in case of action research is simpler and flexible.

Advantages of Action Research

The advantages of action research are as follows:

- Since the solution to a problem has been found taking into account all the typical local conditions, chances of its being successfully implemented are more.
- The problems of action research are the felt needs of practitioners; hence there are greater chances of the results of action research influencing the existing practices in the field.
- Since the practitioners themselves are involved in the process of research, the findings are their own and not thrust upon them by outsiders; hence they are more likely to implement them.

Areas of Action Research

Areas of action research can fall under the categories related to the following:

- Learner
- Teacher
- Methodology
- Evaluation
- Curriculum
- School administration
- Educational context
- Parental co-operation

The following are the area-wise specifications:

- Related to learner
 - Motivation
 - Learning style
 - Attention span
 - Concentration
- Related to teacher
 - Level of competencies
 - Commitment
 - Teaching style
 - Motivation
 - Attitude towards weak students
 - Attitude towards notoriously inquisitive students
 - Social profile
- Related to methodology
 - Activity-based teaching
 - Playway approach
 - Child-centred learning
 - Project approach
 - Positive reinforcement
 - Efforts to incorporate mediated learning
- Related to evaluation
 - Criterion reference testing
 - Diagnostic testing
 - Formative testing

- Illuminative testing
- Achievement testing
- Objective-type testing
- Objective-based testing
- Related to curriculum
 - Mechanism of curriculum design
 - Mechanism of curriculum construction
 - Mechanism of curriculum revision
 - Curriculum structure
 - Teacher's role in curriculum design and development
 - Intended, transacted and hidden curriculum

Concrete Problems of Action Research

The following are the concrete problems:

- Hard spots in Mathematics for IIIrd grade learners (difficult learning points)
- Attitude of SC/ST parents towards schooling
- Survey of language teaching methodology adopted by language teachers of a block
- Survey of gender sensitivity
- Survey of use of audiovisual aids

Action research is a process by which practitioners try to solve their own problems in a scientific way.

Illustrative Example of Action Research Plan

- (i) Topic of action research
Improving supervision of schools
- (ii) Name and address of investigator
- (iii) Background:
Education officers and their representatives are expected to help and bring about improvement in the academic and co-curricular activities of schools. There is some evidence to indicate a downward trend in this regard. This may have some relation to supervision by education officers. Poor and ineffective supervision is one of the reasons of downward trend of schools in a district. It is, therefore, planned to undertake this action research project.
- (iv) Probable reasons:
 - Suggestions given in the supervision report are vague and not clear
 - More emphasis is given on negative comments rather than on positive or suggestive aspects in the report
 - Suggestions given are over-ambitious and are not practicable in school situations
 - Supervision reports are not sent on time
 - Report forms need change
- (v) Action hypothesis:
If the supervisory reports are reviewed after improving the report form (if needed) and only practicable suggestions are given in place of negative comments, then the quality of schools can be improved.

- (vi) Tools:
- Proforma for analysing previous supervisory reports
 - Questionnaire for teachers
 - Interview schedule for headmasters
- (vii) Action plan:
- First of all, at least 20 reports of previous supervisions will be analysed and observations will be recorded on a proforma. A list of suggestions which were vague and impracticable will be prepared.
 - On the basis of the preceding information, a questionnaire for teachers and interview schedule for headmasters will be prepared.
 - Data will be collected by the tools prepared, that is, through the questionnaire and interview schedule.
 - If required, new report forms will be prepared.
 - Supervisors will be oriented with new forms and style of supervision.
 - A sample of at least 10 schools will be selected for testing the hypothesis.
 - Academic achievement and status of schools in others activities will be recorded.
 - Supervision will be made and reports will be sent to schools on time.
 - Post-supervision achievement and status of schools in other activities will again be observed after sometime (say about 4 months).
 - Difference in pre-supervision and post-supervision status will be determined and inferences drawn.
- (viii) Time budgeting (see Table 1.1)

Table 1.1 Time budgeting

Activity	Time	Duration
1	Analysis of previous supervision reports	10 days
2	Preparation of tools	15 days
3	Data collection from teachers and headmasters	30 days
4	Preparation of new report forms and orientation of supervisors	15 days
5	Selection of schools and recording of their status (academic as well as co-curricular)	15 days
6	Supervision and sending reports	2 Months
7	Recording of post-supervision status after 4 months	15 days
8	Analysis of data-testing the hypothesis	10 days
9	Preparation of report of the work done	10 days
10	Financial implications (for illustration only)	
	(i) Printing of tools	Rs 4000/-
	(ii) Books	Rs 6000/-
	(iii) Typing and contingency	Rs 2000/-
	Total	Rs 12000/-

Activities

- Mention four characteristics of action research.
- Formulate two action research problems.

- (iii) Select a suitable problem for action research and formulate main action hypothesis related to it.
- (iv) Prepare an action research plan for an action research problem.

Evaluate Yourself

- (i) Define action research.
- (ii) How many forms of educational research?
- (iii) List the steps of action research
- (iv) Give an example of an action research problem.
- (v) What is action hypothesis?
- (vi) Differentiate between action research and fundamental research.

Identification of the Problem

The first and the most important step in action research is the identification of the problem. In order to identify the problem, the teacher should be sensitive towards job activities and curious enough to isolate it from the broad field. It requires certain qualities like imagination, honesty and devotion towards duty. Suppose the teachers find that the children in their classes do not have good handwriting in Hindi and they are eager to improve the handwriting of their students.

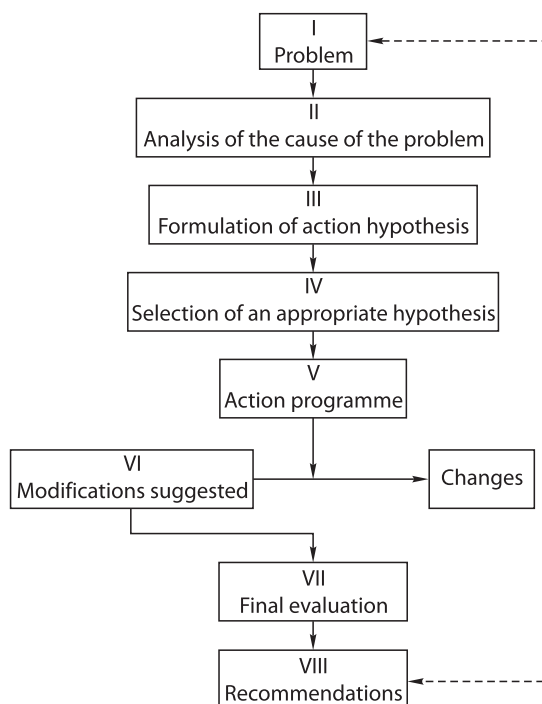


Figure 1.2 Steps of action research

Defining and Delimiting the Problem

After identification, the investigator defines the problem clearly and precisely so that the goal may be specified. While defining a problem, the investigators try to delimit the problem in terms of class, subject, group and period in which they perceive the problem. For example, for the preceding problem, the pin-pointed problem may be—‘A study for improving handwriting of VIth class students in Hindi.’

Analysing the Causes of the Problem

The next important step in action research is to think about the probable causes related to the problem. The nature of the cause is analysed whether it is under control or beyond the control of the researcher. The investigator finds out external factors responsible for the problem. To know this, the investigators consult their colleagues, students and experts in the field. For example, for the earlier-mentioned problem, they find out that the probable causes for bad handwriting can be the following:

- The children do not have enough good specimens of handwriting to copy.
- The children do not have comfortable seats.
- They do not have proper pencils to write.
- The handwriting of Hindi teacher is not legible.
- No proper supervision by the Hindi teacher/parents.

Formulation of Action Hypothesis

From the probable causes, those most relevant to the situation in the school are selected and from them the action hypotheses are framed. The statement of action hypothesis consists of two aspects—action and goal. It indicates that some action should be taken for achieving the goal.

Thus, we can have one or more hypotheses depending upon the nature of the problem and the circumstances. In the present problem, for example, we can have the following hypothesis—‘If the teacher provides specimens of good handwriting and good writing material to the students then, the handwriting of the students can be improved.’

Design for Testing the Action Hypothesis

A design is developed for testing the most important action hypothesis. Here, on the basis of action hypothesis, some action is taken in the prevailing situation. The relevant evidences are gathered. For the present problem, the action plan may run as shown in Table 1.2.

Table 1.2 Steps of action plan

Duration of Period	Action to be Taken	Procedure and Tools Used
Regular classroom period	Orientation of the students regarding problems of handwriting.	Distributing two loose sheets to every student and instructing the students to write on these pages from any Hindi newspaper or any other source except regular Hindi textbooks.
Two days	Directing students to write on the given sheets at their homes.	Requesting the teachers of the same class not to give heavy homework in their subjects for these two days and the parents to let them free.
Regular classroom period	Collection of sheets from the students.	Collecting the sheets by taking the help of the monitor of the class.

Table 1.2 (Continued)

Duration of Period	Action to be Taken	Procedure and Tools Used
Two days	Evaluation of the sheets and division of the class into three groups—good, average and poor—on the basis of their handwriting.	Evaluating of handwriting of students on the basis of a set criterion.
One week	Selection of specimens of good handwriting and writing material for the students.	Consulting literature and relevant books available in school library and collecting good specimens of handwriting from drawing teachers of various schools.
Regular classroom period	Distribution of these specimens to the three groups of the class.	Classifying the specimens according to the level of difficulty into three so that they can be given separately to students with good, average and poor handwriting.
Two days	Drill work/practice exercises.	Providing the material of good handwriting to students.
Two days	Proper checking of the notebooks (collected by the students).	The teacher will do this work in the free period.
Regular classroom period	Organizing of a handwriting competition.	The teacher will ask the students to write 10 lines on any Hindi essay of their choice.

Evaluation of the Action Programme

After repeating the cycle mentioned, the teachers will come to know how far they have been successful in improving the handwriting of their class students. For this purpose, after three months, the teachers will again evaluate Hindi handwriting and will make a comparison of the results achieved in the improvement of handwriting of the children of the class. On the basis of this evaluation, the hypothesis framed will either be established or rejected.

Follow-up and Communication of the Findings to Others

The results arrived at may then be used by the teachers themselves for bringing improvement in their own practices. The results may be checked again for communicating to others.

Difference Between Action Research and Fundamental Research

From the preceding discussion on action research, it is clear that the purpose of action research is limited to the solution of immediate problems at hand and no sophisticated technique is needed for conducting it. We can see the following features which distinguish this type of research from the fundamental research.

- The purpose of fundamental research is to develop theories by discovering broad generalizations and principles.
- In action research, problem is narrow and it does not need a trained and specialized researcher. The practitioner in the field becomes the researcher whereas in fundamental research, the problem is broad and a person with specialization in the field is required.
- The action research hypotheses are formulated on the basis of causes of problem and one hypothesis is tested at a time, whereas in fundamental research, the hypotheses are formed on the basis of some rationale and all the hypotheses are tested by one design of research. As we have observed, in action research, one hypothesis is tested at a time.

- The design of action research is flexible whereas the design of fundamental research is rigid, which cannot be changed.
- No sampling is needed in action research, since here the practitioner has to deal with all the people concerned who form the limited and accessible population. Whereas in fundamental research, a representative sample is selected from a well-defined population by using various sampling techniques.
- No special tools for collection of data are needed in action research as the efficacy of the remedial measures taken has to be assessed with the same instruments that had recorded the deficiencies whereas in fundamental research, usually the standardized tests are used for collecting data.
- In action research, knowledge of descriptive statistics is enough. As no inferences have to be drawn about the population from the study of sample, the inferential statistics do not come into picture, whereas in fundamental research, the parametric statistical techniques are used for analysing the data.
- These two types of researches also differ from the point of view of usage of the researches. The conclusions drawn from action research are in the form of remedial measures, which are used for improving the current practices, i.e., it does not contribute to the fund of knowledge whereas conclusions of fundamental type researches are in the form of generalization. The generalization may be a new theory or new fact or new truth or new interpretation.

Stephen M. Corey was the person who first applied action research in education. Action research is undertaken to solve an immediate practical problem. Here, the goal of research in terms of adding to scientific knowledge by arriving at sound generalizations takes a backseat.

This research places importance on a specific problem which is present here and now. As its methodology is not rigorous as that of pure research, the persons facing the problem, that is, the teachers, the administrators, the supervisors or the examiners, can undertake it themselves.

The following are the steps of action research:

- (i) Identifying of the problem
- (ii) Defining and delimiting the problem
- (iii) Analysing the causes of the problem
- (iv) Formulating action hypothesis
- (v) Designing for testing the action hypothesis
- (vi) Evaluating the action programme
- (vii) Following-up and communicating the findings to others

Action research strategy is dynamic and sensitive. Its design is of a changeable type rather than fixed and rigid as in fundamental research. Fundamental research aims at extension of knowledge and theory building, while action research is concerned with problem solving. In other words, we can say that the use of action research is ameliorative or remedial—to solve the problem of a school or the difficulty of a classroom situation.

Evaluate Yourself

- (i) What do you mean by educational research?
- (ii) List the three different forms of educational research.
- (iii) What is the major difference between the three forms of educational research?

▲ Need and Importance of Research in Education

Need

Research in the field of education is needed for man's purposes, but those especially noteworthy are the following:

- Research is needed to understand the action and reaction of a number of apparent and hidden forces in the all-round development of personality, which is the main aim of education.
- Education has strong roots in fields like philosophy, history, economics, psychology and sociology. It is through an intensive process of scientific enquiry about the philosophical, historical, economical, psychological and sociological impact on various aspects of education that sound theories can be established.
- Education has two aspects:
 - (i) The corpus of theory which provides the basis
 - (ii) The conduct and improvement of the skill of art of instruction

The former may be called 'science' and the latter 'art of education'.

As a science, education has a corpus of knowledge concerning the nature of individuals and their growth and development, the laws of learning, educational policies and planning, and theories of administration.

As an art, it seeks to impart knowledge effectively. For example, 'How the teacher can play an effective role in the classroom and outside?' is a vital question before the educationists which needs careful research efforts to enhance teacher's effectiveness.

- Besides the general theories and practices of education, the effect of different environmental setting on students of different age, sex, intelligence, socio-economic and other groups have to be investigated.
- Knowledge is expanding in all subjects. Research is needed to discover new methods of teaching in accordance with the new subject matter.
- Research is needed for evolving appropriate tools for making objective measurements for educational research.
- Proficient and able workers required for the reconstruction of our country can be produced only by setting up an appropriate educational system through research.
- The implementation of new policies and practices which can be achieved through research needs careful empirical testing.
- Man has a craving to know his history, hence there is need of historical research also in education.
- Education is a means to achieve certain goals through purposely organized programmes. Since objectives need revision time and again, due to the changing socio-economic and political conditions, there is always a need to modify educational theories and practices which would need active research.
- To reap the maximum benefit of industrialization in our country, simultaneous modernization is required. But it can only be possible by changing the thought processes of the people by establishing an appropriate educational system through research.
- Participation in research has a good impact on the personality of teacher. It keeps the minds of the teachers alert and fresh and gives them an objective look. It prevents the teachers from becoming stale and subjective. Thus, we see that research is needed in the field of education to find effective means for the teachers so that they can play their role effectively in the teaching learning process.

Importance

Following are the important factors which have led to an increasing emphasis on educational research:

- *Research brings objectivity:* In the absence of research, opinion of a few distinguished educators dominates the educational reforms—an aspect, which is suicidal. Educational research brings objectivity.
- *Research brings a sense of awareness:* Everett Walters describes the importance of research to teachers in these words: ‘The teacher who carries on an active research programme has at his command a sense of awareness and of deep understanding. He has at his fingertips illuminating examples and searching questions which can give his lectures or discussions that vibrancy and sparkle which make for real teaching.’
- *Research promotes educational reform:* In the words of Walter R. Brog: ‘Although research is still in its infancy, it has in its short span already produced much useful knowledge and has brought about great changes in educational practices and in the thinking of educators.’
- *Research leads to refinement:* In the words of J. W. Best: ‘The secret of our cultural development has been research, pushing back the areas of ignorance by discovering new truth, which in turn, lead to better ways of doing things and better products.’
- *Research keeps us alert:* Research is a tool ‘par excellence’, which adds to our existing knowledge in an orderly manner. It makes our educators alert and keeps them awake and alive.
- *Research leads to better understanding of the teaching–learning process:* John Best observes: ‘In the field of education, we identify research with a better understanding of the teaching–learning process, and the conditions under which it is most successfully carried on.’
- *Research as a controlling factor of social behaviour:* According to P. V. Young: ‘The primary goal of research, immediate or distant, is to understand social life and thereby gain a greater measure of control over social behaviour.’
- *Research economizes effort and increases efficiency:* Rusk describes this as: ‘Research should accordingly, by putting more scientific weapons at the disposal of the teacher, economise effort and increase efficiency. It is in fact likely to lead to what Ballard has termed “Leisurely methods”. The leisurely methods of today are just as effective as the strenuous methods of the past.’
- *Research dignifies the work of the teacher:* According to Buckingham: ‘Research will not only powerfully and rapidly develop the technique of teaching, but will also react to vitalize and dignify the work of the individual teacher. It is my firm belief that the emancipation and professionalizing of the teacher’s calling rests for upon any considerations having to do with salary, tenure or legal status. Society to be respectable. If, as has often been observed there is no such general belief in the public is right about it—whether the teacher readily has, to the extent that the professional or craft worker has, a special competency peculiar to his calling. In my judgment nothing would so effectively obtain for a teaching body the professional expertness and the reputation for having it as the open eyed, open minded scientific spirit of inquiry.’
- *Research brings confidence to the teacher:* Rusk writes: ‘When the teacher’s technique is based on research, teaching will no longer be regarded as one of the black arts, but will assume the status not a dismal science, but of a progressive and enlightened procedure. The more highly skilled and better informed teacher will find new interest in his work and a new confidence in his own abilities.’
- *Research leads to the adaption of new methods:* Research will put an end to the a priori criticism and rejection of new methods. If one is not prepared to accept the results of a method based on scientific research, one must repeat the investigation and find out the flaws in the procedure.

- *Research needed for selection:* The Education Commission 1964–66 pointed out the necessity of educational research as, ‘Much of the opposition of a policy of selective admission would disappear if good methods of selection were evolved... what is needed is a reliable method of selection, which will take account of past performance, native talent and the principles of social justice. Educational research will have to develop vigorously to discover such methods.’
- *Educational research for identifying talent:* The Education Commission observed that a bunch of competent and trained manpower is now felt in nearly every branch of national life and is probably one of the biggest bottlenecks to progress. Poor as we are financially, the poverty of trained intellect is still greater. We might well remember Whitehead’s warning, ‘in the modern world the rule is absolute—any race which does not value trained intelligence is doomed’. The commission further observed that if intelligence is duly discovered and developed, our large population can be our most valuable asset. It is, therefore, very important that we should search separately for each special talent, whether in mathematics, science, literature, fine arts, sports or technology. Sustained and energetic search for talent is needed and it must become a continuous process.
- *Research for studying the child:* According to a UNESCO publication, the *Organization of Educational Research* (1966), ‘In many of its recommendations, the International Conference on public Education has stressed the need for psycho-educational knowledge of the child as the starting point for any educational activity. It has also shown that research forms an indispensable basis for any national organization of education, especially as regards curricula, syllabuses and methods as well as financing education for its planning. And for the building of schools.’
- *Research for increasing knowledge and wisdom:* Research breaks new grounds and improves knowledge and wisdom.

▲ Role and Significance of Research in Education

In the present situation, education is being increasingly linked with national development. Increased amount of research in various fields of education makes progress possible. As we have already learnt, research in education not only follows scientific method but also plays a major role in inculcating scientific and inductive critical thinking. It promotes the development of logical habits of thinking and organization.

The role of research in several fields of education, whether related to psychology, technology, economics, planning, administration and supervision, as a whole has greatly increased in modern times. The increasingly complex nature of teaching and learning has focused attention on the use of research in solving problems. In educational research, therefore, the first priority is given to problems relating to the conceptualization of variables with regard to teaching and learning for the formal, non-formal and informal situations.

Research provides the basis for solving nearly all problems relating to teacher preparation, educational administration and supervision. The efficiency to teaching–learning programmes hinges mostly on the expediency of educational administration and supervision.

Another area in education where research is necessary is collecting information on the ability, motivation, attitudes and personality of the practitioners involved in the process of teaching and learning. Research has its special significance in solving various problems of educational measurement and evaluation. The problems of content, methodology and evaluation in respect of teacher education programme form a part of research on teacher preparation.

Research provides the intellectual satisfaction of knowing a few things for the sake of knowledge. It also has practical utility because it enables the researchers to do something better or in a more efficient manner. Research in education is concerned both with knowledge for its own sake and with knowledge for what it can contribute to practical concerns.

The significance of research can also be understood keeping in view the following points:

- Research may mean an outlet for new ideas and insights to philosophers and thinkers.
- Research may mean a careerism or a way to attain a high position in social structure to those students who are engaged in writing a master's or PhD thesis.
- It may be a source of livelihood for the professionals in research methodology.
- Research may mean the development of new styles and creative work for literary people.

In a nutshell, we can say that educational research is the fountain of knowledge for the sake of knowledge. It provides important guidelines for solving different educational problems. At the same time, it is a sort of formal training which enables the researcher to understand the new development in educational discipline/field in a better way.

▲ Scientific Method

The process of scientific use for the collection of data and verification of scientific knowledge is called scientific method. Scientific method is mostly used in research studies that are empirical in dealing with observable evidence—evidence which is the common experience of trained investigators.

A critical domain of modern, scientific research is the building of theories that system actually organizes the available facts in a way which yields general explanation about a wide range of phenomena. Scientific theories deal not only with verified facts but also with the hypothesized facts. The scientific theories tend to generate a new and creative research. It brings additional knowledge, brings modification to the existing theories and the building of new theories.

In scientific research, the systematic and empirical study of relationship among variables is a major issue. It will be extremely important for the students to learn to conceptualize any research problem in these terms. The scientific study of human behaviour is based upon observations of that behaviour. In order for the observations made by behavioural scientist to have that scientific behaviour, these observations must be capable of variation from person to person. Such observations are called variables. There are two broad classes of variables: those which vary in quality and those which vary in quantity. For example, sex is a qualitative variable and intelligence is a quantitative variable.

Most researches will require the identification of independent and dependent variables. In the simplest research (and often the most profound), only two variables are studied—one independent and the other dependent. The investigators are interested in determining whether or not a relationship exists between the two, and if it does indeed exist, they want to know about the nature of that relationship. Suppose, for example, that educational researchers wish to determine whether the traditional textbook or a new programmed textbook is more effective for teaching elementary algebra to students with low aptitude for studying mathematics. They might arrange to teach one group of students from the traditional textbook and another group from the new programmed textbook. At the conclusion of the learning experience, an examination would be held to determine as to what extent the students learned their algebra. Then, they would determine whether one group learned more than the other, if so, which, and perhaps, how much more. In this simple research project, the two textbooks used constitute the independent variable, and the examination held at the end is the dependent variable.

In the situation in which the investigator is seeking to predict human behaviour of some sort, the independent variable is used as the predictor and the behaviour to be predicted is the dependent variable. Suppose, for example, an air force psychologist is seeking to predict from an aptitude test whether or not an air force cadet will successfully complete pilot training. This aptitude test is the independent variable and performance in pilot training is the dependent variable.

In an experimental setting, the independent variable is manipulated by the experimenters and dependent variable is the criterion by which they determine whether or not anything of consequence happened when not necessarily because they manipulated the independent variable. However, a great deal of very important behavioural research is undertaken in which the investigators do not manipulate the independent variable, they merely observe and explain. Such research is called *ex post facto* research in contradiction to the experimental research in which the independent variable is manipulated. Suppose that the educators in the example cited earlier had been interested in the relationship between the sex of student and achievement in the study of algebra. In this case, the sex of the student is the independent variable.

Now let us suppose that the educators mentioned in the earlier example are primarily interested in comparing the relative effectiveness of the two different textbooks, but they suspect that other variables, such as IQ and sex of the student, may also influence the dependent variable and affect the outcome the experiment. This suggests that independent variables should be broken into groups; the experimental variables which the investigator is interested in studying to determine their influence upon the dependent variable which they wish to control. The problems of organizing, carrying out and interpreting behavioural research revolve around these three kinds of variables:

- Independent variables whose effects are to be studied
- Independent variable whose effects are to be controlled
- Dependent variables that are observed in order to determine the consequence

The planning of research taking into consideration these three kinds of variables is ordinarily referred to as experimental design.

In this chapter, we have learnt that our educational institutions require a constant supply of information regarding new technologies, methods/procedures and tools. This is possible through research. Educationists collect all reliable and valid information by employing the process of scientific procedure. That is why, educational research is said to be a systematic attempt in the direction of understanding educational problems and processes which help in improving teaching–learning process. Laws and generalizations discovered by educational research contribute a lot in improving and modifying the teaching–learning process.

We have also discussed about the following three forms of educational research:

- Fundamental research
- Applied research
- Action research

The three forms have different goals. The goal of fundamental research is to discover new theories and truths, and that of applied research is to apply established law and constructed theory in specific educational situations. But the goal of action research is to solve immediate problems faced by the practitioners. We have also discussed about the need, role and significance of research in education. Education is a science as well as an art. We have learnt that as a science, education has a corpus of knowledge concerning the nature of individuals and their growth and development, the laws of learning, educational policies and planning. As an art, it seeks to impart knowledge effectively. Educational

research keeps teacher always alert and fresh. It helps the teacher in modifying objectives which need revision from time to time with the changing needs of the society. In the concluding paragraphs we learnt that research is a useful tool for solving nearly all practical problems relating to teaching-learning process.

▲ Summary

- Research has been defined as the systematic and objective analyses and recording of controlled observations that may lead to the development of generalizations, principles or theories resulting in prediction and possibly ultimate control of events. The characteristics of research that may help to clarify its spirit and meaning have been presented.
- The meaning and different definitions of educational research enabling you to learn that research is a systematic and scientific process of understanding and solving problems. Research is essentially an intellectual and creative activity.
- We have also learnt about the purpose, aims and characteristics of educational research.
- It is clear that research helps us to improve our existing conditions and develop insight in understanding the educational process and the behaviour of individuals and groups.
- Action research is a new movement in education, which is carried out by the teachers or educational practitioners with the aim of improving the educational process and class practices.
- To formulate an action research plan along with the main steps to be followed. Research finding in a logical and convincing manner is both a technique and an art.
- Fundamental or basic research is the formal and systematic process of deductive-inductive analysis, leading to the development of theories.
- Applied research adapts the theories, developed through fundamentals research, to the solution of problems.
- Research is essentially an intellectual and creative activity. The mastery of techniques and process does not confer research, though these skills may help the creative problem-solvers to reach their objectives more efficiently.

▲ Key Words

- *Research*: Research is a systematic, objective, reportable deliberate attempt to answer meaningful questions pertaining to a field of study or about phenomenon or events in a given situation.
- *Educational Research*: Educational research is a systematic, objective and deliberate attempt to answer meaningful questions pertaining to educational processes, forms, organizations and thoughts.
- *Action Research*: Action research is the process by which the practitioners solve the various immediate problems of educational institutions through scientific approach.
- *Action Hypothesis*: Action hypothesis describes a relationship between the proposed action and the anticipated consequence.

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Selecting Research Problems

2

Research deals with systematic problem-solving activity. It may also be due to their enthusiastic but native way of providing a solution to a problem quickly and immediately. Research work is oriented towards the solution of a problem, which is governed by reflective thinking. The thinking of normal humans may be classified into four: convergent, divergent, reflective and scientific thinking. In reflective thinking, an individual conceives a new solution for an old problem. Before considering the ways by which problems may be identified, we should discuss a few characteristics of the research and the activities of the researcher. Research is more often a team endeavour than an individual activity. Researchers working in a group attack problem in different ways, pooling their knowledge and ideas and sharing the result of their efforts. Research, however, is a process of testing rather than proving and it implies an objectivity that lets the data lead where they will. The problem has several dimensions, but these can be studied simultaneously.

▲ Identification of Research Problems

Entering the field of research can pose many difficulties for beginning researchers in identifying a suitable research problem, as they are yet to develop problem sensitivity. After gaining some experience, they find problems in various areas of their work. For example, in the case of textbooks, many research issues relating to it will emerge, such as gender preference in textbooks and suitability of experiments in science textbooks.

If we consider a teacher, we come across many problems related to them such as, What are the qualities that make one a successful teacher? Do socio-economic and family influences determine the success of a teacher? Which teacher behaviour is conducive to better learning? If we consider students, again there are a host of research issues related to them, such as, Why does a student fail? What are the difficulties in concept acquisition in subjects like science and mathematics? What are the common errors that students commit at the primary stage in mathematics? Which teacher is more popular with the students? How to deal mentally superior and mentally retarded children? What are the causes of delinquency and how to deal with them?

In this way, irrespective of the areas we consider, such as curriculum, evaluation, educational technology or even school building and furniture, we can list out hundreds of research problems, meaning thereby that there is no dearth of research problems. The only thing is that one must be sensitive to recognizing problems.

Research work is oriented towards the solution of a problem or to seek an answer to a question. The first step of a research process is identifying a problem. The selection of a problem is governed by *reflective thinking*. Unthinking activity is governed completely by tradition or by emotion. Primitive

life was largely without effective reflective thoughts, until some intelligent individuals conceived of a new solution for an old problem. Therefore, higher educational groups always do much careful ordered thinking. The normal human mind thinking may be classified into four categories: convergent, divergent, reflective and scientific thinking. In reflective thinking an individual conceives a new solution for an old problem. But scientific thinking is in terms of carefully organized reflection.

▲ Selection of a Problem

The identification and analysis of a research problem is the first and foremost step of a research process. A problem cannot be solved effectively unless a researcher possesses the intellect and insight to isolate and understand the specific factors giving rise to the difficulty.

The present research scholars understand that identification of a problem means to select a topic of research or a statement of the problem. It is wrong to think so. A topic or statement of the problem and a research problem are not synonymous, but they are inclusive. The problem concerns with the functioning of the broader area of the field studied, whereas a topic, title or statement of the problem is the verbal statement of the problem. A topic is the definition of the problem that delimits or pin-points the task of a researcher.

It is the usual practice of the researchers to select the topic of the study from different sources, especially from research abstracts. They do not identify the problem, but a problem is made on the basis of the topic. Ultimately, the researchers have no involvement in their research activities and they do it mechanically.

Since identifying the exact nature and dimensions of a problem is of major importance in research work, it is very essential that investigators should learn to recognize and define a problem. They should proceed step by step in locating the research problem. The following are the steps in identifying a research problem:

- (i) The researcher should determine the field of research in which they are keen on doing research work.
- (ii) The researchers should develop mastery in the area or it should be the field of their specialization.
- (iii) They should review the researches conducted in the area to know the recent trend and also the studies conducted.
- (iv) On the basis of this review, they should consider the priority field of the study.
- (v) They should draw an analogy and insight in identifying a problem or employ their personal experience of the field in locating the problem. They may take the help of a supervisor or an expert of the field.
- (vi) They should pinpoint specific aspect of the problem which is to be investigated.

For example, researchers want to work in the field of teacher education, which is the field of their interest. They have deep insight and mastery over the area. On the basis of the review and their personal experience, the researchers perceive a problem in the field of teacher-education programme that training institutions and colleges of education are not able to produce effective teachers although a large number of such institutions have been opened after independence. This problem has several dimensions, but these can be studied simultaneously. The researcher further visualizes that the potential candidates are not admitted in this programme. A question arises, Are the potential candidates admitted in our teacher-education problem? Thus, the procedure of identification of a problem can be shown with the help of a paradigm.

The following are the major tasks to be performed in analysing a problematic situation:

- (i) Accumulating the facts that might be related to the problem
- (ii) Setting by observations whether the facts are relevant
- (iii) Tracing any relationship between facts that might reveal the key to the difficulty
- (iv) Proposing various explanations for the cause or the difficulty
- (v) Ascertaining through observations and analysis whether these explanations are relevant to the problem
- (vi) Tracing relationship between explanations that may give an insight into the problem solution
- (vii) Tracing relationship between facts and explanations
- (viii) Questioning assumptions underlying the analysis of the problem
- (ix) Tracing the irrelevant facts, which are not concerned with the problem
- (x) Locating the irrelevant explanations, which are not related to the problem

After going through these processes, the researcher will be able to define or state the problem...

▲ Sources of Problems

The selection of a suitable problem is not an easy task. It is a major responsibility to commit oneself to a problem that will inevitably require much time and energy, and which is so academically significant. The following are the main sources to which one may proceed for a suitable research problem.

- (i) Personal experiences of the investigator in the field of education are the main sources for identifying a suitable problem. Many of the problems confronted in the classroom, the school or the community lead to investigation that are perhaps more appropriate for the beginner researchers than the problems that are more remote from their own teaching experiences.
- (ii) The other source of problem, which is most frequently used by the investigators as suggested by the supervisors, is the extensive study of available literature-research abstracts, journals and handbooks of research international abstracts. They can draw an analogy for selecting a research problem or can think a parallel problem in the field studied in their own country.
- (iii) In the choice of a suitable problem, the researchers have to decide their field of investigation. They should study the field intensively in the specific area, which may enable them to identify a problem from the specific field.
- (iv) The new innovations, technological changes and curricular developments are constantly bringing new problems and new opportunities for educational research.
- (v) The most practical source of problem is to consult supervisors, experts and most experienced persons of the field. They may suggest most significant problems of the area. They can discuss certain issues of the area to emerge a problem.
- (vi) It is a general practice that researchers suggest some problems in their research reports. The researchers can pick up a suitable problem for their own study.

In order to help a new research worker locate a suitable research problem, some sources are being indicated as follows.

National Policies

There are two ways in which research is related to national policy.

- There are some researches, the findings of which lead to the formulation of some national policies and programmes. For example, when it was found on the basis of research that a majority of

children at the primary stage suffer from malnutrition and do not join school due to poverty, the programme of midday meals was launched.

- There are researches conducted after launching certain national policies and programmes in order to evaluate their impact, or to find out the shortcomings. For example, after the launching of SUPW programme at a secondary stage, some studies were conducted to evaluate its effectiveness. Similarly, some research was conducted to evaluate the scheme of internal assessment launched by the Board of Secondary Education, Rajasthan.

Field of One's Work

If research workers are sensitive towards the problems related to their day-to-day work, they will come across many research problems. Similarly, teachers can sense problems related to students, colleagues, higher officers, parents, textbooks, curriculum, the way of presenting the subject matter, use of educational technology and evaluation, and have to do armchair thinking for locating such problems. They may come across problems related to the field of work during discussions with colleagues.

Societal Needs

Another important source of research problem is the society. If research workers are aware of the burning problems of the society, which have a bearing on education, they can locate a large number of research problems. For example, the educational problems of children coming from orphanages, drugs and schools, children from broken homes, first generation learners and their educational problems, educational disparities, language problems, value crisis and education.

National Priorities

There are certain thrust areas of research based on the national priorities that might change from time to time, which should be taken into account while selecting a research problem. Some of the national priority areas, from which research problems can be identified, are given below.

- Universalization of primary education
- Education of women
- Education of scheduled castes and scheduled tribes
- Education for environment
- Population education
- Value education

Literature

Before finalizing a research problem, a research scholar should undertake an extensive survey of the related literature available in the library. These may include the following:

- Completed researches
- Research journals
- International dissertation abstracts
- Surveys of research
- Books on the subjects
- Reports of commissions and committees
 - National
 - International
- Emerging trends

The completed research work generally has a section in which the research worker suggests lines for further research. These can help the new research workers in selection of the problem.

When research workers scan the title of the research work in research journals, research abstracts and surveys of research, they come across many research issues, which may be of interest and may help in taking up a new problem in such areas.

Evaluate Yourself

- (i) What are the steps in identifying a research problem?
- (ii) What are the main sources of research problems?

▲ Criteria for Selection of a Problem

Two factors are generally considered for selection of the problem i.e., external and personal. External criteria deal with matters such as novelty and importance for the field availability of data and method, and institutional or administrative cooperation. Personal criteria involve considerations such as interest, training, cost and time.

Thus, the criteria for the selection of the problem suggested by Good and Scates are the following:

- (i) Novelty and avoidance of unnecessary duplications
 - (ii) Importance for the field represented and implementation
 - (iii) Interest, intellectual curiosity and drive
 - (iv) Training and personal qualifications
 - (v) Availability of data and method
 - (vi) Special equipment and working conditions
 - (vii) Approachability of the sample
 - (viii) Sponsorship and administrative cooperation
 - (ix) Hazards, penalties and handicaps
 - (x) Cost and returns
 - (xi) Time factor
- (i) *Novelty and avoidance of unnecessary duplication:* The question of novelty or newness is not merely one of duplication of the earlier investigations. It involves the recency of the data summarized especially in the case of survey studies made during a period of great economic, educational and social changes.
 - (ii) *Importance for the field represented and implementation:* The criterion of importance in choice of a problem involves such matters as significance for the field involved, timelines and practical value in terms of application and implementation of the results.
Scientific research in education, psychology and social science in general has an urgent obligation to play a social role rendering service to the society and humanity.
 - (iii) *Interest, intellectual curiosity and drive:* One of the personal motives of research most frequently mentioned by scientists themselves is pure curiosity, accompanied by genuine interest and a derived satisfaction and enjoyment.
 - (iv) *Availability of data method:* The data under consideration must meet certain standards of accuracy, objectivity and verifiability.
 - (v) *Special equipment and working conditions:* The major purpose of equipment is to define the process of observation to provide control of conditions and accuracy for permanence of recording.

- (vi) *Sponsorship and administrative co-operation*: It is a common practice for the thesis to be sponsored by a faculty adviser in whose area of specialization the problem lies.
- (vii) *Costs and returns*: The candidates must consider carefully their own financial resources in the light of such facilities and assistance as can be provided by the institution.
- (viii) *Time factor*: As a general rule, the minimum duration of graduate work for the master's degree is 1 year and for the doctor's degree is 3 years.

Historical, experimental case and longitudinal genetic studies frequently require more time than several types of normative survey work.

Kerlinger has identified three criteria of good problem statements.

- A problem should be concerned with relation between two or more variables.
- It should be stated 'clearly and unambiguously in question form'.
- It should be amenable to empirical testing.

Meeting these criteria in their problem statement will result, on the research part, in a clear and concise idea of what they want to do; this sets the stage for further planning.

Defining a Problem

Defining a problem means to pinpoint the problem or to reach the core of the problem, i.e., threadbare analysis.

- (i) *Need for defining a problem*: The definition of a problem serves the following purposes:
 - (a) It sets the direction of the study.
 - (b) It reveals the methodology or procedure of the study.
 - (c) It helps the researcher to control subjectivity or biases of the researcher.
 - (d) It suggests and specifies the variables to be taken up into the investigation through a problem involving many variables.
 - (e) It makes the research work practicable.
- (ii) *Precautions to be taken in identifying the problem*: The following precautions should be taken into consideration for identifying a problem:
 - (a) The words used for defining a problem should have a single meaning.
 - (b) The statement of the problem must be brief but comprehensive.
 - (c) The assumptions are to be recognized for the study.
 - (d) The problem should have practical importance in the field of education.
 - (e) The definition or the statement of the problem should have certain rationale.
- (iii) *Steps in defining a problem*: The following steps should be considered in defining a problem:
 - (a) Developing a conceptual framework of the problem, so that it can be stated in a verbal form.
 - (b) Delimiting the elements of the problem.
 - (c) Classifying the elements in the homogeneous group.
 - (d) Locating the key points in the conceptual framework.
 - (e) Evaluating the theoretical security of the problem.
 - (f) Formulating the final form of the statement of a conceptual framework of the problem in a verbal form.
 - (g) Deciding the practical difficulty in conducting the study.

1. *Analysis of the problem into its elements:* The major problem is divided into subordinate questions or problems. The definition of the problem is really the planning of the investigation with an indication of the data and techniques need to answer. The questions raised. The schematic analysis of a problem has been shown in Figure 2.1.
2. *Orientation and related literature:* Avoidance of unnecessary duplication in the selection of the problems suggests library procedures that should provide the setting for the investigation under consideration and an overview of the related studies. Detailed information consider the use of the appropriate library guides and illustrative review of some reports of research to devote a section or chapter of earlier investigations in the same field. The workers themselves are obligated to make critical examination of such related studies. Literature may provide hypotheses, suggestive methods of research and comparative data useful in the interpretation of results.

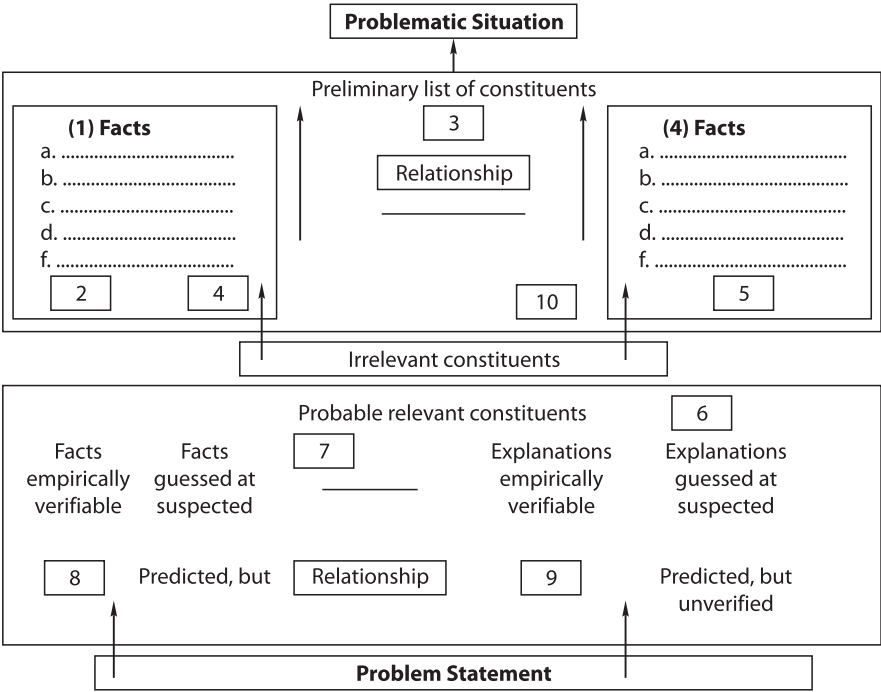


Figure 2.1 Schematic analysis of a research problem

Sources of Data and Methods

For an adequate definition of the problem, sources of data and methods for securing evidences must be carefully selected and clearly outlined in the introductory section of the report. Therefore, as a matter of intellectual honesty and for accuracy of interpretation and reporting, any limitation in the source procedure must be pointed out candidly but not apologetically.

- (i) *Terminology:* Technical terms and words or phrases with special meaning should be defined adequately.

- (ii) *Initial assumptions*: Research like geometry begins with certain basic assumptions or postulates. Assumptions underlie each step of research. They should be stated not only in the definition of the problem and procedure, but also with the conclusions of which they are an integral part.
- (iii) *Ways to define the problem*: The following are the various ways of defining a problem:
- Analyse the major problems or problems in terms of subordinate problems
 - Statement that delimits the scope of the study
 - Orientation of the problem in a unique direction
 - A historical account, remote or recent
 - A survey of previous study or related studies
 - An analysis of previous studies or related subjects
 - Preliminary survey or pilot work
 - Description of the general nature of the problem
 - Type
 - Source
 - Procedure
 - Statement of limitations of the techniques employed
 - Recognition of assumptions and implications
 - Importance or significance of the study of education
 - Definition of terms used

Evaluation of the Problem

When considering a problem, which researchers may undertake for investigation, they are required to ask themselves a series of questions about it. These questions are helpful in the evaluation of the problem on the basis of personal suitability of the researcher and that on social value of the problem. All these questions must be answered affirmatively before the study is undertaken.

■ *Is the problem researchable?*

There are certain problems that may not be effectively solved through the process of research. The question such as, 'Is it good to provide sex education in the secondary schools?' is a value question and can be answered only on the basis of value judgement. The educationists, parents, students and teachers may provide answers to such type of questions, but in practice questions involving philosophical issues are hardly answered by scientific investigation. Science cannot provide answer to philosophical and ethical questions. A reasonable problem is always concerned with the relationship existing between two or more variables that can be defined and measured.

From the foregoing discussion it may not be assumed that research cannot be used in developing solutions to philosophical and ethical issues. The point that is being emphasized here is that the problem must be stated in workable research questions that can be answered empirically. For instance, the above question might be restated as, 'What is the effect of sex education in the secondary schools on the attitudes of adolescent girls towards premarital indulgence in sex?' The researcher can design a study to obtain information on this type of question that can be used in developing a solution to the ethical question, 'Is it good to provide sex education in the secondary schools?'

■ *Is the problem new?*

There is no purpose in studying a problem that had already been adequately investigated by other researchers. By ignorance, some researchers undertake a study which is neither new nor original. They, therefore, needlessly spend time on a problem already investigated by some other researcher.

To avoid such duplication, it is essential to examine very carefully the record of previous studies completed in one's field. The researchers should not select a problem until they are convinced that it is really a new problem and has not been investigated so far. However, this does not mean that a problem, which has been investigated in the past, is no longer worthy of study. The researchers may repeat a study when they want to verify its conclusions or to extend the validity of its findings in a situation entirely different from the previous one.

■ *Is the problem significant?*

The question of the significance of the problem usually relates to what researchers hope to accomplish in a particular study. What are their purposes in undertaking to solve the particular problem they have chosen? What new knowledge do they hope to add to the sum total of what is known? And what value is this new knowledge likely to have? All these questions are directed towards the researchers. Unless these questions are answered clearly by them, the problem should not be selected for research.

The researcher should understand that the study is likely to fill the gaps in the existing knowledge, to help resolve some of the inconsistencies in previous research or to help in the reinterpretation of the known facts. The findings should become a basis for theory, generalizations or principles and should lead to new problems for further research. However, if the findings lack apparent implications, then they must, at least, have some practical application.

■ *Is the problem feasible for the particular researcher?*

A problem may be a good one from the viewpoint of the three criteria mentioned earlier, yet it may not be feasible in view of some of the following personal aspects of a researcher:

- (i) *Research competencies*: The problem should be in an area in which the researchers are qualified and competent. They must be familiar with the existing theories, concepts and laws in order to identify a worthwhile problem. They must also possess the necessary skills and competencies that may be needed to develop, administer and interpret the necessary data-gathering tools. Furthermore, they need to consider whether they have the necessary knowledge of research design and statistical procedure that may be required to carry out the research through its completion.
- (ii) *Interest and enthusiasm*: The problem should be one in which the researchers are genuinely interested and about which they are truly enthusiastic. It should be meaningful and arouse real curiosity of the researcher. The investigation of a problem in which the researcher has little or no interest can prove to be the most tiresome kind of distasteful task.
- (iii) *Financial considerations*: The problem should be one which is financially feasible. The researchers should ascertain whether they have the necessary financial resources to carry out the investigation of the selected problem. They must have an estimate of the expenditure involved in data-gathering equipment, printing, test materials, travel and clerical assistance. If the research project is an expensive one, the researchers may determine the possibility of getting financial assistance from the state and private agencies and central organizations like the University Grants Commission, the National Council of Educational Research and Training and the Indian Council of Social Sciences Research.
- (iv) *Time requirements*: The problem should be one that can be studied and completed in the allotted time. The researcher should select a problem that can be investigated with little expenditure of time or energy. It is worthwhile to plan for the time that will be needed for the development and administration of tools, processing and analysis of data and writing of the research report. If the problem is comprehensive, it is essential to explore the possibilities of seeking cooperation from others and taking it up as a team project.

- (v) *Administrative considerations*: In addition to personal, financial and time requirements, the researcher should consider the kinds of data, equipment, specialized personnel and administrative facilities that are needed to complete the study successfully. The researchers must ascertain whether the pertinent data are available and accessible to them. They must also check whether the authorities permit them to contact the students, administer the necessary tools or conduct necessary experiments, interview the teachers, or have access to important records and documents.

Hildreth Hoke Me Ashan has proposed an objective guideline for judging the merits of a problem. The following questions may be raised for this purpose.

- (i) Is the problem really important?
- (ii) Is the problem interesting to others?
- (iii) Is the chosen problem a real problem?
- (iv) Does the problem display originality and creativeness?
- (v) Am I really concerned with finding the solution?
- (vi) Am I able to state four hypotheses from the problem in a testable form?
- (vii) Will I learn something new from this problem?
- (viii) Do I understand the relationship of this specific problem to the broader problem area?
- (ix) Will I be able to select a sample from which I can generalize to some population? Are the sample subjects approachable?
- (x) Will some other intelligent person be able to replicate the study?
- (xi) Will my proposed data-gathering instruments actually give the information which I want?
- (xii) Is the study, including the application of its result, practical?

The number of affirmative answers should be required for a suitable problem.

Evaluate Yourself

- (i) What criteria are adopted for selection of a problem?
- (ii) What techniques are used for evaluation of a problem?

▲ Areas of Educational Research

Selection of topics for research and their significance: If educational research is to point at the lines that future developments in education should take, the selection of topic and subjects for research has a significant role to play. Sporadic studies aimed no higher than at merely satisfying the requirements of a university degree can hardly be expected to contribute to the educational needs of the country. A knowledge of what has gone before and an understanding of the educational needs of this and the next generation of Indian children can very well synthesize the needs of a researcher to win a degree and the national cause of educational development.

Areas of research: The field of education is a very large one and may not be conveniently divided into several major and non-overlapping areas.

A recent large volume produced for the American Educational Research Association, N. L. Gage's *Handbook of Research on Teaching* covers a multitude of topics. Experts in all branches of education have contributed reviews of research in their respective fields and attached useful bibliographies to the articles.

▲ Priority Areas of Educational Research in India

The following are the priority areas of education research in India:

- *Research studies in the field of educational wastage*
 - Case studies of practices, which have been successful in reducing wastage arising from non-promotion and early school leaving.
 - Research to bring out the relative importance of various educational factors such as teacher-training, teachers' salaries, teacher–pupil ratios, school facilities and student welfare services in reducing wastage (this may be done along the lines of factors analysis).
 - An experimental study in practices designed to reduce dropouts).
- *Research area in educational finance*
 - Growth of public expenditure on education, region wise, state wise and at the central level
 - Budgetary allocations to educations at various levels
 - Resources for education from various channels like central government, fees and private organization
 - Utilization of non-monetary outputs
 - Costs of education—social, institutional and private
 - Working out educational cost indices
 - Relationship between investment in education and economic growth
 - Socio-economic background of the students of different categories in educational institutions
 - Utilization of educational infrastructure
 - Systems of assistance from the government
- *Research areas in educational management administration*
- *Role conflict in an educational institution*
- *An analysis of educational acts*
- *Critical factors influencing the globalization of education*
- *Development and try-out of leadership training programmes*
- *Institutional viability in terms of size and curriculum offering*
- *Evaluation of management practices adopted by different educational agencies and effective functioning and management of colleges*
- *Research areas in creativity*
 - Socio-psychological factors related to creativity among school children
 - Development of tools for measuring creativity
 - Teaching models for the development of creative thinking abilities
 - Curriculum innovations for the development of creative thinking abilities
 - Teacher behaviour especially relevant to the development of creative thinking abilities among pupils from communities and socio-economic strata
- *Research areas in organizational climate*
 - Development of a sophisticated battery of tests for the measurement of organizational climate
 - Examining the influence of organizational structure on school climate
 - Developing strategies and models for changing the organizational climate
 - Relationship between organizational climate and school output variables

- Percolation of school climate into the classroom
- Perceptual relationship among organizational demands, individual needs and personal satisfaction
- Relationships between personality characteristics of principals as well as teachers with organizational climate of schools

■ *Research areas in social-psychological factors in education*

- Self-perception, level of aspiration, needs, interests and values of students coming from disadvantaged homes and sections of the society
- Parents' perception of their children from disadvantaged homes and sections of the society
- Teacher's perception of their students coming from disadvantaged homes and sections of the society
- Socio-psychological factors related to underachievement and failure
- Socio-cultural milieu and deviant behaviour

■ *Research areas in examination and evaluation*

- What do the examinations measure?
- Action research on improving examinations marking system
- Research in comparing direct grading with the procedure of marking and then translating marks into grades
- Time spent by paper setters in preparing a question paper
- Time spent in examining answer scripts: reading and marking, checking and adding up marks, filling in tabulation sheets, other paper work
- Marking systems of different universities in the same subject
- Comparing objective and traditional examination predictors of future results
- Socio-economic status and examination results

■ *Research areas in exceptional children*

- Studies of physically challenged children
- Studies of mentally challenged children
- Studies of socially challenged children
- Studies of gifted children

■ *Research areas in non-formal education*

- Philosophy and goals of non-formal education
- Life style and life experiences of the clientele
- Integrating non-formal education with other formal systems of education
- Interdisciplinary collaboration in developing the emergent areas of non-formal education

■ *Research in basic education*

Shriman Narayan writes in *On Education*: 'There is scope for endless experiment in Basic education. I will not like any kind of rigidity imparting basic education. Even area, every village, will be different and basic education should be imparted according to the need, environment and other available opportunities in those areas. For instance, one village will be suitable for imparting education through spinning and weaving, another village through oil crushing. Some stereotyped training everywhere is no good.'

■ *Single-teacher schools and educational research*

J. P. Naik, in his book *Single-teacher School*, stresses the urgent need of research and experimentation in the problems involved in the working of single-teacher schools. He writes: 'Our educational research is definitely out of its cradle; but even today, it is so fully occupied with urban problems that it is not even possible to indicate when it will walk out to the villages and

stand face to face with the single-teacher school. Research and experimentation on the problem should be organized through universities, Education Department and suitable private agencies. This will generate a new life and create a new literature that will enable the single-teacher schools to come into their own, and thereby help to build up a new life in thousands of our small villages.’

■ *Research in rural institutes*

‘The purpose of research in rural institutes,’ according to a booklet *Rural Institutes in India*, ‘is not to take in hand a complex and fundamental sort of research, which can be suitably done by a highly qualified staff under most favourable conditions and with a highly expensive equipment and library, but is to strengthen the teaching programme and to enrich the student’s knowledge consistent with his mental development at the undergraduate level. The programme envisages a study of rural life in its various aspects. In rural institutes, survey, collection of data, its analysis and interpretation and finally compilation of a report. The idea is to develop in the students the faculty of study, thinking and expression.’

■ *Research in school planning*

Report on Planning Schools for India published in 1959 made the following observations regarding research: ‘In view of the non-existence of much objective data on the planning of schools, there is a great need for a nation-wide programme of research in school planning. It should however, be noted that no single agency by itself can solve the many problems that affect the health achievements of our children and the efficiency of our teachers. Many government services (education, public works, finance, planning, etc.) besides many non-government agencies, will have to give their assistance in this important matter. Moreover, until more research is done in this field a high percentage of money now spent for schools will be wasted because poorly planned and consequently inadequate facilities have a short useful life and as a result are very costly on a cost-per-pupil per year basis.’

■ *Major research needs in educational planning*

- *Teacher:* Ways of supplying needs by stepping up recruitment; improving conditions and rationalizing the work of teachers; possibilities of increasing the numbers of female staff; the role of the rural teachers in community development.
- *Requirements in skilled manpower:* Comparative analysis of methods for estimating requirements; evaluation of actual needs of middle-level technical staff in different sectors and of the educational qualifications necessary for these jobs; adaptation of vocational training system to the needs of developing countries; ways of influencing popular preferences regarding education so as to bring them in line with national development and avoid intellectual unemployment.
- *The planning process:* Effective results so far obtained through planning (comparative studies); possibilities of improving the planning process; organization and administration of planning; international aspects; external aid for educational planning; more efficient utilization of external aid due to the planning of education; adaptation of imported educational models to the needs of developing countries; role of expatriate experts; better use of fellowships for study and training abroad.

■ *Problems of priority for research in curriculum*

An International Advisory Committee on the school curriculum in its third session, held in Paris from 29 September to 11 October 1958, suggested that the subject of adaptation of curricula to the

age and growth levels of children had prior claims for research and recommended the following areas of such research:

- Research and experimentation of fitting the curriculum to individual differences among children of the same class of age and designed to suit the brighter as well as the handicapped and backward groups of pupils
- Studies in failure and retardation, their extent, causes and remedies
- Development of diagnostics techniques to discover gaps in the achievements of pupils at various levels and experimentation with remedial programmes to fill those gaps
- Studies in vocabulary selection involving the study of the vocabulary of children, of adults and of everyday current literature along with a study of the vocabulary difficulties, which children experience in their learning of language and literature and of such subjects as arithmetic, social studies and general science
- A conceptual analysis of subjects of the curriculum with a view to determine degrees of difficulty of the various concepts and to establish certain sequences in their teaching
- Studies on the optimum age for beginning the teaching of certain subjects, and possible additional studies to determine age grade, placing of topics in the curriculum as well as testing programmes of successive age groups to discover the average chronological age at which certain notions are acquired by children
- Studies of interests and activities of children to serve as a basis for the selection of curriculum materials and units
- Experiments with various methods of integrating school studies and methods of teaching particular subjects, especially where the methods of presenting a notion may affect its level of difficulty for a child
- The development of tests of intelligence; of aptitudes of personality and of educational achievement with a view to using them as instruments in the research recommended earlier
- Research in global methods of teaching, reading and their effect on all aspects of language skills, particularly spelling
- Research in the development of ideas of space and time in the age span 6–11 years, as these affect the teaching of geography and history

■ *Problems relating to training of teachers*

Studies in optimum utilization of fully trained professional manpower in education (teachers), experimental studies in the use of auxiliaries, lay readers and team teaching for minimizing teacher costs and maximizing educational output.

Evaluative studies of correspondence, part-time and in-service teacher education programmes based on assessments of costs and effectiveness of different measures.

Activities

- (i) Study any Ph.D. thesis/M.Ed. dissertation or some research journals and list out any two educational research problems you have come across.
- (ii) Examine the existing teacher education programme and identify any two research problems related to it.

▲ Major Areas in Educational Research

At the outset it will be useful to present to the research scholar a few areas of educational research. On the basis of one's interest, expertise and inclination, one has to choose the appropriate area.

- Teacher education
- Pre-primary (early childhood) education
- Universalization of education
- Secondary education
- Higher education
- Vocational education
- Special education
- Adult education
- Open and distance education
- Non-formal education
- Education of deprived section of society (e.g., SC/ST/minorities)
- Education of girls
- Educational technology
- Educational and vocational guidance
- Educational management, planning and finance
- Economics of education
- Curriculum development
- Evaluation
- Textbooks and learning material
- Life in classrooms (e.g., classroom interaction, classroom climate, sociometric studies)
- Environmental education
- Population education
- Comparative education
- Physical and health education
- Science education
- Mathematics education
- Language teaching
- Social science education
- Value education
- Art education and aesthetics
- Teaching methods, strategies and models of teaching
- Historical studies in education
- Philosophical studies related to education
- Sociological studies in education
- Creativity and education
- Innovations in education
- Correlates of achievement
- Psychological studies in education

Thrust Areas in Educational Research

For the benefit of research scholars, a few thrust areas have been picked up and some concrete themes suggested.

■ *Teacher education, training and extension*

- Duration of teacher education courses
- Curriculum components of teacher training courses
- Strengthening of teaching practice/student teaching
- Efficacy of teacher training in classroom situation
- Development of instructional material for training courses
- Mutli-grade teaching methodologies
- Admission criteria for different teacher education courses
- Teacher's ability (/ies) to handle children with different disabilities
- On-the-job support required by teacher educators and teachers
- Needs of teachers in dealing with special groups of learners
- Gender-sensitive teacher training
- Training modules
- Organization of teacher education institutions, i.e., IASE, CTE, DIET, SIERT, STC, SIE, SCERT, NCERT, NCTE
- Revitalizing teacher education in the light of changing scenario at national and global levels
- In-service education of teacher educators and teachers
- Organizing education extension services for teacher education institutions and schools
- Comparative teacher education (both at the intra- and inter-institutional levels)
- Evaluating teacher performance
- Teacher competence and accountability
- Teacher education in the light of NPE
- Manpower planning and unit cost study in teacher education

■ *Curriculum*

- Curriculum policy
- Translation of curriculum into specific learning tasks
- Analysis of curriculum in the light of NPE and national goals
- Interaction between learner and curriculum
- Curriculum in action/transaction
- Curriculum change
- Curriculum transaction in varying social contexts
- Analysis and evaluation of curriculum material (i.e., textbooks) with reference to learning load
- Activity-based/child-centred curriculum
- Evaluation of instructional material
- Methodology of evaluation
- Different methods and approaches of teaching (including models of teaching)

■ *Innovations and experiments*

- Innovations and change in education
- Futurology
- Environmental education

- Population education
- Vocationalization of education at school level/school–industry linkage and related problems
- Global and international education
- Open education and distance learning
- Alternative systems of education
- *Educational technology*
 - Educational technology and the instructional process
 - Systems approach in education
 - Developing instructional material for teaching and training
 - Teacher behaviour and educational technology
 - Computer and/in education
 - Multimedia learning and training packages
 - Mass media for education
 - Simulation and games in teaching and training
 - Computer-assisted instruction (CAI)
- *Planning and management*
 - Constitutional provisions
 - Federal and state-level framework and the impact on educational administration, planning and finance
 - Policy, pronouncements, planning for all children specifically girls, SC/ST children
 - Decision-making in educational institutions
 - Communication
 - Manpower planning in education and in teacher education
 - Organizational behaviour in educational institutions
 - Leadership behaviour
 - Organizational climate
 - Unit-cost studies and financing of education
 - Institutional planning and micro-planning
 - Organization of institutions of higher education, distance education and open education
 - Supervision
 - Comparative study of various educational systems
 - Training needs of educational managers, administrators and planners
 - NGOs and their role in educational management
- *Universalization of elementary education*
 - Critical appraisal of the programme of UEE
 - Dropout and retention
 - Use of mother tongue and local environment in primary schools
 - Rationale of Minimum Levels of Learning (MLL)
 - Interaction between learner and curriculum in primary classes
 - Development of new strategies of UEE
 - Role of voluntary agencies
 - Management of elementary education
 - Operation blackboard
 - Multi-grade teaching
 - Non-formal education

■ *Society and education*

- Demands for education among different socio-economic groups
- Learning styles of boys, girls and adults
- Gender-sensitive education
- Value education
- Educational needs of different regions
- Socialization and social change
- Vocationalization of education
- NPE '86 and education
- Education of special groups
- Educational status, needs and problems of different special groups such as SC/ST, girls, handicapped gifted/slow learners
- Education of special learners and implications for curriculum transaction and teacher training
- Training needs of teachers in dealing with special groups
- Development of instructional material for children with special needs

Suggestive List of Research Problems

In 1996–97, NCTE organized four national workshops in New Delhi, Mumbai, Hyderabad and Pune. In these workshops, some crucial research problems related to education were worked out. After going through the list of problems, these could be regrouped in the following broad areas.

Problems

The problem areas are categorized as follows:

■ *Teacher education*

- Comparative study of objectives, materials and techniques of various training agencies
- Developing training programmes for various levels of functionaries
- Developing multiplier (cascade) model of training programme for adult education functionaries
- An investigation into the problems faced by the trainers in organizing training programmes
- Developing strategies to be adopted for mobilization of resources for effective training of functionaries
- A study of organizational and management skills needed by teacher trainers for conducting training
- Developing training programmes to cater to the psychological, vocational and community needs of learners
- Survey of learners' needs in the context of volunteer/instructors training
- A follow-up study to evaluate the extent to which the trainees are able to translate into classroom practice the knowledge and skills acquired during training

■ *Teaching-learning process*

- A study of teaching-learning process in the training centre/school/college
- Analysis of the instructional process with special references to communication skills in the training programme
- Study of teaching styles of teachers trainers
- Study learning styles of students/trainers

- A critical analysis of the use of learning materials and aids used by teacher/trainer
- A study of identification of the teaching skills relevant to teacher training
- *Development of teaching competencies*
 - An in-depth study of the training competencies of teacher educators/adult education instructors
 - An experimental study of the use and suitability of technology for improvement of teaching competencies
 - A study of entry and exit behaviours of trainees
 - A study of teaching behaviours (interaction analysis of teachers/trainers)
 - Evolving a training package for the development of competencies in trainees
- *Adult education*
 - A survey of characteristics of adult education functionaries
 - A study of motivational phenomena in relation to people who opt for joining, continuing or dropping out of adult education
 - A study to differentiate characteristics of effective versus ineffective adult education functionaries
 - Evolving a training package for the development of competencies in adult education functionaries
- *Non-formal education*
 - Identifying parameters for assessing effectiveness of NFE facilitators' training programme
 - A study of the role of mass-media in teacher training programme for NFE
 - A study of the cultural context of NFE and its implications for education of NFE facilitators
 - Developing a training programme for NFE supervisors emphasizing their role as facilitators of creative teaching at NFE centres

In addition to the above problems, which emerged through the deliberations in the four national workshops organized by NCTE, a few more problems in the area of educational research are given in the following so as to enable a new research scholar to develop an insight into the nature of the problems.

▲ General Research Problems in Education

The following are the general research problems in education:

- Survey of:
 - working conditions of teachers and administrators
 - school finance
 - educational finance
 - existing school practices and ways of improving them
- Supervision of schools and how to make them more effective
- Administrative set-ups in different states
- Relationship between educational administration and general administration
- Human relationships and group dynamics between various levels of administrators and between administrators and the community
- Relation between school and community
- Problems of wastage and stagnation in schools
- Problems of attendance in schools
- Problems of compulsory attendance

- Administrative problems of basic education
- Study of educational legislation of the states and the Union Government
- The constitution, functions and working of the various examination boards in India
- Training of teachers, pre-service and in-service
- Problems of educational administration at various levels
- Problems of decentralization in education
- Recruitment and preparation of school administrators
- Student's welfare schemes
- Curriculum research
- Theoretical problems of educational research in terms of social and political philosophies

List of Research Problems

- Study of the organizational climate of the government and primary schools
- Job satisfaction of primary school teachers, their relationship with personal, professional and organizational characteristics
- Critical inquiry into in-service educational programmes conducted by DIETs
- Self-concept of teachers and their emotional adjustment
- Training of primary school teachers in the context of education for all
- A study of the relationship between certain psycho-sociological factors and achievement of student teachers in teacher training institutions
- A study of the attitude of teachers towards environmental/population education
- A study of role conflicts of teachers
- Secondary teacher education programme—a status survey
- Relationship among teaching style, learning gains and teaching effectiveness
- A comparative study of the different feedback methods for changing teacher behaviour
- Effectiveness of inquiry training and advance and organizer models for teaching social studies
- A critical study of the Gandhian philosophy of education
- Humanism in the educational philosophy of Sri Aurobindo
- Educational thoughts in Srimad Bhagwat Geeta
- Ethics of trade unionism in education
- Professional ethics of teachers
- Comparative study of the aims of education and curriculum in democracy
- Post-Independence development of education and its impact on the social life of villagers
- Study of the growth and development of high education during the British period in India
- History and survey of education in a district
- A survey of the development of school education in the state of Rajasthan
- Cost and benefits of teachers' education
- Unit cost and efficiency of certain colleges of education
- A study of parent investment on primary education in some selected schools
- The place of the distance education in Indian economy
- A study of the characteristics of innovative educational administration
- A study of the administrative behaviour of secondary school principals
- Organization, functions and problems of an open university; a case study
- Inspection and supervision of primary schools

- Psycho-social factors of wastage and stagnation among tribal students
- Case studies of innovative institutions
- Study of the leadership behaviour of DIET principals
- Study of the managerial styles and achievement motivation of headmasters
- Case studies of single-teacher primary schools
- Academic leadership and student unrest
- A study of intelligence, self-concept and level of aspiration of adolescents
- Study of the effect of home and school environment on the creativity of children
- Educational/vocational aspiration of students
- Correlational study of personality patterns, occupational choices and subject preferences of tribal learners
- Evaluative study of students' personal services in public schools
- Educational problems of girl child
- A study of the mental health and adjustment problems of school-going girls
- A study of the role commitments and conflicts of women teachers
- A study of occupational choices of adolescent girls and factors influencing them
- A study of the adjustment problems of scheduled tribe students in schools
- A socio-psychological study of adjustment of SC and ST students
- A study of cognitive process and motivational patterns of deprived students
- Scheduled tribe students—their values, problems and level of frustration
- Cognitive style and cognitive ability of tribal and non-tribal children
- A study of the achievement motivation of tribal students
- A study of concept learning in the disadvantaged school children
- Cognitive processes and personality characteristics of primary school children
- A study of the curriculum for primary schools of Lok Jumbish project
- A study of the learning disabilities of primary school children
- A study of barriers in the primary education of girls
- A study of the impact of midday meals programme on enrolment and retention in primary schools
- A study of dropouts and failures in primary classes
- A case study of model primary school
- A study of grade basic vocabulary of standards I–IV
- An investigation into the effect of the reading improvement programme in Hindi
- A study of the moral education of primary school children
- A study of the acquisition of concepts in mathematics of pupils at primary school level and its relation to some personal and environmental variables
- A study of the effectiveness of educational television on the educational development of primary school children
- A study of the nature and incidence of reading disability among school children

Evaluate Yourself

- (i) What are some of the more effective ways to find a suitable research problem?
- (ii) Enlist the criteria of good research problem.
- (iii) How can a research problem be carefully defined and delimited?

Summary

- Identification of research problem is a complex task for the beginners. In this chapter, various sources are discussed so as to help one develop problem sensitivity in different areas of education.
- A comprehensive area-wise list of different research problems has also been included to give an idea about various problems related to the educational process. The next step would be the formulation of the research problem.
- The choice of a suitable problem is one of the most difficult tasks faced by the beginning researcher. Students tend to define problems that are too broad in scope or that deal with too fragmentary aspects of the problem.
- Problems are found in the teacher's daily classroom, school and community experiences. Technological and social changes call for research evidence to chart new courses in educational practice.
- A good research problem has the qualities of significance, originality and feasibility.
- The researcher should evaluate a proposed problem in the light of the project, the limitation of time and the possible difficulties and social hazards involved.

Key Words

- *Research Problem*: It is systematic problem-solving activity and governed by reflective thinking.
- *Sources of Problems*: Personal experiences of the investigator, study of available literature research abstracts, journals, handbooks of research abstracts, new innovations, etc. of Sources of Problems.
- *Defining a Problem*: To pinpoint the problem or to reach the core of the problem.
- *Research Competencies*: The problem should be in an area in which the researchers are qualified and competent.

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Preparing a Research Proposal

3

Research begins with certain basic assumptions or postulates. Assumptions underline each step of research. After selecting a problem, it should be stated carefully to the researchers to delimit their task and to isolate a specific problem before they can proceed with an active planning of the study. This type of decision is cultivated in the problem statement. It is essential for the researchers before they proceed with their study that they convert their tentative topic into a precise researchable problem. A research proposal or research synopsis is an outline of proposed work required by many universities, which serves as a useful basis for the evaluation of a project as well as a guideline for the researchers.

The research proposal or synopsis contains a clear and concise statement of the problem, the hypothesis involved, recognition of the significance of the problem, definitions of the important terms, assumptions and limitation, a resume of related literature, an analysis of proposed research procedures and a time schedule. The preparation of a research proposal or synopsis is an important step in the research process. A worthwhile research work is likely to result only from a well-prepared and well-designed proposal or research synopsis.

▲ Formulation of a Research Problem

After identification of the research problem it should be tested by empirical methods, that is, through the collection of data. There are three specific things to be discussed: characteristics of a good research, format of a research proposal and some illustrations, which are presented in the following.

Characteristics of a Good Research Problem

After going through the related literature, the research scholars come across a number of problems of their interest, and finally they have to select one out of them. While selecting the final research problem, certain considerations are to be borne in mind, which are given under.

Precision

Initially, broad areas such as learning, creative children, reinforcement and backwardness might occur in the mind of a researcher. These are very broad areas out of which a large number of specific problems can be formulated. The problem should be pinpointed, specific and precise. It should specify what limited variables are going to be studied and what would be the focus of the problem.

Focused Scope

It is not desirable to aspire to investigate too many things in a single research study. A neat and clean study limits itself to a small number of variables and attempts to make an in-depth study of the relationship

between such variables. Thus, it is necessary for a research worker to delimit the scope of the study. It may be in terms of the geographical region, age or sex depending upon the priorities determined while listing the objectives of the study.

Critical Thrust Areas

A research study becomes more worthwhile if it touches certain vital thrust areas or throws light on some important national problems. Hence, while selecting a problem this consideration should occupy an important place in the mind of a research worker. For example, researches relating to girlchild enrolment, achievement and retention; and management of elementary education under the Panchayati Raj system: issues, problems and success criteria.

Access of Data

A problem may be very interesting. However it can only be completed if the researchers have access to the relevant data needed for the research. Often, after selecting a problem, they find it very difficult to obtain the necessary and valid data. Hence, this factor should be carefully examined before finalizing the research problem.

Utilizing Expertise of the Research Scholar

A problem may be very interesting, but the researchers have to examine whether they have the necessary expertise to deal with it. If a research problem involves a detailed psychoanalytical study, then it is essential that the research workers must have a thorough grounding in the theory and practice of psychoanalysis, otherwise select some other problem for which they have the necessary background.

Completion Within Reasonable Time Limits

A research study is worthwhile only if made available within reasonable time limits. If it takes too long to complete a research project, the findings of the study may become obsolete due to changes in the circumstances.

No Duplication

There are instances where after completing some researches and publishing the findings, it is found that a similar study had already been completed years back, somewhere else. This leads to frustration and also wastage of time and energy of the research worker. Hence, while formulating a problem, extreme care must be taken to ensure that the research has not been undertaken earlier in the same form. Duplication would be permissible only if the research worker is taking some unexplored dimensions of a problem, which have not been already investigated.

Not Exploring the Obvious

There are certain conclusions which are well established, and there is hardly any need for undertaking research to establish such conclusions. A research study in such areas is a futile exercise; for example, studying the relationship between positive reinforcement and academic achievement.

Not Creating a Sensation

Some people have the tendency to take up a research study for creating sensation in the society. For example, one must have come across reports by some scholars that Shakespeare did not exist. Such research might create a sensation, but does not help in taking the discipline ahead.

Not Against Ethical Norms

Research that harms the existing ethical norms of the society should be avoided as far as possible. An attempt to justify prostitution or the dowry system, on the basis of research, would not be desirable from the point of strengthening the social fabric.

Activities

- (i) Formulate a precise research problem in each of the following broad areas:
 - Falling academic standards
 - Poor enrolment at the primary stage
 - Medium of instruction
 - Teacher effectiveness
- (ii) The following are some research questions that have been listed to formulate a research problem covering these questions:
 - What is the level of achievement motivation of the primary school teachers?
 - Is there any relationship between the achievement motivational level of teachers and their students?
 - Are there any differences between the achievement motivational levels of boys and girls?

Format of the Research Proposal

After selecting and formulating the research problem, the research worker prepares a research proposal for submission to some university for fulfilment (or partial fulfilment) of a degree or to some agency for getting financial assistance. A research project may be undertaken individually or on an institutional basis. Hence, two formats of preparing proposals are given here:

- (i) Individual research proposal
- (ii) Institutional project formulation

A detailed research proposal develops a good insight in the research worker with regard to the objectives of the research, methodological issues, and the procedure of data collection and analysis. Hence, it is always desirable to invest substantial time for drawing up a good research proposal.

It would be worthwhile to mention here that the research proposal serves as a guideline for the research worker, but it should not be treated as a rigid frame. There should always be flexibility according to the situation arising during the course of research.

Individual Research Proposal

A tentative format is being suggested for preparing an individual research proposal as outlined briefly in Figure 3.1. The headings given here are only suggestive, some changes in the nomenclature of these headings cannot be ruled out. Its main purpose is to include all the significant aspects of the research study in the proposal.

- (i) *Problem/title of the research*: Under this section, the investigator should state the problem/title of the research study in very precise terms. As far as possible, the title should be short and pin-pointed to give the reader an idea about the nature of work being done in the proposed research.
- (ii) *Introduction (context and justification)*: The research worker should devote a paragraph or two for introducing the problem to the reader, spelling out how the problem emerged, its social and

educational context, its importance to education in particular and society in general, and other justifications for taking up the study.

- (iii) *Brief review of related literature:* It is always desirable for research workers to devote some time in reviewing the related literature to know the studies already conducted in the field and to ensure that what they are going to do is not just a repetition of the previous work. Under this section, the research worker should report some significant and landmark studies in the area of the research in hand. As far as possible, the latest studies should be mentioned giving evidence that the research worker is well versed with the latest position of research in the area of work.

While reporting a research study, the researcher should be brief and at the same time should ensure that the reporting of a study should include the objectives of the study, the sample of the study, the main methodology used and the main findings. Sometimes, if a novel technique or tool of data collection or analysis is used in the study, it should also be reported.

- (iv) *Objectives:* Under this section, the research scholars should list out in specific terms what they are going to achieve through research. These are to be stated in the form of objectives of the study. The objectives should be tangible to ensure that they can be achieved through the research study. Care should be taken to include only specific objectives in the study and exclude others which are not feasible during the study. The list of objectives should not be too lengthy and ambiguous. It should be worked out keeping all the constraints in mind, like limitation of time and resources.
- (v) *Hypotheses/research questions:* In the experimental and action research studies, the researchers start their research with the formulation of some hypotheses. These suggest either the tentative solution to the problem or the likely relationship between the dependent and the independent variables. The hypotheses are tested through the research and are either accepted or rejected depending upon the evidence emerging in the study.

In some non-experimental research also, it is possible to formulate hypotheses and test them but, at times, some research workers prefer to raise certain research questions and try to answer them on the basis of the evidence collected through the research. Therefore, under this section, one may list either the hypotheses to be tested or research questions to be answered.

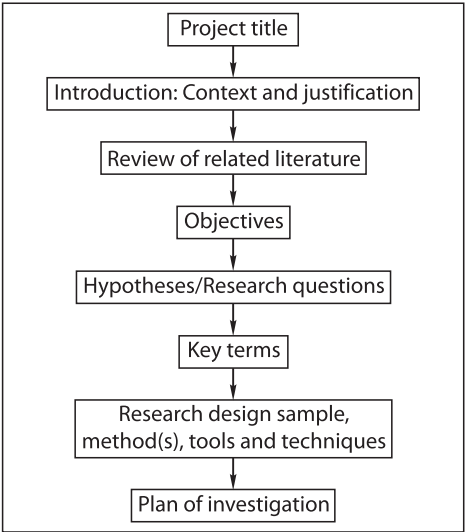


Figure 3.1 Individual research project proposal

- (vi) *Key terms:* Every research study involves certain key/technical terms, which have some special connotation in the context of study. Hence, it is always desirable to clarify such key terms at the beginning of the study. A study based on Shikshakarmi Yojna or Lok Jumbish should necessarily clarify these terms. A study on vocationalization should clarify the term 'vocationalization'. Similarly, a study on organizational climate, organizational behaviour or cognitive style should clarify these terms. The crucial and significant terms that are most frequently used in the study should not only be defined, but also be clarified in the context of study.
- (vii) *The sample:* Under the sample, the researcher should describe the sample on which the findings will be based. The sample should include the unit of sample, the size and its structure. The procedure of selection of sample should also be spelt out in detail. The unit of sample may be a student, a school, a teacher, a village, a parents or a textbook. In one study, research workers may take more than one type of unit as the basis of study. The various units of sample, which have been included in the study, should be clearly stated.

Under the size of the sample, a research worker mentions the number of each type of units being included in the study, for example, 20 schools, 100 teachers, 500 students. The size should be adequate enough to draw valid conclusions for the whole population under study. While describing the structure of the sample, it should be clarified from which area these units will be drawn. One may mention 10 students, 3 teachers and 1 headmaster from each of the 10 schools under study or 50 male students, 50 female students and 10 students from each of the five boys' schools and five girls' schools. While describing the work, the scholar should clarify the method adopted for selecting the sample. It may be random sampling, stratified random sampling or purposive sampling. If random selection has not been made, justification for adopting the alternative procedure should be given.

Explanatory Note on Sampling Procedure

Random sampling

In this method of selection, the chances of every unit of the population being selected in the sample have equal probability. There are mainly three ways of selecting a random sample.

- The units of the population are allotted several numbers and a required number of units are picked up using a table of random numbers.
- Units of the population are allotted serial numbers. These serial numbers are written on separate chits, these chits are folded and put in a bowl and from the bowl the desired number of chits are picked up and the serial numbers written on the chits denote the units to be included in the sample.
- After allotting serial numbers to all the units of population, every n th item is picked up and included in the sample, for example, every fifth house in a street of every tenth roll number appearing in the BA final examination.

Stratified random sampling

When the population is heterogeneous or is divided into various strata, it is desirable to randomly select a certain number of units from each strata for inclusion in the sample.

Purposive sampling

In some research studies, it becomes essential to select only those units of the population for the sample, which would be most suited for achieving the purpose of the study. For example, if we want to undertake a study of an educational institution, it would be desirable to include those teachers/workers in the sample, who have a long and close association with working of the institution rather than selecting some teachers/workers randomly.

- (viii) *Method, tools and techniques*: Under this section, the method employed for the research should be explained. Occasionally, a research study may employ more than one method. In that case, all such methods should be mentioned. It is not sufficient to give theory behind the method, but it is more important to explain how this method will be used in a particular study. The investigator should also describe the main tools and techniques, which may be employed for data collection. The tools may be described in two categories: (a) standardized tools and (b) tools developed by the investigator. In case of standardized tools, information about their validity and reliability should be furnished. In case of the tools developed by the investigator, the procedure to be followed for the development of tools should be described in brief.
- (ix) *Data analysis*: A paragraph indicating the procedure to be followed for analysing the data should be indicated. If any statistical technique is to be used, it should be referred. It is not sufficient to mention only the name of statistical technique, but it must be clarified for what purpose a particular technique will be used. A technique will be justified only in terms of objectives of the study.
- (x) *Plan of investigation*: Under this section, the investigator describes the plan step by step for carrying out the investigation.

Institutional Project Formulation

The institution can also take up some research projects. But before launching the project, an exercise on project formulation has to be undertaken. It serves a twofold purpose. It will help the project team to gain an understanding of the whole project and the proposal can be sent to some agency for seeking financial assistance. Different agencies have prescribed different formats for submission of project proposals. Here an attempt has been made to suggest a format for preparing project proposals, which includes the main aspects of a project. This is given in the form of a flowchart in Figure 3.2.

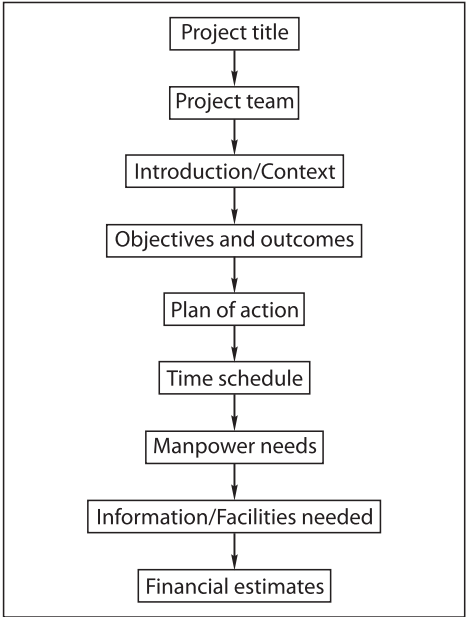


Figure 3.2 Institutional research project proposals

In this format, most of the terms used have already been explained while describing the format for an individual research proposal. The new terms used in the institutional formats are, however, explained in the following:

- (i) *Project team*: It should include one principal investigator and one or two associate investigators. A brief note about the research background of the team members would be helpful to the authorities in sanctioning financial support.
- (ii) *Project outcomes*: Under this section, the research worker should spell out the broad generalized achievement anticipated as a result of the completion of a project. For example, the outcomes of the project need identification of teacher education institutions in various areas such as (a) academic, (b) infrastructural and (c) manpower. Care should be taken to relate the anticipated outcomes with the objectives of the study.
- (iii) *Financial implications*: Under this section, a cost estimate has to be worked out based on the following:
 - Remuneration to project team
 - Contingency expenditure, which includes books, journals, reference material, tools, stationery, printing, photocopies and report writing
 - Travel expenses

It will be better if expenditure on various items of contingency is worked out separately. Generally, the funding agencies do not provide financial support for purchase of new equipment.

Activities

Prepare one institutional research project on any of the following research areas:

- Training needs of teacher educators
- Intervention efforts to check dropouts
- Educational disparities

Illustrative Research Proposals

A few sample proposals are given here.

Individual Research Proposal–1

- (i) *Title*: Preparation and efficacy of tutorial courseware in physics.
- (ii) *Background/introduction*: With the development of educational technology and computer science, it is being increasingly realized that many of the problems relating to instruction can be taken care of by using computers in schools. Keeping in view the importance of computer-assisted instruction (CAI) and dearth of suitable courseware available for the school-level target groups, the researcher decided to develop a courseware, which can utilize the capabilities of a computer. CAI modes like drill and practice, tutorial, games, simulation and specifically the tutorial mode can be most suitable for giving new content and effective interaction. Hence, the present research is planned.
- (iii) *Objectives of the study*: The following are the major objectives:
 - To prepare/develop a courseware in physics on formation of images through lens
 - To find out the differences, i.e., gain in achievement between the pre-test and post-test scores

- To find out relationship between the variables; gain in achievement, intelligence and time taken for working on courseware
 - To compare the gain in achievement of boys and girls
 - To judge the suitability and efficacy of prepared courseware
 - To bring out educational implications of the study
- (iv) *Hypotheses*: The main hypotheses are as follows:
- There is no significant difference between means of pre-test and post-test scores.
 - There is no significant relationship between IQ and gain.
 - There is no significant relationship between time taken and gain.
 - There is no significant relationship between time taken and IQ.
 - Boys and girls do not differ significantly in gain.
- (v) *Methodology*: Quasi-experimental method with a single group will be employed. Pre-test, post-test design (T1-X-T2) also known as pre-post experimental design will be used. The following tools will be employed:
- Dr Jalota's group general mental ability test to find out IQ of the subjects of study
 - Two parallel pre-tests and post-tests based on the same blueprint will be developed by the investigator to find out achievement of the subjects in the selected topic of physics
 - Self-made observation schedule for recording learner's interaction with the courseware
 - Two self-made questionnaires, one for the learners and another for the experts to judge the suitability of courseware
 - Self-made courseware for experimentation
- The following techniques will be used.
- Observation techniques
 - Statistical techniques (t-test, Spearman's rank difference correlation and Mann Whitney U-test)
- (vi) *Sample*: A sample will be drawn by employing non-probability random sampling based on the judgement of the researcher. A total of 30 students studying in classes IX and X will be selected, which will have an equal number of boys and girls. 10 teacher educators having science background will be requested to validate the content and its presentation in the courseware.
- (vii) *Steps*: The following are the major steps:
- Study of related literature
 - Preparation of pre-test and post-test
 - Administration of pre-test
 - Treatment with courseware and observation
 - Administration of post-test
 - Administration of test of IQ and collection of other data
 - Analysis of data and interpretation
 - Reporting

Individual Research Proposal-2

- (i) *Title*: Diagnosis of the difficulties in biology practical at secondary level.
- (ii) *Background introduction*: We live in an age of science. It is essential that today's students, who will occupy different positions in the future, should have a sound background of a modern and forward-looking programme in science. As scientists, biology students must be accurate and uptodate in both the biology content and the comprehension of science and scientific methods.

Understanding the nature of biology and its processing is important, particularly because the biological sciences provide new and important insights into the nature of environment of the Earth. Does it then not become the duty of biology teachers to see that the young members of the society under their guidance learn the discipline to the best of their capacity? An important step in this regard would be to diagnose the difficulties and to find out what are the causes responsible for the difficulties, especially in relation to the practical work related to the subject. The falling standards of achievement in biology practicals at the secondary stage call for such a diagnosis. The review of research literature also reveals that although diagnostic and remedial work has been done in the areas of mathematics and languages, yet hardly any work has been done in the area of practical work related to teaching of biology. It is with this background that the researcher thought it worthwhile to make a diagnostic study of difficulties in biology practicals at a secondary level.

(iii) *Objectives of the study:* The following are the main objectives of the study:

- To diagnose the difficulties of students in biology practicals on the basis of the following:
 - Administering a self-made diagnostic test
 - Observation of actual dissection with the help of skill scorecard
- To analyse the practical work of the biology student for the purpose of diagnosis of difficulties
- To prepare a diagnostic test to assess the theoretical knowledge needed for dissection
- To prepare a skill scorecard for observing the skills and steps involved in the dissection
- To suggest remedial measures in biology practicals

(iv) *Delimitations:* The study has some limitations as follows:

- It will be restricted to secondary schools in the state of Rajasthan.
- Only Class X science students will be included in the study.
- Only the portion on 'dissection of frog' of the biology practical will be dealt with.

(v) *Justification:* It is generally observed that negligence of students' difficulties in lower grades develops into a chronic weakness in the subject later on, which ultimately results in hatred towards that subject. The right kind of help given at the early stages can prevent weakness and failure in the later stages and thereby minimize the possibility of lagging behind. Thus, importance of diagnostic and remedial work becomes a crucial aspect of any educational programme.

(vi) *Sample:* The sample of the study would include 120 students of Class X selected from 12 secondary schools of the state of Rajasthan. Out of the 120 students, 60 will be boys and 60 girls. The schools would be selected from six educational zones of Rajasthan, two schools would be selected from each zone and students from each school would be selected in a random manner.

(vii) *Method:* Normative survey method will be followed for the present study.

Tools: No standardized tests will be used in the study. The following tools will be developed by the investigator:

- Diagnostic test
- Skill scorecard

Techniques: Observation techniques will be used to observe the actual frog dissection in the laboratory, and data will be recorded on the skill scorecard.

(viii) *Steps of investigation:* The following are the main steps of investigation:

- Review of related literature
- Construction of tools
- Data collection
- Analysis and interpretation

Individual Research Proposal–3

- (i) *Title:* Study of intelligence, adjustment and creativity of handicapped children.
- (ii) *Background introduction:* One of the most diverse groups of exceptional children is a group of physically-challenged children. Physical disability in children interferes with their ability to use their body. Some physical disabilities are very obvious while others are not. Some of these are caused by injuries. Children with physical disabilities require modifications in the environment, contents or skills to benefit from education.

The physically challenged are as much citizens of the country as normal people. Sometimes, a defect in body may stimulate the activities of other organs and senses. The fact remains that the abilities and potentialities of the handicapped children have not been explored and have remained a neglected area. The Constitution of India has assured equality of opportunity for all with special assistance to the weaker sections. This dream can only be translated into reality if proper attention is paid to the neglected groups like physically-challenged children so as to ensure their full participation in the mainstream of social life. Thus, the education of physically-challenged children becomes a crucial issue. It is for this reason that the researcher decided to study the intelligence, adjustment and creativity of handicapped children.
- (iii) *Objectives of the study:* The following are the major objectives of the study:
 - To study the level of intelligence of handicapped children
 - To study the adjustment of handicapped children on three important dimensions—emotional, social and educational
 - To study the creativity in handicapped children
 - To study the relationship between intelligence adjustment, intelligence and creativity and adjustment and creativity
- (iv) *Definition of terms*
 - *Handicapped child:* A handicapped child is one who suffers any continuing disability of the body, which restricts normal functions.
 - *Intelligence:* A general capacity for processing information and for utilizing abstract symbols in the solution of abstract problems.
 - *Creativity:* It is the quality of creating or pertaining to creation, originality and productivity.
- (v) *Delimitations:* The study would be delimited to the following:
 - Children of 14–18 years of age
 - The state of Rajasthan
 - The school-going children only
 - Children with physical impairment
- (vi) *Sample:* 50 physically-challenged children and 50 normal children would be selected on random basis from secondary schools of Udaipur division.
- (vii) *Hypotheses:* The main hypotheses are the following:
 - The physically-challenged children will not be low on measures of intelligence.
 - The adjustment of physically-challenged children is similar to that of normal children in the areas of social, emotional and educational dimensions.
 - There are no significant relationships among three variables, i.e., intelligence, adjustment and creativity.

- (viii) *Methodology*: The following methods will be employed:
- Survey method will be used in the study.
 - The following standards will be used.
 - (a) The verbal test of creativity by Professor Baquer Mehdi
- (ix) *Steps*: The following are the major steps to be followed:
- (a) Review of related literature
 - (b) Data collection
 - (c) Analysis and interpretation of data
 - (d) Reporting

Institutional Individual Research Proposal–4

- (i) *Title*: Study of ‘on the job’ support required for elementary teacher educators.
- (ii) *Name, designation and address of researchers*
(Research team)
 - (a)
 - (b)
 - (c)
- (iii) *Name and address of the institution*
- (iv) *Abstract/executive summary*: The proposed research study aims at identifying on-the-job support needed by teacher educators working in the elementary teacher education institutions. The specific objectives of the study include job analysis of elementary teachers and elementary-level teacher educators, in the light of their expected roles. The study would employ survey methods using various techniques like workshops, group discussions, interviews, observations and task analyses. The findings of the study would be based on the study of elementary teacher-education institutions located in the states of Rajasthan, Madhya Pradesh and Gujarat. Expected outcomes of the study are in the form of job charts of the elementary teacher educators, limitations and inadequacies in elementary teacher educators with respect to contents, curriculum transaction, educational technology, evaluation and so on. It is also proposed to develop on-the-job support based on differential training packages to be developed in the study. The purpose is to enable elementary teacher educators to perform their job effectively.
- (v) *Related literature*: This would include latest research studies having a bearing on the theme of research.
- (vi) *Scope and sample of the study*: This study will be conducted in three states—Gujarat, Rajasthan and Madhya Pradesh. The sample size will be as follows:

Sample groups	State							
	Rajasthan		Madhya Pradesh		Gujarat		Total	
	M	F	M	F	M	F	M	F
Elementary teacher								
Educators	30	30	15	15	15	15	60	60
Elementary teachers	30	30	15	15	15	15	60	60
Heads of Elementary Schools	5	5	5		5	10	10	

- (vii) *Objectives of the study:* The following are the main objectives of the study:
- To carry out the job analysis of elementary teacher educators
 - To identify the expected roles and competencies of elementary teacher educators
 - To identify on-the-job support needed by the elementary teacher educators pertaining to content, pedagogy and educational technology evaluation
- (viii) *Output of the study:* The output of study will be as follows:
- Job chart of an elementary school teacher
 - Job chart of an elementary teacher educator
 - Limitations and inadequacies of an elementary teacher educator with respect to content, pedagogy, educational technology and evaluation
 - Differential on-the-job support training package for an elementary teacher educator
- (ix) *Method:* The study will be conducted in the form of a survey using following techniques:
- Workshops for elementary teacher educators
 - Observation of elementary teacher education institutions
 - Interviews of experts
 - Task analysis of elementary teachers and teacher educators

Tools: Questionnaire, interview schedule, observation schedule (all these tools will be developed by the investigator)

- (x) *Work plan of activities*
- (a) Preparation phase—2 months
 - (b) Execution phase (data collection)—3 months
 - (c) Data analysis—2 months
 - (d) Report writing—3 months
- (xi) *Financial assistance sought*
- | | |
|--|-----------------------|
| (a) TA/DA to the participants for workshop | Rs 30,000.00 |
| (b) Payment to research assistant | Rs 36,000.00 |
| (c) TA/DA for data collection | Rs 30,000.00 |
| (d) Printing of tools | Rs 12,000.00 |
| (e) Stationery | Rs 2000.00 |
| (f) Contingency | Rs 1,02,000.00 |
| Total | Rs 1,02,000.00 |

Summary

- The preparation of a research proposal or synopsis is an important step in the research process.
- A research work is likely to result only from a well-prepared and well-designed proposal or research synopsis.
- A research proposal includes various essential parts, i.e., statement of the problem, the review of related literature, the objectives and hypotheses, the methodology and procedure, educational implications, delimitations of the study, tentative structure of report, bibliography and so on.
- Formulation of a research problem requires experience as well as the knowledge of certain basic characteristics and components that lead to meaningful research.
- We have learnt certain important considerations, which should be kept in mind while formulating a research problem. Examples given about individual and institutional research proposals will enable one to formulate such proposals. The next step will open up on tools and techniques needed in conducting researches.

Key Words

- *Research Proposal*: It is known as synopsis which contains a clear and concise statement of the problem.
- *Intelligence*: It is the ability of learning for utilizing abstract symbols in the solution of abstract problems.
- *Creativity*: It is the quality of creating originality and productivity.

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Review of Related Literature

4

The review of related literature is the main step in the process of research. In simple words, query-type information, written or verbal, printed or hand written, contained in books or journals, in paintings or sculptures, on rocks or leaves, in folklores, in idioms or proverbs, which in some way or the other is connected with the problem or research is called related literatures. The study of related literature implies locating, reading and evaluating reports of research, as well as reports of casual observations and opinions that are related to the individual's planned research project. In research methodology, the term 'literature' refers to the knowledge of a particular area of investigation of any discipline, which includes theoretical, practical and research studies.

▲ Meaning of Related Literature

The study of related literature implies locating, reading and evaluating reports of research as well as reports of casual observation and opinion that are related to the individual's planned research project. As observed by J. W. Best, 'practically all human knowledge can be found in books and libraries. Unlike other animals that must start anew with each generation, man builds upon the accumulated and recorded knowledge of the past.'

▲ Importance of Related Literature

Related literature is very important because it provides the following information:

- The review of the related literature enables the researchers to define the limits of their fields. It helps them to delimit their problems.
- By reviewing the related literature, the researchers can avoid unfruitful and useless problem areas. They can select those areas in which positive findings are very likely to result and their endeavours would be likely to add to knowledge in a meaningful way.
- Through the review of the related literature, researchers can avoid unintentional duplication of the established findings. It is of no use to replicate study when the stability and validity of its results have been clearly established.
- It helps the researcher to know about the tools and instruments, which proved to be useful and promising in the previous study. The advantage of the related literatures is also to provide insight into the statistics methods through which validity of results is to be established.
- Another purpose of reviewing the related literature is to know about the recommendations of previous researchers for further research, which they have listed in their studies. This type of knowledge will help the researcher in the selection of the problem.

- The review of related literature helps in speculating useful hypotheses and provides helpful suggestions for significant investigation. The studies that show substantial agreements and those that seem to present conflicting conclusions will help the researchers to sharpen their understandings.
- The existing knowledge in the problem area provides background of the research project and makes the researcher aware of the status of the problem.
- By reviewing the related literature, the researcher is able to formulate an appropriate research design. The researcher studies the procedure employed by the previous researchers and on the basis of this knowledge formulate a design suitable to the problem in hand.

▲ Identification of Related Literature

The first step in reviewing the related literature is the identification of the material that is to be read and evaluated. The identification can be made through the use of primary and secondary sources available. The meaning of these two terms is made clear in the following lines.

Primary sources: It is a direct description of the study by the individual who actually observes or witnesses the occurrence and carries it out.

Secondary sources: This is an indirect source material in education, which includes publication written by an author who is not a direct observer or participant in the events described, for example, textbooks, directories and encyclopaedias.

A textbook may contain some portions that may be termed as 'primary'. For example, the portion of a book that describes the result of experiments that the author himself has carried out may be treated as a primary source and the other portion of the book that describes the results or experiments conducted by others may be considered as a secondary source.

To make it clear, in the primary sources of information the author reports his own work directly in the form of research articles, books, monographs, dissertations or theses. Such sources provide more information about a study than is found elsewhere. Although consulting such sources is a time-consuming process for a researcher, yet they provide a good source of information on the research methods used. On the other hand, in secondary sources the author is not on the scene; he reports the testimony of an actual witness or of a participant in an event, for example, the indexes, abstracts, biographies, autobiographies and books.

▲ Need for Review of Related Literature

The review of the related literature is essential for the following reasons:

- It is the basis of most of the research projects in the physical sciences, natural sciences, social sciences and humanities.
- It gives the scholar an understanding of the previous work that has been done.
- It actually provides the data used in the research.
- It enables us to know the means of getting into the frontier in the field of our problem. Until we have learnt what others have done and what still remains to be done in our area, we cannot develop a research project that will contribute to further knowledge in our field.
- It develops the insight of the investigator.
- It helps the researcher to save time and energy.
- It helps in delimiting the research problem and defining it better.

- It gives the students the insight they need to convert their tentative research problem to a specific and concise one.
- It also helps the research workers in making them alert to research possibilities that have been overlooked.
- In the process of reviewing the literature the students are on the alert for finding out research approaches in their area that have proved to be sterile.
- It provides us with an opportunity of gaining insight into the methods, measures, subjects and approaches employed by other research workers. This in turn will lead to significant improvement of research design.
- A careful consideration of the chapters entitled recommendations for further research in various research studies guides us regarding the suitability of a problem and assists us in delimiting research problems.
- It provides ideas, examinations and theories of research, valuable in studying the problem.
- It prevents repetition of research.
- It helps in locating comparative data useful in the interpretation of results.

According to Walter R. Borge, 'the literature in any field forms the foundations upon which all future work will be built.'

The author further observes that if we fail to build this foundation of knowledge provided by the review of the literature, our work is likely to be shallow and naïve, and will often duplicate the work that has already been done better by someone else.

Carter V. Good thinks: 'The keys to the vast storehouse of published literature may open doors to sources of significant problems and explanatory hypotheses, and provide helpful orientation for definition of the problem, background for selection of procedure, and comparative data for interpretation of results in order to be truly creative and original, one must read extensively and critically as a stimulus to thinking.'

▲ Review of Related Literature

Research takes advantage of the knowledge, which has accumulated in the past as a result of constant human endeavour. It can never be undertaken in isolation of the work that has already been done on the problems, which are directly or indirectly related to a study proposed by a researcher. A careful review of the research journals, books, dissertations, theses and other sources of information on the problem to be investigated is one of the important steps in the planning of any research study. As indicated in the last chapter, a review of the related literature must precede any well-planned research study.

▲ Principle of Review of Related Literature

Review of the related literature, besides allowing the researchers to acquaint themselves with the current knowledge in the field or area in which they are going to conduct their research, serves the following specific purposes:

- The review of related literature enables the researchers to define the limits of their field. It helps the researchers to delimit and define their problem. To use an analogy given by Ary et al. (1972: 56), a researcher might say: 'The work of A, B and C has discovered this much about my question; the investigations of D have added this much to our knowledge. I propose to go beyond D's work in the following manner'. The knowledge of related literature brings the researcher up to date on the work, which others have done and thus to state the objectives clearly and concisely.

- By reviewing the related literature, the researchers can avoid unfruitful and useless problems. They can select those areas in which positive findings are very likely to add to the knowledge in a meaningful way.
- Through the review of related literature, the researchers can avoid unintentional duplication of well-established findings. It is of no use to replicate a study when the stability and validity of its results have been clearly established.
- The review of related literature gives the researcher an understanding of the research methodology, which refers to the way the study is to be conducted. It helps the researcher to know about the tools and instruments, which proved to be useful and promising in the previous studies. The advantage of the related literature is also to provide insight into the statistical methods through which validity of results is to be established.
- The final and important specific reason reviewing the related literature is to know about the recommendations of the previous researchers listed in their studies for further research.

▲ Sources of Related Literature

The first step in reviewing the related literature is the identification of the material that is to be read and evaluated. The identification can be made through the use of primary and secondary sources available in the library.

In the primary sources of information, the author reports his own work directly in the form of research articles, books, monographs, dissertations or theses. Such sources provide more information about a study than can be found elsewhere. Primary sources give the researcher a basis on which to make his own judgement of the study. Although consulting such sources is a time-consuming process for a researcher, yet they provide a good source of information on the research methods used.

In the secondary sources, the author compiles and summarizes the findings of the work done by others and gives interpretation of these findings. The author usually attempts to cover all the important studies in an area in the form of encyclopaedia of education, education indexes, abstracts, bibliographies, bibliographical references and quotation sources. Working with secondary sources is not time-consuming because of the amount of reading required. The disadvantage of the secondary sources, however, is that the reader is depending upon someone else's judgements about the important and significant aspects of the study.

The decision concerning the use of primary or secondary sources depends largely on the nature of the research study proposed by the researcher. If it is a study in an area in which much research has been reported, a review of the primary sources would be a logical first step. On the other hand, if the study is in an area in which little or no research has been conducted, a check of the secondary sources is more logical. Sources of information, whether primary or secondary, are found in a library. The researcher must, therefore, develop the expertise to use resources without much loss of time and energy. To aid the researcher in locating, selecting and utilizing the resources, a study guide is provided in relation to their use in educational research.

▲ Sources for Survey of Related Literature

The survey of the sources requires a planned, systematic and alert reading in the major field of the problem. The sources can be found in the library as it is the storehouse of knowledge and wisdom. It is an ever blossoming garden from where the seekers of knowledge can get the sweetness of life. Efficiency in the use of library is very important. One should have the ability to locate the sources and to use

them. It has a wide variety of materials. It demands an organized system of library. One should not expect from the researcher the efficiency of a librarian. Fortunately, a planned and organized system had been introduced in every library; therefore, an efficient use of a library has not remained a difficult task. The libraries have printed indexes and guides, which are fundamental for locating the material. The investigators should thoroughly acquaint themselves with the regulations governing the use and circulation of materials. They should get a good grasp of the organization of the library and its material. Besides, they must make a self-survey of the following:

- Will I be able to recognize the useful reference books?
- Will I be able to skim the library reading?
- Will I be able to judge the relevant material?

If they get positive answers to these questions, only then they can intelligently plan for the survey of library material.

▲ Use of Library

The researchers must follow a specific procedure of logical searching. They should get a clear-cut picture of their own problem; otherwise reading will be a random one. If they have grasped the general nature of their problem, then they should proceed on research for library material. Proficiency in the use of library consists of the abilities to perform the following:

- To locate the sources directly
- To browse through the multiple sources quickly
- To cull the relevant material
- To organize what has been accumulated
- To interpret it

Search for library material should be systematic and thorough. One should begin from reference cards, and then prepare a bibliography. Then one should make a general evaluation of the essential sources. Once the proper keys of literature related to the problem are found, one should start reading, find the relevant material and after sorting, the listing should be done about what is significant and pertinent for this purpose. Thus, library work consists of the following steps:

- (i) Compiling the bibliography
 - (ii) Preliminary reading
 - (iii) Critical reading
 - (iv) Note taking
- (i) *Compiling the bibliography*: One of the fundamental activities, which is connected with scientific investigation is to compile a good bibliography. It should be accurate in every aspect. It should be complete but not padded. It should follow a uniform pattern and classification. The following should appear in each complete bibliographication.
- (a) The author's name is arranged thus—surname—first name—middle name.
 - (b) The title is given in full as it appears on the title page of the publication.
 - (c) If this title is taken from a book, then name of the book, place of publication, name of publisher, copyright date of edition and number of pages should be given.
 - (d) If the reference is taken from a journal/periodical, name of the journal/periodical, volume and number, and month and year of publication should be given.

The annotated bibliography should be relatively short, as well as strictly to the point. The bibliography is also included in the final typed or published report in the form of an appendix. The reason for including the annotated bibliography in the final report is threefold—it is an index of the control of the research worker, it is the duty of the research worker to establish a continuity of study, it helps the next student as a highly useful and up-to-date material is handed over to him.

- (ii) *Preliminary reading*: Preliminary reading is done keeping in view or with the purpose of ascertaining whether it has some relevance to one's problem. One can see table of contents, indexes, headings of chapters, sub-headings and illustrations. If the sources give necessary and sufficient information, then the most effective way of skimming through some material is to read the first and last lines of a paragraph and evaluate it rapidly. In this way one can judge whether it has relevance or not.
- (iii) *Critical reading*: In the preliminary reading, if it is found that the source is useful, relevant and suitable for study, then one should intent to thoughtful reading, which involves reflective thinking and serious evaluation. It is on the basis of this critical reading that the source is taken for bibliography.
- (iv) *Note taking*: It is a very important research activity. A careful note taking enables one to assimilate and retain much of what has been read or consulted as a reference material. It is done in a form that can be recalled and used very easily. The various ways of note taking by researchers are the following:

- Read the publications themselves, underline the lines and write in the margins
- Use notebooks and loose sheets for taking down the important points and quotations
- Use card system for this purpose

The criteria which is considered good for note taking is that in which there is easy handling of material, flexibility, uniformity, accuracy and fitness of assembling. It has been observed that students do some common errors in note taking. They do not systematically organize the material. This results in duplication of work. Similarly, lack of bibliographical reference results in wastage of time if the reference has to be located again or if the bibliographical note has to be given in the report. It may be helpful to classify the notes in the following categories.

- Reproduction of the exact words of the author, as also the exact page reference
- The author's ideas are restated in reader's own words.
- *Evaluation*: The author's points of view are recorded with reader's own impressions and reactions.
- *Criteria considered useful for note taking*: Effective methods of note taking are based on thorough skimming of the material. Certain criteria useful for note taking are:
 - (i) Using cards or slips of paper instead of notebooks—index cards of 10 cm × 15 cm size are convenient to carry and easy to arrange
 - (ii) Arranging topic-wise and file each note card under a definite topic or heading. Include only one topic on one card. In case notes are lengthy, use more than one card
 - (iii) Placing the subject heading at the top of the card
 - (iv) Giving complete bibliographical reference at the bottom of the card
 - (v) Taking notes that are complete and clearly understandable
 - (vi) Using cards of different colours for the data of different categories
 - (vii) Distinguishing clearly between summary, quotation, a reference to the author's source and an evaluative statement
 - (viii) Taking the notes correctly on the very first occasion
 - (ix) Keeping the notes carefully filed, lest they get lost or misplaced
 - (x) Do not plan to recopy your notes

There are certain dos and donts in note taking which are explained in the following:

- Some dos in note taking are as follows:
 - (i) Keep the objectives of your research constantly in mind
 - (ii) Accuracy and correctness are extremely important in preparing bibliographical cards
 - (iii) Determining carefully the most useful material to be noted down
 - (iv) Taking notes as briefly as possible
 - (v) Recording your reactions, if any, related to the material immediately
 - (vi) Taking bulk of reference material at one time it avoids duplication of material
 - (vii) Copying only those quotations that are stated very skilfully or in very concise terms
 - (viii) Taking the advantage of modern facilities wherever available
 - (ix) Obtaining, if possible, microfilm or Photostat copies of any reference not locally available
 - (x) Consulting other libraries also

Sometimes a reference is not available in the library. In such situations the reader must consult the 'Union catalogue', which lists references found in other libraries. Such references may be obtained by inter-library loan system, by requesting an abstract or translation of the portion of a desired references or by requesting microfilm or microfiche.

- Some don'ts in note taking are as follows:
 - (i) Do not dispose of the work in a hurry
 - (ii) Do not view the relevant material from the secondary sources
 - (iii) Do not concentrate only on educational journals and dissertations
 - (iv) Do not overlook newspapers and library magazines, which also contain articles and educational topics
 - (v) Do not copy too many materials on note cards
 - (vi) Do not fail to define satisfactorily the topic limits of the review of literature

▲ Some Important Reference Materials

The following are some of the important reference materials:

- The direct sources of information are: (1) periodical literature found in educational journals; (2) books, year-books, monographs and bulletins; (3) theses—graduate, doctoral and others; (4) government and non-government publications; and (5) university publications.
- The indirect sources of information are: (1) encyclopaedias of education, (2) education indexes, (3) education extracts, (4) bibliographies and directories, and (5) quotation sources.

The research workers have to acquaint themselves with the specific publications and other items to which they turn for collecting information. Some of the most important reference materials are discussed in the following:

- (i) *Research journals and periodicals*: For the most up-to-date and the latest information about any field, the research workers will have to turn to the research journals and periodicals. There are innumerable research journals and periodicals, which can be gone through with sufficient advantage. Some of the most important ones are as follows:
 - *Journal of Educational Research*: Published nine times a year by Dembar Publications, 303 East Wilson Street, Madison 3, Wisconsin.

- *Journal of Educational Psychology*: Published eight times a year by Warwick and York, 10 East Center Street, Baltimore.
 - *Journal of Experimental Education*: Published four times a year by Dembar Publication, 303 East Wilson Street, Madison 3, Wisconsin.
 - *California Journal of Educational Research*: It is published five times a year by the California Teachers Association for the California Advisory Council on Educational Research, 693 Sutter Street, San Francisco 2, California.
 - *Research Bulletin of the National Educational Association*: Published four times a year by the National Education Association, Research Division, 120 Sixteenth Street, N.W. Washington, DC.
 - *Bulletin of International Bureau of Education*: Published by International Bureau Publication, Palais Wilson, Geneva, Switzerland. It is a quarterly journal.
 - *Education Quarterly*: Published by Ministry of Education, Theatre Communication Building, Connaught Circus, New Delhi.
 - *Teacher Education*: Published by NCERT, New Delhi.
- (ii) *Research bibliography and directories*: There are a number of bibliographies, which serve as a useful guide for research work. The following are some of them:
- *Doctoral Dissertations Accepted by the American Universities*: It is published by the Association of Research Libraries every year since 1934.
 - *Researches in Educational Psychology*: It is the directory of dissertations in the subject presented for higher degrees in the universities of UK and the Irish Republic since 1918.
 - *Research Studies in Education*: It is a subject-wise coverage of doctoral dissertations, reports and field studies. It is compiled by Mary Louise Lyda and Stanley B. Brown. It was first published in 1953.
 - *Bibliography of Doctorate Theses in Science and Arts*: It has been published by the Inter-University Board of Indian Universities. Theses are enlisted University-wise with subject sub-headings including education.
 - *Register of Educational Research in India*: It presents a bibliography of educational research undertaken in various parts of the country.
- (iii) *Research abstracts*: These provide a summarized list of reference sources, including brief summaries of each research work. Some of the well-known research abstracts are as follows:
- *Educational Abstracts*: It is an American journal established in January 1936. It presents concise abstracts from books, journals and monographs in both American and foreign literature, five times a year.
 - *Psychological Abstracts*: It is a monthly publication by American Psychological Association and it contains abstracts of articles appearing in various journals in psychology and related areas.
 - *Review of Educational Research*: It is published five times a year by American Educational Research Association since 1931. It briefly summarizes research findings in education under 11 major areas.
 - *Education Abstracts*: Published by Paris UNESCO, 1940 onwards, monthly except in July and August. Each introductory essay is devoted to a particular aspect of education and it is followed by abstracts of books and documents selected from various countries.
 - *Dissertation Abstracts*: Published by Ann Arbor, Michigan University, Microfilms, Inc. since 1955. It is a monthly compilation of abstracts of doctoral dissertations. Abstracts give a good coverage of the essentials of dissertations.

- *Indian Education Abstracts*: The Ministry of Education, Government of India has been issuing this quarterly abstract since 1985. It abstracts the contents of books and periodicals in education published in India in English and Hindi. Subject headings under which the abstracts appear are Philosophy of Education; Educational Psychology; Teacher Education Ment and Testing Examination; Vocational Guidance; Students and Student's Vocational and Technical Education, and Social Education.
 - *Review of Educational Research, Research in Education (RIE)*: This presents a comprehensive publication of research materials in education today. RIE is published since 1966 by the Educational Resources Information Centre (ERIC) and indexed annually.
- (iv) *Encyclopaedia of Education*: These are very huge and multivolume publications. The spirit of the material of a good encyclopaedia is always scholarly. It gives far complete and balanced selection of topics accurately representing education at all stages and in its various aspects. They are the works of experts in the various areas of education. Organization of their contents is usually alphabetical.
- *Encyclopedia of Education Research*: It was prepared by Walter Scott Monroe under the auspices of the American Educational Research Association in 1941 and it was revised in 1950. It aims to present a critical evaluation, synthesis and interpretation of research studies in education. Its new edition has a much wider coverage including reports of educational research not only in the USA, but also in other countries.
 - *Encyclopedia of Modern Education*: It was prepared by Henry D. Rivlin and H. Schueller which was published in New York in 1943 by the Philosophical Library. It is the work of over 200 eminent contributors and covers the entire fields of education.
 - *Encyclopedia of Education Research*: It was prepared under the auspices of Education Research Association, was edited by Chester Harris and published by Macmillan, New York. It is not merely a revision of earlier editions, but a completely rewritten volume that has attempted to put into a new prospective the findings of research.
 - *Encyclopedia of Childcare and Guidance*: It was published in 1968 by Garden City, New York, Doubleday and Co. It is a comprehensive work on the problem of childhood. It also suggests ways to deal with such problems.
 - *Encyclopedia of Philosophy*: It was published in 1967 by Macmillan-Free Press, New York. It is an authoritative and comprehensive reference work covering both Western and Eastern thought—ancient, medieval and modern.
- (v) *Dictionaries*: They serve as a constant guide to the research workers. These deal with the works—technical and professional—of some special subject, in alphabetical order. The following are some of the important dictionaries:
- *Dictionary of Education* (New York: McGraw-Hill Book Co. 1973): This dictionary covers 33,000 technical and professional terms. It includes educational terms used in various countries.
 - *Dictionary of Education*, Carter V. Good, ed. (New York: McGraw-Hill Book Co.).
 - *A Dictionary of Psychology*: H. C. Warren, ed. (Boston: Houghton Miffling Co.).
 - *New Dictionary of Psychology*, Phillip L. Harriman (New York: Philosophical Library).
 - *Dictionary of Sociology*, H. P. Fairchild, ed. (New York: Philosophical Library).
 - *Comprehensive Dictionary of Psychological and Psycho-analytical Terms*, Horace B. English and Ava C. English (New York: Longmans Green and Co.).

- *Roget's International Thesaurus of Words and Phrases* (New York: Crowell, Collier and Macmillan): A Thesaurus is the opposite of a dictionary. One turns to the Thesaurus when one has an idea but does not yet have appropriate words to convey it. Thesaurus lists synonyms and antonyms of words together. A researcher should use this dictionary in conjunction with a good dictionary to ensure precision of expression.
- (vi) *Yearbooks of Education*: These are published once in a year. These contain date and educational papers, which are prepared by eminent scholars and educationists. They are a very useful source of information for the students of education, educational administrators and research workers. Among year-books of education the following deserve special mention:
- *International Yearbooks of Education*: Published by UNESCO in 1964. It presents reports from more than 100 countries and trends in various aspects of education.
 - *Yearbooks of Education*: J. A. Lanwerys and others, eds, London Evans Bros. Ltd. It is prepared under the joint responsibility of the University of London, Institute of Education and the Teachers, College, Columbia University. Each of its issue is reserved for one particular aspect of education, which is discussed at length by eminent educationists in the fields.
 - *Educational Yearbook of the International Institute of Teachers*: College: New York: Bureau of Publications, Columbia University. It is prepared by I. L. Kandel, ed., and is one of the outstanding reference books for comparative education.
- (vii) *UNESCO Publications*: A number of international publications on education have been brought out by UNESCO which are very useful as reference material. These are as follows:
- *World Survey of Education*: It consists of three different volumes on the aspects of educational organization and statistics, primary education and secondary education. These volumes contain up-to-date descriptions and statistics on the educational systems of almost 200 countries and territories.
 - *Educational Planning*: Research in comparative education. Owing to the increasing rapidity of social changes, the extraordinary advances in scientific discovery and to ever-growing needs of all countries are being forced to find systematic means of balancing their resources with one another and in relation to the future. Relevant to educational planning, a bibliography and a directory of training and research institutions have also been published.
 - *International Guide to Educational Documentation*: This guide is published every 5 years. It indexes annotated bibliographies covering major publications, bibliographies and national directories written in English, French and Spanish.
 - *Educational Publishers*: It facilitates exchange of information on textbooks by providing librarians, educators and research workers with reference information on educational publishers, and helps to stimulate closer co-operation among publishers and national and international educational bodies. Part I lists international and national publishers' association. Part II deals with individual educational publishers and producers of teaching materials grouped by country.
 - *Educational Periodicals*: Part I of this volume covers periodicals by international bodies and all countries except the USA. Part II lists the educational periodicals appearing in the USA. The two parts total approximately 5000 current educational periodicals from 100 different countries and territories.

- *Teacher's Association*: It is designed to facilitate and encourage co-operation between various associations of teachers and individual members of the teaching professions. It enlists names, addresses, membership details, functions and publications of teachers' association in 127 countries. It is trilingual—English, French and Spanish.
- *Statistics on Special Education*: It carries statistics from more than 50 countries on general or vocational education given to children who are physically or mentally challenged.

Evaluate Yourself

- (i) What is the importance of survey of related literature in educational research?
- (ii) Clarify is the source of survey of related literature in educational researcher.
- (iii) Describe the procedure which the researcher should adopt in organizing the related literature in a systematic manner.

If little or no research has been conducted, a check of the secondary sources is more logical. Sources of information, whether primary or secondary, are found in a library. The researchers must, therefore, develop the expertise to use resources without much loss of time and energy. To aid the researchers in locating, selecting and utilizing the resources, a study guide is provided in relation to their use in educational research.

▲ Sources of Information

Researchers should be familiar with the library and its many facilities and services. They should also be acquainted with the regulations governing the use and circulation of materials. Many libraries use a printed guide that contains helpful information. The guide uses a diagram to indicate the location of the stacks, the periodicals section, reference section, reading rooms and special collections of books, microfilm or microcard equipment, manuscripts or pamphlets. The guide lists the periodicals to which the library subscribes and the names of special indexes, abstracts and other reference materials.

The regulations concerning the use of stacks, the use of reserve books, the procedures for securing reference materials held by the library or those that may be borrowed from another library are also included in the guide.

Research scholars and other readers are usually issued a library card which gives them access to the stacks. They may take the help of library staff or may carry on the independent searching for the books and other reference materials. After using the books, it is desirable for the readers to leave them on the table so that the library staff will return them to their proper position on the shelves.

Sometimes a reference is not available in the library. In such a situation the reader must consult the 'Union' catalogue, which lists references found in other libraries. Such references may be obtained in the following ways from the library:

- *Inter-library loan system*: The reader requests the librarian to borrow the desired reference from other library where it is available.
- *Requesting a photostat copy*: The reader may request the librarian to obtain the Photostat of a page or a number of pages of a desired reference from the source.
- *Requesting an abstract or translation of the portion of a desired reference*: Some large libraries have abstracting and translating service that provides abstracts, or copied or translated portions of needed materials at an established fee.

- *Requesting microfilm or microfiche:* The teacher may purchase a microfilm that can be projected on library microfilm equipment. A microfiche is a sheet of film that contains microimages of a printed manuscript or a book. Its development has been one of the most significant contributions to library and information services by providing economy and convenience of storing and distribution of long runs of scholarly materials.

The size of the internationally standardized microfiche is 105×148 mm, which contains 98 images (7 rows with 14 micro images) having a reduction ratio 24x. The American National Micrographics Association has approved this, while the size of the British Standard microfiche is smaller, which can have 60 images (BS 4187 1973).

A superfiche, which has been recently developed by the PCMI process of National Cash Register, has a 75x reduction ratio and contains up to 1000 pages of printed material on a single $4' \times 6'$ transparent card. An even more significant development is the *ultra-fiche*. It has a reduction ratio of 150x and has the capacity of 3200 pages per fiche (Mittal 1979: 10).

Various types of cameras are used to record microimage on roll film.

Planetary camera is a 35 mm or 16 mm still camera, which is mounted on a vertical column that can be moved up and down to change the reduction ratio between 10x and 50x. At a time, it can be loaded with 100 ft of roll film. It does not cost much.

Step-and-repeat camera is a costly camera, which is used to record automatically microimages on microfiche one by one.

Rotary camera, like the planetary camera, records microimages on roll film and has the capacity to change the reduction ratio as desired.

Flow camera costs less than half of a planetary camera. Its reduction ratio is fixed unlike previously mentioned types of camera.

All these cameras make use of *silver*, *diaz* or *vesicular* film for recording microimages.

Generally, six types of *Readers* are used for reading microfilms or microfiche (Mittal 1979: 13).

- (i) *Cuddly microfiche reader* is a portable reader and can be used by keeping it in one's lap. It is very cheap and can be lent to library members for home use.
- (ii) *Microfilm and microfiche readers.*
- (iii) *Universal machines.*
- (iv) *Reader/printer* is a push-button machine, which not only helps in reading a microfilm/microfiche, but also is capable of producing a full-sized paper copy of the frame on the screen.
- (v) *Production printer/enlarge printer* is an automatic machine and can print the requisite number of copies of a microfilm or selected portions of a microfilm. It is used for mass production of full-sized copies of microfilms.
- (vi) *Xerox copy flow machine* is a costly machine, and, therefore, is beyond the reach of ordinary libraries. In can print a microfilm into a readable size, and, as such, a single copy of any requisite document can be obtained at low cost and in less time.

▲ Card Catalogue in the Library

The card catalogue is the index to the entire library collection. It lists the details of publications found in the library, with the exception of serially published periodicals.

Generally, the card catalogue contains author, title and subject cards arranged alphabetically. A great deal of information about a book can be found on the cards. Besides the title of the book and the name of the author, the reader will find the date of birth of the author, the edition, the publication date,

the number of pages, and the name and location of the publisher. Other items listed on the cards are bibliographies, maps, portraits, illustrations, tables, series (if any) in which a book appears and a brief description of the book—whether the book is a translation and who did the translation.

▲ Library Classification Systems

Library classification systems provide ingenious ways of systematizing the placement and location of books. Every system is based upon a methodology that is logical and orderly to the smallest detail. The two principal systems of library classification in the USA are the Dewey Decimal system and the Library of Congress system.

The Dewey Decimal system is a decimal plan with the numbers running from 001 to 999.99. The Library of Congress system is particularly used in large libraries. It provides 20 main classes instead of 10 of the Dewey Decimal system. The system uses letters of alphabet for the principal headings and numerals for further sub-grouping.

In a library, all books have a call number or letter that appears in the upper left-hand corner of the author, subject or title card, and on the back of the book. These call numbers or letters are used to arrange the books serially on the library shelves and within each classification, the books are arranged alphabetically by author's last name, and deal with history, theory, research, philosophy, as well as the structure and fabric of education.

- *Encyclopedia of Modern Education*: Henry D. Rivlin and H. Schueller, eds (New York: Philosophical Library, 1943). Henry D. Rivlin and H. Schueller have edited this comprehensive work of about 200 authorities. It stresses present-day problems, trends, theories and practices. The articles are accompanied by brief bibliographies and there is a system of cross-references.
- *Encyclopedia of Education Research*: Walter Scott Monroe, ed., rev. ed. (New York: Macmillan, 1950). Monroe's *Encyclopedia of Educational Research* was prepared under the auspices of the American Education Research Association. It aims to present a critical evaluation, synthesis and interpretation of research studies in the field of education. All the articles, arranged alphabetically, are provided with bibliographies.
- *Encyclopedia of Educational Research*: Chester Harris, ed. 3rd ed. (New York: Macmillan, 1960). Harris's *Encyclopedia of Educational Research* is also prepared under the auspices of the American Educational Association. It is not merely a revision of earlier editions, but a completely re-written volume that has attempted to put into a new perspective.
- *Encyclopedia of Educational Research*: Robert L. Ebel, ed., 4th ed. (New York: Macmillan, 1969). Ebel's *Encyclopedia of Educational Research* provides concise summaries of research and many references for further research. The articles deal with persistent educational problems and continual educational concerns.
- *Encyclopedia of Educational Research*: Harold E. Mitzel, ed., 5th ed. (New York: The Free Press, 1982). The contents of the encyclopaedia have been classified under 18 broad headings alphabetically ranging from agencies and institutions related to education; counselling, medical and psychological services; curriculum areas to teachers and teaching. The new concepts and topics, viz. Computer-based Education, Drug Abuse Education, Equity Issues in Education, Ethnography and Neurosciences, are also included in this volume. These additions reflect recent events and developments in the world to which education must attend.
- *The International Encyclopedia of Education*: Torsten Husen and T. Neville Postlethwaite, eds (New York: Pergamon Press, 1985). This publication is the first major attempt to present an up-to-date

overview on educational problems, practices and institutions all over the world. The information available in this volume provides answers to three basic questions: What is the state of the art in the various fields of education? What scientifically sound and valid information is available? What further research is needed in various aspects of education?

- *The Encyclopedia of Comparative Education and National Systems of Education*: T. Neville Postlethwaite, ed. (New York: Oxford Press, 1988). This encyclopaedia has two parts: the first part presents a series of articles about comparative education; the second part provides description of 159 different systems of education in various countries.
- *International Encyclopedia of the Social Sciences* (New York: Macmillan Co., 1968): It was prepared under the direction of 10 learned societies. This reference work treats topics in all of the social sciences.
- *Encyclopedia of Childcare and Guidance* (Garden City, New York: Doubleday and Co., 1968): It is a comprehensive treatment of the nature of the problems of childhood. It also suggests the methods of dealing with such problems.
- *Encyclopedia of Social Work* (New York: National Association of Social Workers, 1965): This reference work presents extensive articles on all aspects of social work.
- *Encyclopedia of Philosophy* (New York: McGraw-Hill Book Co., 1971): This encyclopaedia contains more than 7000 articles written by more than 2000 contributors in all areas of science and engineering.
- *Encyclopedia of Philosophy* (New York: Macmillan-Free Press, 1967): It is an authoritative and comprehensive reference work covering both Western and Eastern thought—ancient, medieval and modern.

Dictionaries

They serve as constant guides to the researcher. A few known dictionaries are detailed in the following:

- *Dictionary of Education* (New York: McGraw-Hill Book Co., 1973): This dictionary covers 33,000 technical and professional terms. It also includes educational terms used in various countries.
- *Comprehensive Dictionary of Psychological and Psycho-analytical Terms* (New York: David McKay Company): It contains more than 13,000 terms, which are defined in non-technical terms.
- *Dictionary of Sociology* (Totowa, NJ: Littlefield, Adams and Co.): In this dictionary, sociological terms are defined in non-technical language.
- *Roget's International Thesaurus of Words and Phrases* (New York: Crowell, Collier and Macmillan): A Thesaurus is the opposite of a dictionary. One turns to the Thesaurus when one has an idea, but does not yet have an appropriate word to convey it. Thesaurus lists the synonyms and antonyms of words together. A researcher should use this reference in conjunction with a good dictionary to ensure precision of expression.

Yearbooks, Almanacs and Handbooks

A large amount of current information on educational problems, thought and practices may be found in yearbooks, almanacs and handbooks. Some yearbooks cover a new topic of current interest each year and some others give more general reviews of events. A list of some yearbooks, almanacs and handbooks is given in the following:

- *The Handbook of Research on Teaching*. N. L. Gage, ed. (Chicago: Rand McNally & Co., 1963): This handbook presents comprehensive research information on teaching with extensive bibliographies.

- *The Rand McNally Handbook of Education*, Arthur W. Foshay, ed. (Chicago: Rand McNally & Co, 1963): It is a convenient source compilation of the most important facts about education in the USA. This handbook provides a quick-reference comparison of education in England, France and Russia.
- *Education Yearbook* (New York: Macmillan Co., 1972–): This is an annual publication. It includes statistical data on major educational issues and movements with a comprehensive bibliography and reference guide.
- *Mental Measurement Yearbook* (Highland Park, NJ: Grayphon Press, 1938–): It is compiled by Oscar K. Buros and provides a comprehensive summary on psychological measurement and standardized tests and inventories. It is published every 4 years and includes reviews on all significant books on measurement and excerpts from book reviews appearing in professional journals.
- *Indian Mental Measurement Handbook: Intelligence and Aptitude Tests* (New Delhi: National Council of Educational Research and Training, 1991): The handbook is one of the major efforts of National Library of Educational and Psychological Tests (NCERT) to present before the researchers, a review of the standardized tests, particularly in the areas of intelligence and aptitude. It makes available the organized information on tests developed in India and the Indian adaptations or standardization of foreign tests. The information covers not only tests, which are commercially available to test users and those available for restricted use, but also tests for which only specimen sets are available. Test reviews have been included in this handbook in order to help the readers to evaluate the tests more critically.
- *The Student Psychologist's Handbook: A Guide to Sources* (Cambridge, MA: Schenkman Publishing Co., 1969): This handbook describes the major content areas of psychology, with sources of information, methods of data collection and the use of reference materials.
- *Data Processing Yearbook* (Detroit: Frank H. Gille, 1952–): This yearbook is published irregularly and includes articles on equipment, techniques and developments in data processing. It also provides information about institutions offering data processing and computer courses.
- *United Nations Statistical Yearbook* (New York: United Nations, 1949–): This is an annual publication. It presents statistical data on population, trade, finance, communication, health and education.
- *World Almanac—Book of Facts* (New York: Newspaper Enterprise Association, 1968–): This reference guide is published annually. It provides up-to-date statistics and data concerning events, progress and conditions in social, educational, political, religious, geographical, commercial, financial and economic fields.
- *The Standard Education Almanac*: It provides a record of facts and statistics on virtually every aspect of education.

Directories and Bibliographies

Directories are used by the researchers to locate the names and addresses of persons, periodicals, publishers or organizations and to obtain information about financial assistance, or research material and equipment. Directories may help the researchers to find people or organizations who have similar professional interests or who can answer their queries or help them to solve their problems.

A few important directories in the USA and the UK are the following:

- *Guide to American Educational Directories*: It lists in one volume over 12,000 educational and allied directories. The directories are listed alphabetically and are arranged under subject headings.

- *The Education Directory* (Washington: US Office of Education, Superintendent of Documents, 1912–): This directory is published annually in five parts. It deals with names, educational agencies, officials, institutions and other relevant data.
- *NE-4 Handbook for Local, State and National Associations* (Washington, DC: National Education Association, 1945–): This is an annual publication and contains listings and comprehensive reports of state and national officers of affiliated associations and departments.
- *Educator's World* (Englewood, CO: Fisher Publishing Co., 1972–): This is an annual guide to more than 1600 education associations, publications, research centres and foundations.
- *National Faculty Directory* (Detroit: Gale Research Co., 1964–): This annual publication lists alphabetically the names and addresses of more than 300,000 full-time and part-time faculty members and administrative officials of colleges and universities in the USA.
- *Encyclopedia of Associations* (Detroit: Gale Research Co., 1964–): This directory lists alphabetically more than 14,000 national associations of the USA. It includes information on membership, addresses, names of executive secretaries and statement of purpose of these associations.
- *Directory of Exceptional Children* (Boston: Porter Sargent Publishing Co., 1962–): This directory provides a description of schools, camps, homes, clinics, hospitals and services for the socially maladjusted and mentally- or physically challenged-children in the USA.
- *A Mental Health Directory* (Washington, DC: National Institute of Mental Health, Government Printing Office, 1964–): This annual publication lists national, state and local mental health agencies in the USA.
- *American Library Directory* (New York: R.R. Bowker Co., 1923–): This directory provides a biannual guide to private, state, municipal, institutional and collegiate libraries in the USA and Canada. It includes information on special collections, number of holdings, staff salaries, budgets and affiliations.
- *A Select Bibliographies of Adult Education in Great Britain*, K. Thomas, ed. (London: National Institute of Education, 1952); *Blackwell, A.M.A list of Researches in Educational Psychology presented for Higher Degrees in the Universities of the United Kingdom and the Irish Republic from 1918* (London: Newnes Educational Publishing Co., 1950).

In India, a very few bibliographical guides to educational research on a national basis have appeared. *Bibliography of Doctorate Theses in Science and Arts* accepted by the Indian universities for 1946–48 and 1948–50 has been published recently by the Inter-University Board of India. These are listed under the respective universities, with subject sub-headings including education.

The Index

A periodical index serves the same purpose as the index of a book or the card file of library. It identifies the source of the article or the book cited by listing the titles alphabetically under author and the readers should read all such directions before trying to locate the references.

A list of some important educational indexes is given in the following:

- *Education Index* (New York: H.W. Wilson Co., 1929–): One valuable and work-saving guide created for educators is Education Index. It is published monthly (September through June), cumulated annually and again every 3 years. It indexes more than 250 educational periodicals, and many yearbooks, bulletins and monographs published in the USA, Canada and Great Britain. The material on adult education, business education, curriculum, educational administration, educational psychology, educational research, exceptional children, higher education, guidance,

health and physical education, international education, religious education, secondary education and teacher education are included in this index.

- *Canadian Education Index* (Ottawa, ON: Canadian Council for Educational Research, 1965–): This index is issued quarterly and indexes periodicals, books, pamphlets and reports published in Canada.
- *Current Index to Journals in Education* (New York: Macmillan Information, 1969–): This index is published monthly and cumulated 6 monthly and annually. It indexes about 20,000 articles each year from more than 700 education and education-related journals, under author and subject headings.
- *ERIC Educational Documents Index* (Washington, DC: National Institute of Education, Government Printing Office, 1966–): This index is published annually. It is a guide to all research documents in the Educational Resources Information Centre collection.
- *Index of Doctoral Dissertations International* (Ann Arbor, MI: Xerox University Microfilms, 1956–): Published as the issue *13 of Dissertation Abstracts International* each year, it consolidates into one list all dissertations accepted by American, Canadian and some European universities during the academic year, as well as those available in microfilm.
- *International Guide to Educational Documentation* (Paris: UNESCO): This guide is published every 5 years. It indexes annotated bibliographies covering major publications, bibliographies and national directories written in English, French and Spanish.
- *British Education Index, Vol. I*: August 1954 to November 1958. This index is compiled by the Librarians of Institutes of Education and it includes references to articles of educational interest published during the period of 4 years. The index covers more than 50 periodicals.
- *Index to Selected British Educational Periodicals* (Leeds: Librarians of Institutes of Education, 1945–): This index is issued thrice a year and it covers 41 educational periodicals excluding those on fundamental and adult education.

▲ Research Periodicals

Information about new ideas and developments often appear in periodicals long before it appears in books. There are many periodicals in education and in other closely related areas that are the best sources for reports on recent research studies. Such periodicals give much more up-to-date treatment to current questions in education than books possibly can. They also publish articles of temporary, local or limited interest that never appear in book form. The periodicals of proper dates are the best sources for determining contemporary opinion and status, present or past.

It has been estimated that there are about 2100 journals that are specifically related to the field of education. In all such journals one may also find articles of interest devoted to psychology, philosophy, sociology and other subjects.

All those engaged in educational research should become acquainted with certain educational periodicals and they should also learn to use the indexes to them. Knowledge about the editor of a periodical, the names of its contributors, and the associations or institutions publishing it may serve as clues in judging the merit of the periodical.

Ulrich's Periodicals Directory: A Classified Guide to a Selected List of Current Periodicals, Foreign and Domestic, 12th ed. (New York: Bowker, 1967) provides a comprehensive list of periodicals relating to education. In this directory, periodicals are grouped in a subject classification and are alphabetically arranged. Each entry includes title, sub-title, date of origin, frequency of publication, annual index, cumulative indexes and item characteristics of each periodical.

In India, many periodicals are published by some associations or institutions. They provide a medium for dissemination of educational research and exchange of experience among research workers, teachers, scholars and others interested in educational research and related fields and professions.

Abstracts

Abstracts include brief summaries of the contents of the research study or article. They serve as one of the most useful reference guides to the researchers and keep them abreast of the work being done in their own field and also in the related fields.

In the USA, the most useful of these references are the following:

- *The Review of Educational Research*: It gives an excellent overview of the work that has been done in the field and about the recent developments. This publication, between 1931 and 1969, reviewed about every 3 years each of the following 11 major areas of education: (1) administration; (2) curriculum; (3) educational measurement; (4) educational psychology; (5) educational sociology; (6) guidance and counselling; (7) language arts, fine arts, natural sciences and mathematics; (8) research methods; (9) special programmes (10) mental and physical development; and (11) teaching personnel.

Since June 1970, the *Review of Educational Research* has pursued a policy of publishing unsolicited reviews and research topics of the contributor's choosing. The role played by this publication in the past has been assumed by the *Annual Review of Educational Research*.

- *Research in Education (RIE)*: This represents the most comprehensive publication of research materials in education today. RIE is published monthly since 1966 by the Educational Resources Information Centre (ERIC) and indexed annually. Each monthly issue of RIE is divided into three sections: (1) document section; (2) project section; and (3) accession numbers section.
- *Psychological Abstracts*: This useful reference is published by the American Psychological Association since 1927. It is published bimonthly and contains abstracts of articles appearing in over 530 journals, mostly educational periodicals. The biannual issues (January–June, July–December) contain both author and subject indexes.
- *Education Abstracts*: This is a publication of UNESCO, which began in 1949 and has been published monthly except in July and August. Each introductory essay devoted to a particular aspect of education is followed by abstract of books and documents, selected from various countries dealing with the topic under consideration. In addition to the above periodicals, a researcher may also consult the following publications:

- *Annual Review of Psychology* (1950–)
- *Child Development Abstract and Bibliography* (1927–)
- *Psychological Bulletin* (1904–)
- *Sociological Abstracts* (1952–)
- *Educational Administration Abstracts* (1966–)
- *Sociology of Education Abstracts* (1965–)
- *Mental Retardation Abstracts* (1964–)
- *Dissertation Abstracts International* (1952–)

In India, the Ministry of Education and Social Welfare, Government of India (now Ministry of Human Resource Development), New Delhi, since 1955 has been issuing *Indian Education Abstracts* every 3 months. It abstracts the contents of books and periodicals on education published in India in English and Hindi. Most of the Indian journals are indexed in various issues. The abstracts appear under

the following subject headings: Philosophy of Education; Educational Psychology; Measurement and Testing; Examinations; Students and Students Organizations; Educational and Vocational Guidance; Teacher Education and Training; Curriculum; Basic Education; Health and Physical Education; Primary, Secondary, Higher, Vocational and Technical Education; and Social Education.

Many professional periodicals and yearbooks, in India and abroad, include some reviews of research and technical discussions of educational problems in one or all the issues of their series. Some of the publications are listed in the following:

- USA: *Journal of Educational Research*, *NF-4 Research Bulletin*, *Educational and Psychological Measurement*, *Journal of Experimental Education*, *Research Quarterly*, *Journal of Research in Music Education*, *American Educational Research Journal*, *Reading Research Quarterly*, *Journal of Educational Psychology*, *Journal of Psychology*, *Journal of Social Psychology*, *Journal of Applied Psychology*, *Sociology of Education*, *American Journal of Sociology*, *American Sociological Review*, *Sociology and Social Research*, *Harvard Educational Review*, *Journal of Teacher Education*, *Elementary School Journal* *History of Education Quarterly* and *Educational Forum*
- UK: *British Journal of Educational Psychology*
- India: *Indian Educational Review*, *Journal of Psychological Researches*, *Indian Journal of Applied Psychology*, *Indian Journal of Experimental Psychology*, *Journal of Education and Psychology*, *The Education Quarterly*, *Perspectives in Education*, *Journal of Educational Planning and Administration*, *University News* and *Journal of Higher Education*

▲ Theses and Dissertations

Theses and dissertations are usually preserved by the universities that award the authors their doctoral and masters degrees. Sometimes these studies are published in whole or in part in various educational periodicals or journals. Because the reports of many research studies are never published, a check of the annual list of theses and dissertations issued by various agencies is necessary for a thorough coverage of the research literature.

In the USA, references of doctoral dissertations in all fields, including education, can be found in sources compiled by various agencies. For the period 1912–38, the Library of Congress issued the annual *List of American Doctoral Dissertations* for published studies. The Association of Research Libraries published the list of *Doctoral Dissertations accepted by American Universities* from 1933–34 to 1954–55. This service was continued by the index to *American Doctoral Dissertations* 1956–63, which became the *American Doctoral Dissertations*, from 1963–64 till date. It lists all doctoral dissertations accepted by the American and Canadian universities and other educational institutions.

- *Dissertation Abstracts International*: It is published monthly. For each dissertation, there is a 600-word abstract that provides the researchers enough information to satisfy their needs. If the researchers want to read a complete copy of a dissertation that is presented in *Dissertation Abstracts International*, they can purchase a microfilm or Xerox copy from the University Microfilms. The reference number for placing an order and price are provided in the abstract.

In India, only a few universities publish abstracts of dissertations and theses that have been completed at the institution. Kurukshetra University, Kurukshetra (Haryana), published abstract of *M.Ed. Dissertations*. Vol. I, 1966; *Abstract of M.Ed. Dissertations*, Vol. II, 1967; *Abstract of M.Ed. Dissertations*, Vol. III, 1968; *Abstract of M.Ed. Dissertations*, Vol. IV, 1969; *Abstract of M.Ed. Dissertations*, Vol. V, 1970; *Abstract of M.Ed. Dissertations and Ph.D. Theses*, Vol. VI, 1973.

- *A Survey of Research in Education*, M. B. Buch, ed. (Centre of Advanced Study in Education, MS University, Baroda, 1973): This publication contains all the research studies in education completed in Indian universities till 1972. The break up of the studies in the said volume is 462 Ph.D. studies and 269 project research. The abstracts of all the studies have been classified into 17 meaningful areas of education. They are: (1) Philosophy of Education, (2) History of Education, (3) Sociology of Education, (4) Economics of Education, (5) Comparative Education, (6) Personality, Learning and Motivation, (7) Guidance and Counselling, (8) Tests and Measurement, (9) Curriculum, Methods, and Textbooks: (10) Educational Technology, (11) Correlates of Achievement, (12) Educational Evaluation and Examination, (13) Teaching and Teaching Behaviour, (14) Teacher Education, (15) Educational Administration, (16) Higher Education and (17) Non-formal Education.
- *Second Survey of Research in Education (1972–78)*, M. B. Buch, ed. (Society for Educational Research and Development, Baroda, 1979): This publication incorporates 839 research studies completed during the period 1972–78 and follows the same pattern of organization of 17 research areas as *Fourth Survey of Research in Education (1973)*. The first chapter gives a broad perspective of the place and function of research for educational development including historical account of the development of educational research in India. Each subsequent chapter includes a report based on the abstracts of research studies giving the trend of research in the area including the gaps, and highlighting the research priorities as perceived by the author. The abstracts are arranged alphabetically for each area and continuously numbered throughout the volume. Each abstract contains the title of the study, the objectives and/or hypotheses examined, methodology including the sample, tools of research, the statistical techniques used and the findings. A special feature of this publication is the incorporation of a large number of studies on educational problems completed in the university departments of social sciences and humanities other than the departments of education. The trend reports are based not only on the research completed during the period 1972–78, but also on the total research activities during the period 1940–78.
- *Third Survey of Research in Education (1978–83)*, M. B. Buch, ed. (National Council of Educational Research and Training, New Delhi, 1987): The publication consists of 20 chapters beginning with a comprehensive review of the general trend of research in education in India based on a quantitative and qualitative analysis of the studies. The trend reports in different areas of education have been developed by eminent educationists on the basis of studies conducted during the period of four decades, from 1943 to 1982. In all, 1481 research abstracts have been presented after being classified under 17 areas. Each research abstract reports in brief the problem, objectives of the study, research techniques adopted, and the findings and conclusion of the study. A special feature of the volume is the chapter 'Research on Indian Education Abroad', which presents a review of 192 doctoral dissertations submitted to American and British universities covering a period of around two decades. Another significant inclusion in the volume is the chapter on 'Priorities in Educational Research'. The volume also makes available at one place a complete list of all researches in education conducted in India till 1983.
- *Fourth Survey of Research in Education (1983–88)*, M. B. Buch, ed. (National Council of Educational Research and Training, New Delhi, 1991): This publication, published in two volumes, covers researches in education till 1988. It comprises 31 chapters beginning with a comprehensive review of the general trend of research followed by trend reports in different areas of education developed by eminent educationists on the basis of studies conducted during the period of about four and a half decades—1943–88. In all, 1652 research abstracts have been presented after classification in 29 areas. The volume makes available a complete list of all the 4703 educational researches

conducted in India since 1943. The Fourth Survey has a new dimension. There is a chapter on 'Review of Research' at the M.Phil. level in Indian Universities.

▲ Newspapers and Pamphlets

Many articles of particular interest to a researcher may be located through pamphlets and newspapers. Current newspapers provide up-to-date information on speeches, seminars, conferences, new trends and a number of other topics. Old newspapers, which preserve a record of past events, movements and ideas, are particularly useful in historical inquiries. Some libraries catalogue pamphlets and newspapers in their reference sections.

▲ Government Documents

Government documents are a rich source of information. They include statistical data, research studies, official reports, laws and other materials that are not always available elsewhere. These are available in national, regional, state as well as local-level government offices.

▲ Monographs

Monographs are also major sources of information on ongoing research. In the USA, universities and teachers' colleges publish many research studies in education in the form of monographs. A few examples of these are supplementary educational monographs, educational research monographs and Lincoln School monographs. In England also, various institutes of education publish monographs from time to time. In India, only some universities and research organizations publish a limited number of monographs.

▲ Computer-generated Reference Materials

School Research Information Service (SRIS), Direct Access to Reference Information (DATRIX) and Psychological Abstract Search and Retrieval Service (PASAR) in the USA provide a number of computer-generated reference sources that may save a great deal of time and effort of the researchers. SRIS operated by Phi Delta Kappa (Bloomington, IN) provides a computer printout of abstracts for a moderate fee. DATRIX, a development of the University Microfilms (Ann Arbor, MI) provides computerized retrieval for *Dissertation Abstracts*, from 1928 to date. The researchers can procure information on microfiche or Xerographic copy of the complete dissertation, which they need, from *University Microfilms*, on payment. The PASAR furnishes printouts of abstracts of psychological journal articles, monographs, reports and parts of books for a moderate fee.

Research sometimes requires courage. The history of science reveals that many important discoveries were made in spite of the opposition of political and religious authorities. The Polish scientist Copernicus (1473–1543) was condemned by church authorities when he announced his conclusion concerning the nature of the solar system. His theory that the sun, not the earth, was the centre of the solar system in direct conflict with the older Ptolemaic theory, angered supporters of prevailing religious dogma, who viewed his theory as a denial of the story of creation as described in the book of Genesis. Modern researchers in such fields as genetics, sexual behaviour, and even business practices have aroused violent criticism from those whose personal convictions, experiences or observations were in conflict with some of the research conclusions.

From the examination of the above characteristics, it is evident that the knowledge gained by research is of highest order. It is not based on assumptions, beliefs and untested generalizations. To seek such knowledge a researcher must develop scholarship, accurate observation, integrity, willingness to spend long hours to collect and study all forms of evidence before arriving at conclusions, scholarship and ability to recognize causal relationships and originality and objectivity in thinking. However, it must be recognized that such ideals serve as goals for which researchers should strive. Being human beings, it is difficult for researchers to realize all ideals completely.

▲ Summary

- The review of related literature is the master step in a process of research.
- The study of selected literature implies locating, reading and evaluating reports of research.
- Every type of information, written or verbal, printed or hand written, contained in books or journals, newspaper, thesis, dissertation, which in some way or other connected with the problem or research, is known as related literature.
- For the preparation of the report of the related literature, the researcher should arrange the bibliographic and content cards according to proposed outline of the problem.
- The report of the related literature should begin with an introductory paragraph describing the organization of the report.

▲ Key Words

- *Study of Related Literature*: It implies locating, reading, and evaluating reports of research as well as reports of casual observation and opinion of individuals.
- *Primary Source*: It is a direct source material in Education.
- *Secondary Source*: This is an indirect source material in Education.
- *Research Abstract*: It provides a summarized list of reference sources, including brief summaries of each research work.

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Research, is a process of testing rather than proving and implies an objectivity that lets the data lead where they will. If research is defined as an attempt to solve a problem, it is implied that the researchers select certain directions into which they move. There may be several possible directions, which appear as yielding solution to a problem. The researchers can do one thing: they may go in each direction one by one and if they fail in one case, try the other direction. This is called trial-and-error way of solving the problem. This results in a great wastage of time and energy. Hypothesis of research is just the way of solving a problem, and an important tool of research. The scientific investigation of research process is to formulate hypotheses. It is a tentative solution of a problem.

Concept of educational research, its meaning and forms have been discussed in Chapter 4. Now, we have to know in detail the process of research, how different steps are followed by a researcher in the solution of a problem and formulation of a principle or theory. Recent technological and social changes demand development of new courses and curriculum for students in educational institutions. All these developments constantly bring forth new problems for research.

A scientific study and successful solution of these problems is not an easy task. Researchers have to undertake many steps in a well-regulated order for the solution of problems concerning different aspects of education. In other words, we can say that all such problems in education need to be carefully evaluated through a well-regulated research process. This process of research involves the following steps:

- Identification and definition of the problem
- Survey and related literature/relevant information
- Formulation of hypotheses
- Collection of data
- Analysis of data
- Conclusions and generalizations

In this chapter, we shall deal with these steps in detail and acquaint ourselves with the different techniques/procedures, which a researcher generally uses in arriving at the solution of the problem.

All these steps can be shown by a flowchart as given in figures 5.1, 5.2 and 5.3.

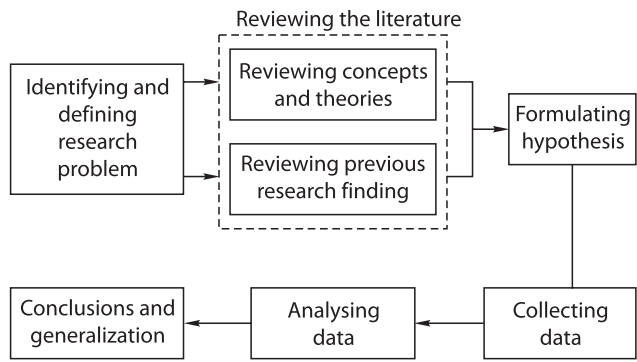


Figure 5.1 Flow chart of research process

Paradigm of Research Process

Figure 5.2 schematically represents the paradigm of a research process.

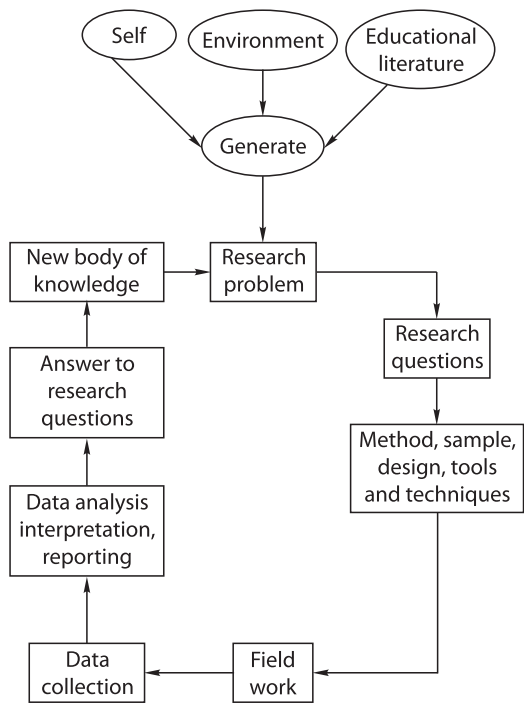


Figure 5.2 Paradigm of research process

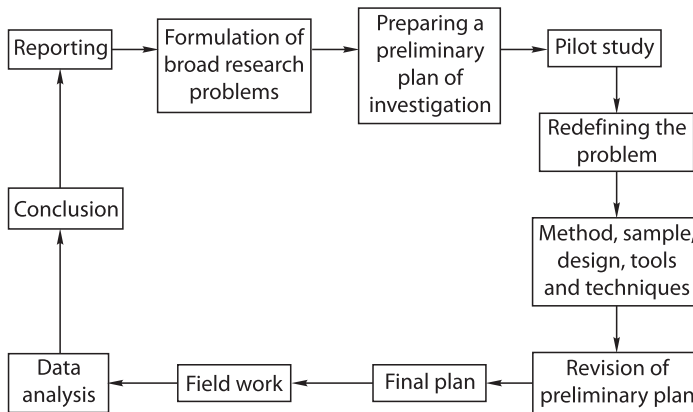


Figure 5.3 Steps of the research process in detail

Identification and Definition of a Problem

The foremost step of research process, i.e., identification and definition of a problem, consists of two parts. First part is concerned with identification of a problem and second one with definition of a problem. Identification of a problem means to ‘identify’ the problem first. Here, the researcher is required to undertake a few steps. The first step in the identification of the problem is the selection of the area. It should be according to the interest and ability of the researcher.

Selection of Area

A thorough understanding of the known facts and ideas in the area selected is the first and foremost step in selecting a problem. This helps the researcher in identifying various problems that remain unsolved.

Initially, the problem is stated in a broad general way and then it is solved. After selecting the broad area, the researcher must narrow it down to a highly specific problem because it is not possible to list all the educational problems.

Researchers select a problem according to their unique purposes. There are few sources which help the researchers in selecting the problem and at the same time help in giving a definite shape to the problem. Some of the important sources are listed as follows:

- List of theses already published can suggest other problems in the same, related or so far neglected areas, e.g., *University News* Published by Association of Indian Universities (AIU) New Delhi.
- One of the most fruitful sources of problems for the researchers is their own experiences, which they have acquired as professional educators. Thus, many of the problems confronted in the classrooms/schools lend them to investigation. In the classroom, there is dynamic interaction between teacher and pupil, between pupil and material and between pupil and pupil.

This interaction acts as a rich source of problems. These problems are solved through educational research. Classroom lectures, class discussions, seminars, reports and exchange of ideas outside the classroom environment suggest many problems.

- Researchers should take advantage of the knowledge, which they have accumulated in the past. The review of this knowledge will acquaint them with the current knowledge in the field of their study. They should review two types of literature: the conceptual literature concerning the concepts and theories and the empirical literature consisting of studies made earlier, which are similar to the proposed one.

The basic outcome of this review will be the knowledge as to what data and other materials are available for operational purposes, which will enable the researchers to specify their own research problem in a meaningful context.

- Contacts and discussions with research-oriented people, attending, conferences, seminars and listening to the learned speakers are helpful in locating research problems.
- Another source of research problem lies in the inferences that can be drawn from educational and psychological theories known to the researchers. The application of general principles involved in various theories to specific classroom situations suggests important problems for research.
- Problems that have come forth as a result of technological and social changes.
- The best way of understanding the problem is to discuss it with one's own colleagues or with those having some expertise in the matter. In academic institutions, the researchers seek the help of guides who are usually experienced persons and have several research problems in their mind.

This in turn helps the researchers in clarifying their thinking, in achieving a sense of focus and in developing a manageable problem from the one that may be vague and complex otherwise. Thus, we see that selection of a problem can be made from a number of sources.

At the same time, researchers should be careful to select only that problem which they feel is interesting, new, significant and feasible by taking into consideration its academic and economic aspects.

The next step after selecting the problem is to define it in the form of a meaningful statement.

Defining the Problem

Defining a problem means to pinpoint the problem or to reach the core of the problem, i.e., threadbare analysis. According to Whiteny (1964), 'to define a problem means to put a fence round it, separate it by careful distinctions from like questions found in related situations of need'.

According to Hillway (1964), researchers should keep in mind the following rules while defining a problem.

- They should make sure that the chosen topic is neither too vague nor too broad in scope.
- They should make the problem clearer and more understandable.
- They should state it in a question form, which requires a definite answer.
- They should carefully state the limits of the problem, eliminating all aspects and factors, which will not be considered in the study.
- They should identify the variables involved in the problem, i.e., independent, dependent, moderator, control and intervening variables.
- They should define any special terms used in describing the variables indicated in the statement of the problem.

From the rules, it is clear that in the formal definition of the problem, researchers are required to describe the background of their study, its theoretical basis and underlying assumptions. After knowing all these, they are in a position to state the problem in a concrete, specific and workable question.

Thus, definition of the problem involves two steps:

- Statement of the problem
- Operational definitions of the main words in the statement

Statement of the Problem

As we have learnt that in the formulation of a problem, the researchers write down the statement. It is in the form of a brief and clear question. Statement of the problem is not exactly the same as the title of thesis. According to C. V. Goode (1954), 'as a rule, the title of thesis can do no more than name the topic or the particular field represented'. It means that the title is nothing except a 'topic of research', while the statement of the problem is something different. It is an attempt to focus on a clear goal. It finds a definite place in the introductory chapter in one or two paragraphs.

A good statement of the problem must clarify exactly what is to be determined or solved. It must restrict the scope of the study to a specific research question. The most important step in this direction is to specify the variables involved in the questions and define them in operational terms.

Example

Suppose a researcher is interested in studying the creativity of engineers and doctors. This statement is broad and infinite. Now what are the researchers supposed to do? They delimit the range of the problem in terms of their interests and skills. They can state the problem more specifically as follows: 'A Comparative Study of Engineers and Doctors Belonging to Different Socio-economic Status in Relation to Their Creativity'. Still the delimitation is not complete. Next step for delimitation is to give operational definitions of the terms used in the topic.

Operational Definitions

Here, the terms used in the topic are defined by specifying what they will mean in the investigation. Care should be taken so that the meaning should be within the accepted concept of the words and not beyond that. The delimitation of the main words, e.g., in the above problem, may be done in the following manner.

- For delimiting the population of engineers and doctors, the population from which the samples will be taken will have to be described as, engineers and doctors studying in the final year of their respective colleges and universities situated in the NCR of Delhi.
- We may define socio-economic Status (SES) and creativity by telling what tools will be used for measuring SES and creativity.

Many researchers keep delimitation apart from the 'definitions' and state only the limits of under it population, after giving the other definitions.

From the above discussion, we might have observed that operational definitions help in narrowing the scope of a general question to specific measurable and observable variables. The formulation of a general topic into specific research problem thus constitutes the first step in a scientific enquiry.

▲ Evaluation of the Problem

There are few questions, which need to be answered before the researchers start working on the problem. These questions are helpful in the evaluation of the problem on the basis of the personal suitability of the

researcher and that on the social value of the problem. Best (1977) mentioned the list of these questions as follows:

- Is this the type of problem that can be effectively solved through the process of research? Can relevant data be gathered to test theory or find the answer to the problem under consideration?
- Is the problem significant? Is an important principle involved? Would the solution make any difference as far as educational theory or practice is concerned?
- Is the problem new? Is the answer already available?
- Is research on the problem feasible? After a research problem has been evaluated, there remains the problem of suitability for a particular researcher. Some of the questions that should be raised are the following:
 - Am I competent to plan and carry out a study of this type? Do I know enough about this field to understand its significant aspects and to interpret my findings? Am I skilful enough to develop, administer and interpret the necessary gathering devices? Am I well grounded in the necessary knowledge of research, design and statistical procedures?
 - Are pertinent data accessible? Are valid and reliable data gathering devices and procedures available? Will school authorities permit us to contact the students, conduct necessary experiments or administer necessary tests, interview teachers or have access to important cumulative records? Will we be able to get the sponsorship necessary to open the door that otherwise would be closed to us?
 - Will we have the necessary financial resources to carry on this study? What will be the expenses involved in data gathering, equipment, printing, test materials, travel and clerical help? If the project is an expensive one, What is the possibility of getting a grant from the agencies like National Council of Educational Research and Training (NCERT), University Grant Commission (UGC), National Council of Teacher Education (NCTE), Ministry of Education and Social Welfare, Indian Council of Social Science Research (ICSSR) and other organizations?
 - Will we have enough time to complete the project? Will there be time to devise the procedures, select data gathering devices, collect and analyse the data and complete the research report?
 - Will we have the enough courage and determination to pursue the study in spite of the difficulties and social hazards that may be involved? Will we be willing to work aggressively when data are difficult to gather and when others are reluctant to cooperate?

Another important question is, Whether the problem is new or a repetition of the previous one? In fact, there is no purpose in studying a problem that had already been adequately investigated. However, even if the researchers want, they may repeat a study and can verify its conclusions or extend the validity of its findings in a situation entirely different from the previous one.

The question of significance of the problem usually relates to what researchers hope to accomplish in a particular study. The researchers should know that the problem, which they have undertaken, is likely to fill in the existing knowledge, to help resolve some of the inconsistencies in the previous research or to help in the reinterpretation of the known facts.

In brief, their findings should become the basis for theory and formation of principles. It should lead to new problems for further research. The research competencies of the researchers, their financial resources, the time at their disposal and administrative considerations are important criteria to determine the feasibility of research problem.

▲ Survey of Relevant Information

It is now clear from the first step of research process that researchers take the help of knowledge, which is already accumulated in the field. This review of the knowledge or study of related literature not only acquaints the researcher with the current knowledge, but also serves many other purposes like the following:

- It helps the researchers in delimiting and defining their problems.
- It helps the researchers avoid unfruitful and useless problem.
- It helps the researchers avoid unintentional duplication of well-established findings.
- It provides insight into statistical methods through which validity of the results is to be established.
- The most important reason for reviewing the related literature is to know about the recommendations of the previous researchers for further research, which they have listed in their studies.

The first step in reviewing the literature is concerned with identification of the material in the library. It can be done through the use of primary and secondary sources available in the library. Before we proceed further, let us first know the definitions of these primary and secondary sources.

Primary sources are those in which the author reports his own work directly in the form of research articles, books, monographs, dissertations or theses.

Secondary sources are those in which the author compiles and summarizes the findings of the work done by others and gives interpretation of these findings.

The use of primary sources is time-consuming in comparison to the secondary sources. The decision concerning the use of primary or secondary sources depends largely on the nature of the research study proposed by the researcher.

The second step in the survey of related literature/relevant information is to locate the source materials. For this, the researchers should be familiar with the library and its many facilities and services. They should also be acquainted with the regulations governing use and circulation of materials. Many libraries use a printed guide that contains helpful information regarding periodicals section, reference section, reading rooms and social collection of books and microfilm manuscripts.

The next task before the researcher is to identify the best available source pertaining to the problem and extracting the reliable information. For this we must develop some library searching techniques, i.e.,:

- The researchers should learn how to use the microfilm manuscripts photocopies and other mechanical aids.
- They should schedule their work section in the library in such a manner that they encounter the least competition for resources and services.
- They should keep a list of the best reference books, indexes, handbooks, historical studies and legal reference in their field of study.

Reference Books

A few reference books are mentioned in the following:

- *A Guide of Reference Books*, 8th ed., Constance M. Winchell (ed.), (Chicago: American Library Association, 1967).
- *Guide to Reference Material*, Albert J. Walford.
- *Reference Books: A Brief Guide for Students and Other Users of the Library*, Mary N. Barton and Marion V. Bell (1962).

- *International Guide to Educational Documentation (1955–1960)* (UNESCO, 1963).
- *Documentation in Education*, Arvind Burke and Mary Burke.
- *The Standard Periodical Directory* (New York: Oxbridge Publishing Company, 1964).
- *Guide to Reference Books for School Media Centres*, Christine L. Woner (Littleton, CO: Libraries Unlimited, 1973).

Encyclopaedias

Encyclopaedias are storehouses of information and usually contain well-rounded discussions and selected bibliographies that are prepared by specialists. The following are a few of them:

- *Encyclopedia of Modern Education*, Henry D. Rivlin and H. Schueller (eds) (New York: Philosophical Library, 1943).
- *Encyclopedia of Educational Research*, rev. ed. Walter Scott Monroe (ed.) (New York: Macmillan, 1950).
- *Encyclopedia of Educational Research*, 3rd ed. Chester Harris (ed.) (New York: Macmillan, 1960).
- *Encyclopedia of Educational Research*, 4th ed. Robert L. Ebel (ed.) (New York: Macmillan, 1969).
- *International Encyclopedia of the Social Sciences* T. Neville (eds) (New York: Macmillan, 1968).

Dictionaries

Dictionaries serve as a constant guide to the researcher. The following are a few known dictionaries:

- *Dictionary of Education* (New York: McGraw Hill Book Co., 1973).
- *Comprehensive Dictionary of Psychological and Psychoanalytical Terms* (New York: David McKay Company).
- *Dictionary of Sociology* (Totowa, NJ: Littlefield, Adams and Co.).

Yearbooks and Handbooks

Yearbooks and handbooks are also helpful to the researcher. A few known yearbooks and handbooks are the following:

- *The Handbook of Research on Teaching*, N. L. Gage (ed.) (Chicago: Rand McNally & Co., 1963).
- *The Rand McNally Handbook of Education*, Arthur W. Foshay (ed.) (Chicago: Rand McNally and Co., 1963).
- *Education Yearbook* (New York: Macmillan Co., 1972–).
- *Mental Measurements Yearbook* (Highland Park, NJ: Gryphon Press, 1938–).
- *Data Processing Yearbook* (Detroit: Frank H. Gille, 1952–).

Directories and Bibliographies

Directories are used for locating the names and addresses of persons, periodicals, publishers or organizations, when the researchers want to obtain informations, financial assistance or research materials and equipments. A few of them are follow:

- *Guide to American Directories*.
- *The Education Directory* (Washington: US Office of Education, 1912).
- *Directory of Exceptional Children* (Boston: Porter Sargent Publishing Co., 1962).

- *Mental Health Directory* (Washington: National Institute of Mental Health, 1964).
- *A Select Bibliographies of Adult Education in Great Britain*, Kelle Thomas (ed.) (London: National Institute of Education, 1952).
- *Bibliography of Doctorate Theses in Science and Arts* (1946–48 and 1948–50).

Index

Index identifies the source of the article or of the book. They are follows:

- *Educational Index* (New York: H. W. Wilson Co., 1929).
- *Canadian Education Index* (Ottawa, ON: Canadian Council for Educational Research, 1965).
- *British Education Index* (August 1954 to November 1958).
- *Index to Selected British Educational Periodicals* (Leeds: Librarians of Institutes of Education, 1954).

Research Periodicals and Journals

Information about new ideas and development often appear in periodicals long before it appears in books. These are the best sources for reports of recent research studies. A few of them are as follow:

- *Journal of Indian Education*, NCERT, New Delhi
- *Journal of Indian Education Review*, NCERT, New Delhi
- *Adhunik Bhartiya Shiksha*, NCERT, New Delhi
- *The Progress of Education*, Pune (Maharashtra)
- *The Educational Herald*, Hyderabad (AP)
- *Naei Shiksha*, Jaipur (Rajasthan)
- *Sodh Prabha*, LBS Vidyapeeth, New Delhi
- *University News*, AIU, New Delhi
- *Sindhu Garima*, CSTT, MHRD New Delhi
- *Pari Pechhya*, NUEPA, New Delhi
- *Kakatiya Journal of Distance Education*, Kakatiya University, Warangal (AP)

Abstracts

Abstracts include brief summaries of the contents of the research study. They are the following:

- Psychological abstract
- Educational abstract

Theses and Dissertations

Theses and dissertations also provide research material to the researchers. They are the following:

- *Dissertation Abstracts International*.
- *A Survey of Research in Education*, Buch, M. B., ed.

Newspapers, pamphlets, government documents and monographs also publish research articles of particular interest to the researchers.

After making a comprehensive survey of the related literature, the next step is to organize the pertinent information in a systematic manner.

▲ Formulation of Hypotheses

The purpose of research is to get a general principle. The very first step in this process, which we have already discussed, is to identify the problem and state it in clear-cut and operationally defined terms. This is possible only by reviewing concepts, theories and previous research findings. The next step in this process of research is to formulate hypotheses and test them. Before we go into the details of this step it is necessary first to acquaint ourselves with the meaning of hypothesis, its sources, qualities and types.

Meaning and Concept of Hypothesis

The term hypothesis consists of two words: hypo and thesis. ‘*Hypo*’ means tentative or subject to verification. ‘*Thesis*’ means statement about the solution of a problem. Thus, the meaning of the term ‘hypothesis’ is ‘a tentative statement about the solution of a problem’.

In accordance with John W. Best (1963), ‘it is a shrewd guess or inference that is formulated and provisionally adopted to explain observed facts or conditions and to guide in further investigation’. According to J. Mouly George (1970) ‘hypothesis is an assumption or proposition, whose tenability is to be tested on the basis of the compatibility of its implications with empirical evidence and with previous knowledge’.

The hypothesis, in a very general way, is defined as the tentative solution to the problem. It is a proposition or a statement, which implies that this may, perhaps, be the answer to the problem and needs to be tested for being established as a fact. According to Van Dalen (1956), ‘a hypothesis serves as powerful beacon that lights the way for the research worker’. It simply means that the hypothesis tells the researchers what to do, how to do and why to do all that in the context of problem–solution. For example, ‘a very bright student fails in the examination’. A researcher gets concerned with the problem and wants to know why, in spite of being bright, the student has failed. After reviewing various factors and circumstances that might have been responsible for this failure, the researchers make a conjecture that the student might have been seriously ill at the time of examination. This conjecture is the form of a hypothesis and determines what the researchers should do to verify whether it is a fact or not. They visit the house of the student to meet parents and enquire about the student’s health at the time of examination. The entire thing is determined by the hypothesis that they had developed.

Hypothesis refers to a conjectural statement about the solution of the problem, which the researchers verify on the basis of relevant information collected by them. It is said to be an informed or shrewd guess, inferences, supposition or hunch about what may be the solution of the problem or answer to a question. It is a statement which is tested and which implies linkages and non-linkages between variables in terms of their relationships, association, differences and prediction, after which the testing are either accepted or rejected. It is a possible explanation for the puzzling condition or event that concerns the researcher.

Importance of Hypotheses

Hypotheses serve various purposes such as:

- Providing direction to research and preventing wasteful activities such as review of irrelevant literature and collection of useless data or excess data and beating around the bush.
- Making the researcher sensitise to certain relevant aspects of the problem and focus on specific issues and select more pertinent facts.
- Clarifying the problem and methods to be used in solving the problem, which results into a systematic research activity enabling to specify and establish relationship between variables to be studied.

- Acting as a framework for the analysis and interpretation of the data and drawing conclusion.
- Suggesting where the researcher should search most profitably for facts and build logical and reasonable relationship between them.

According to Hodnett (1955), 'hypotheses are your eyes as you try to approach problems in a scientific manner. Through them you look into the disorder that is a problem and see the possibilities of order.' To Van Dalen (1962: 146), 'hypotheses are suggested problem-solutions which are expressed as generalizations or propositions. They are statements consisting of elements expressed in an orderly system of relationship which seek to describe or to explain conditions or events that have not yet been confirmed by facts.' In the words of Mouly (1964: 88), 'it is an assumption or proposition whose tenability is to be tested on the basis of the compatibility of its implications with empirical evidence and with previous knowledge.' Kerlinger says, 'an investigator bets first and, then, rolls the dice; he does not roll the dice and then bet; he cannot change his bet after the data are in (1964: 24)'.

All researches need to have research hypotheses irrespective of the nature and kind of research and irrespective of the fact whether the testable hypotheses are generated or not.

Some experts in the field are sceptic about the need for formulating hypotheses for research. Their argument is that if researchers begin with hypotheses, they develop a prejudice in favour of proving the hypothesis. This introduces a bias in the conduct of research, which results into an error affecting the internal-external conduct of research, that adversely affect the validities of the research. In this connection, the view expressed by Mouly (1964: 88) is worth noting, which says: 'Hypotheses are particularly necessary in studies where cause and effect relationship are to be discovered. They are, perhaps, less crucial in studies which the task is one of determining the status of a given phenomenon, although even in such studies the investigator is likely to need some tentative hypothesis to guide him to the areas worth exploring.' Further, Mouly says: 'Though hypotheses are generally useful guides to effective sign of a lack of scientific the historian formulates hypotheses.... But the type of hypotheses and procedures for testing used by the historian usually differ from those that are used by the physical scientist. In the context of descriptive studies they are of a somewhat lower order than those found in explanatory studies' (p. 235).

At present, it is largely believed that the hypothesis formulation can play an important role in all kinds of researches. But, it does not mean that a hypothesis is essential in all kinds of researches. Many descriptive and historical researches have been conducted and can be conducted without formulating hypotheses. But, the quality of research can be improved, particularly in case of situations in which relationship between variables is rough. A well-designed study, however, is supposed to have scientifically developed hypotheses.

▲ Construction of Hypotheses

The process of formulating good hypotheses is not simple. It calls for a good knowledge, deep insight and high level of imagination. Although, it is not possible to lay down precise rules for formulating hypotheses, yet a few conditions that are conducive to construction of hypothesis may be suggested. These are as follows:

- (i) *Background knowledge*: It is essential that the researchers should be thoroughly familiar with established facts, existing theories and previous research related to their problems. The related literature is the most important source of hypothesis formulation. A review of this literature may reveal the variables that have been considered important in relation to their problems. That is, the aspects of the relationships that have already been studied and that still remain to be

studied, the theories that supported the relationships and those that present contradictory relationships. While going through the relevant literature, the researchers may locate the key associations or missing data needed to explain puzzling phenomena. Familiarity with the related literature may give the researcher a tremendous advantage in the construction of hypotheses.

- (ii) *Experience*: One's own experience may be a rich source of hypothesis generation. While working in an environment one comes across many problems, some of which are really serious and requires hard thinking to solve them. For example, a researcher who is working on 'growing tendency to absenteeism among students' can know from experience that academic alienation in students, teachers and even in parents, general climate of the school, political interference, faulty examination system, poor teaching, poor background of students and poor control are the host of factors that may be responsible for the incidence. Just thinking critically about these, it is possible that constructive relationship among some of these factors as variables of student absenteeism spring into the consciousness of the researcher's mind. Personal experiences of individuals as can be seen in biographies, autobiographies, newspaper readings, informal talks among friends and socio-political speeches can be the potential sources of generation of hypotheses. Mouly (p. 90) holds a view that 'a good hypothesis can come only from experience. Some degree of data-gathering such as the recall of past experience, the review of literature or a pilot study most, therefore precede the development and gradual refinement of the hypothesis'.
- (iii) *Analogies*: Van Dalen, 1962 (p. 150) view analogy as 'an ancient order searching tool that man uses to build bridges from the known to the unknown'. Reasoning by analogy is based on similarity and differences between two situations in which the causes of student unrest, the researchers argue within themselves, are as follows: Why the students were not so aggressive, disobedient, disrespectful and rowdies 20–30 years back as they are today? What has changed them; is it the quality of teaching; is it the quality of teachers? Arguing analogically in this way may lead the investigators to clues that may be used for identifying variables and relationships, which form the basis of hypothesis construction, e.g., by comparing the two situations, analysing their similarities and differences. Some rationale may emerge in the mind, which may be an explanation of the phenomenon of student unrest that may take the form of a hypothesis for testing.
- (iv) *Scientific theories*: A systematic review and analysis of theories developed in the field of psychology, sociology, economics, political science and even in biological science may provide the researchers potential clues for constructing hypotheses. For example, a researcher working on student activism may be benefited by the general theory of human behaviour developed in psychology, which says that behaviour (good or bad) is a function of personal and environmental factors interacting with each other.

Whatever be the sources of hypotheses, the relationship visualized between variables involved in the hypotheses must be based on sound rationale supported by some theory, previous research, experience or sound arguments.

Thus, we can define hypothesis as an informed, shrewd guess, inference, hunch or a tentative generalization to the existence of some fact, condition or relationship relative to some phenomena. This shrewd guess or inference serves to explain such facts, which are already known to exist in a given area of research and to guide the search for new truth.

▲ Sources of Hypotheses

The sources of the hypotheses are the same as that of the ‘problem’, which are:

- Study of book related to subject
- Review of research reports and related researches, references, literature (discussed in detail under Section ‘Survey of Relevant Information’)
- Reading of contemporary newspapers and research journals
- One’s own experience
- Conversation with specialists in the field
- Survey of existing situation

But all these sources do not supply ready-made hypotheses. Here the researchers have to apply their creative thinking and ingenuity. For constructing good hypotheses, the researchers usually use two logical processes:

- Inductive thinking
- Deductive thinking

Let us explain both the processes with an example.

Example

- The voters for the parliament are adults (a general truth).
- Amita is a voter for the parliament.
- Amita is an adult (a specific truth).

What do we observe in the said example? We observe that we are extracting a specific truth from a general truth. This is an illustration of deductive thinking in which we deduce specific truth from the general one. But in inductive thinking the procedure is different. Instead of saying that voters for the parliament are adults and then extracting the conclusion that Amita is a voter for parliament, we proceed in the opposite direction, i.e., we will first:

- (i) Examine the age of all the voters of the parliament.
- (ii) After examination, we will find that they are adults.

Now we can say that voters of the parliament are adults (generalization). This process is known as inductive reasoning, i.e., in which we extract a general truth from the specific one.

▲ Qualities of a Hypothesis

Some of the qualities of a good hypothesis should be maintained while formulating it. Travers (1978) suggested some qualities of a hypothesis as follows:

- It should be clearly and precisely stated.
- It should be testable.
- It should state the expected relationship between variables.
- It should be limited in scope.

- It should be consistent and pertinent to the most known facts.
- It should be stated as far as possible in simple terms.
- It should be amenable to testing within a reasonable time. It means that a hypothesis is of great value, if its acceptance or rejection is utilizable for many purposes or opens the door for further research.

For example, the acceptance of hypothesis related with research problem mentioned in the first step will be helpful in finding appropriate creative opportunities to doctors and engineers coming from the middle and lower socio-economic status.

▲ Importance of Hypotheses

The importance of a hypothesis is generally realized in the studies which aim to make predictions about some outcome. Since experimental studies aim at making predictions about the outcome of the experiment, the role of a hypothesis is considered to be of utmost importance. A hypothesis is recommended for all major studies to explain observed facts, conditions or behaviour and, hence, it serves as a guide in the research process. The hypothesis saves time and energy of a researcher in gathering extensive empirical data and in detecting relevant relationships between variables. Without a hypothesis the researcher would find it difficult, laborious and time-consuming to identify pertinent facts needed to explain the problem under investigation. A hypothesis provides definite point to inquiry, aids in establishing direction in which to proceed and helps in delimiting the field of investigation by identifying the specific facts on which to concentrate and specifying the facts which are to be weeded out.

- A hypothesis provides tentative explanations of facts and phenomena. Such explanations, if held valid, lead to generalizations, which help significantly in understanding a problem and thereby extend the existing knowledge in the area to which they pertain.
- A hypothesis provides direction to research. It represents specific objectives and thus helps in identifying the type of data needed to test the proposition. It helps in the selection of relevant facts and variables that the researcher needs in this study. A hypothesis provides basis for selecting the sample and the research procedures to be used in the study. Data analysis techniques (qualitative and quantitative) needed are also implied by the hypothesis. It also helps the researcher to delimit their study in scope so that it does not become broad or unwieldy.
- A hypothesis provides basis for reporting the conclusions of the study. It is convenient for a researcher to test each hypothesis separately and draw conclusions relevant to each hypothesis.

▲ Types of Hypotheses

Generally, hypotheses are classified into two types:

- Directional hypothesis
- Non-directional hypothesis

Directional Hypothesis

It is the one which stipulates the direction of the expected difference or relationships. For example, 'engineers will have more mechanical interests than the doctors'.

Non-directional Hypothesis

It is the one which does not specify the direction of the expected difference or relationship. For example, 'There is a difference in the mechanical interests of engineers and doctors.'

A research hypothesis can be in any one of the following forms:

- (i) Declarative form
- (ii) Null form
- (iii) Question form

In *declarative form*, the researcher makes a positive statement. For example, 'The mechanical interests of engineers are significantly more than that of doctors.'

In *null form*, the researcher makes a statement that no relationship exists, e.g., 'There is no significant difference in the mechanical interests of engineers and doctors,' and the difference that the researcher has found by measurement is only by chance. Because of this sort of no difference assertion of the null hypothesis, this is called by some as a hypothesis of null difference.

The null hypothesis is used for denying many other forms of researcher hypothesis also. For example,

- If a researcher's hypothesis says that there is a correlation between two variables, the null hypothesis declares that there is no correlation if the entire population is taken; and whatever correlation comes is due to sampling chance.
- If the researcher's hypothesis says that distribution of a trait in a population is not normal, the null hypothesis would say that it is normal and non-normality in the sample taken is merely due to sampling chance.

They are also called the testing hypothesis when declarative hypothesis is tested statistically by converting them into a null form. The statisticians use the null hypothesis because it is testable statistically.

In the *question form hypothesis*, a question is asked as to what will be the outcome instead of stating what outcome is expected, e.g., 'Is there any difference in the mechanical interests of engineers and doctors?' After knowing in detail about the word hypothesis, its sources, qualities and types, we are in a position to formulate hypotheses. For any research problem, it is generally possible to derive more than one hypotheses.

Researchers formulate hypotheses by using both induction and deduction approaches. One of the goals of the research is to produce or formulate a principle or a theory, which will provide answers to practical problems.

Now in order to be plausible and have a chance of coming out true, the hypothesis must emanate from the study of previously discovered facts and theories, which the researchers might have made, or out of their own experiences or in discussion with people who may be the specialists in that field.

As research looks for correct generalizations, it would be a sheer wastage of time to offer hypothesis at random to arrive at the correct one by trial and error. Of course, this does not mean that the researcher's hypothesis must always come out true.

There are no precise rules for formulating hypothesis and deducing consequences from them that can be empirically verified. However, there are certain necessary conditions that are conducive to their formulation. These are as follows:

- A researcher may deduce hypothesis inductively after making observation of behaviour, noticing trends or probable relationships. Background knowledge, however, is essential for perceiving

relationships among the variables and to determine what findings other researchers have reported on the problem under study.

- Hypotheses can also be derived through deductive reasoning from a theory. Such hypotheses are called deductive hypotheses.
- Analogies also help the researcher in the formulation of hypotheses by providing clues.

▲ Forms of Hypotheses

A lot of confusion prevails among the researchers about the forms of hypotheses. There are critics who go to the extent of saying that hypothesis formulation is an artefact of authors of the books on research methodology. Their view is that research needs no hypothesis. However, the agreement among the experts is that hypothesis is unavoidable in certain kinds of researches while in some others it is desirable and useful.

Following are the forms of hypothesis, generally used in research.

Question Form

Researchers, having finalized their problem of research, raise certain questions which must be answered through their research. These become their research questions. They express them in the form of questions. For example, if the research problem is, 'a study of student's unrest', they ask questions such as 'What causes students unrest?'; 'Is school organizational climate responsible for this?'; 'Is teacher's teaching ineffectiveness the cause of this?'; 'Is socio-political ecology responsible for this?'. All these are, then, the research questions. In order to find suitable answers to these questions they collect relevant data and analyse them. The process of finding answer is the same as that is adopted in testing other forms of hypotheses. Answering these questions requires a systematic approach and a well-thought-out research design. Such research questions a systematic approach and a well-thought-out research design. They also determine the objectives of the research, variables to be measured, techniques of analysis to be used, results to be drawn and discussed. All researches have research questions irrespective of the fact whether they are written or not, fundamental or applied research, historical research or written or not. All researches may not require hypotheses, but all researchers need to have research questions. Research questions are generally called interrogative hypotheses, though put in a slightly different significantly in favourable and unfavourable institutional climates. The interrogative hypothesis is tested in the same way as other hypotheses are tested. They, too, are accepted or rejected. After testing interrogative hypothesis, a simple post-tested statement is derived based on which generalization can be made.

Research Hypothesis and Null Hypothesis

This is another area where some researchers are confused. Some of them are bewildered as to why should there be a null hypothesis. Even some professors are found to believe that the need for null hypothesis is superfluous. Some authors have written in their books that null hypothesis is another form of directional hypothesis, which is entirely wrong.

The research hypothesis is the theory on which the whole research process is built. It is a positive and general kind of statement, e.g., "There is difference between levels of intelligence of boys and girls".

It is an affirmative statement. There are different names given to the research hypothesis such as 'H' or the 'general hypothesis', 'empirical hypothesis', 'problem hypothesis', 'experimental hypothesis',

‘theory’, ‘substantive hypothesis’, ‘alternative hypothesis’ or ‘operational hypothesis’. This is the form of the hypothesis which cannot be directly tested, proved or disproved.

This is the hypothesis, which constitutes the prediction derived from the theory under test. It is said to be alternative hypothesis as the conclusion about it is drawn only after accepting or rejecting the full hypothesis. Sigel (p. 7) says: ‘If it (i.e., H_0) is rejected the alternative hypothesis (H_1) may be accepted.’ The alternative hypothesis is the prediction derived from the theory under test.

The null hypothesis is the negative statement, which denies what is asserted in the research hypothesis. For example, saying ‘there is no difference in the levels of intelligence of boys and girls’, is a null hypothesis, which denies the theory implied in the research hypothesis. The null hypothesis is also called as H_0 (the hypothesis of no differences), statistical hypothesis or hypothesis of negation. Null hypothesis is formulated for the express purpose of being rejected. If it is rejected, the alternative hypothesis (H_1) may be accepted. The alternative hypothesis is the operational statement of the experimenter’s research hypothesis. The research hypothesis is the prediction derived from the theory under test (Nunnally, p. 7). H_0 is tested against H_1 .

The relationship between research hypothesis (H) and null hypothesis (H_0) is such that if H_0 is rejected, H is accepted, which is the alternative hypothesis. If, on the other hand, H is accepted, the alternative or research hypothesis is rejected.

Directional and Non-directional Hypotheses

This is the classification of hypothesis from the viewpoint of the direction of prediction made in the research hypothesis. When a research hypothesis is stated it may say that ‘there is difference between the two means’. It does not say which mean is greater or smaller. If it says that a particular mean is higher or lower than the other, it would be directional as the direction of difference is indicated in this. Higher or lower can only be in one direction. In case of a directional hypothesis, differences will indicate whether the other mean is higher or lower. It cannot be both. But, in case of non-directional hypothesis the difference can be in any direction. Any mean can be higher or lower. In case of non-directional hypothesis the experimenter is not interested in testing which mean is significantly higher or lower than the other but only wants to know whether the difference between the two is significant or not. In case of directional hypothesis, his objective is to test whether a particular mean is significantly higher than the other or not. Higher can be only in one direction. In this case the positions of the two means are fixed. They cannot be changed. Referring to normal distribution curve, the mean which is lower will occupy the central position and the mean which is higher will be located on the right half of the curve, i.e., the differences to be tested will be taken only on one-half of the curve. The following examples will clarify the differences between the two types of hypotheses:

- There is a significant difference between the achievements in mathematics of boys and girls (non-directional).
- The achievement in mathematics of boys is higher to that of girls (directional).

It to be remembered that at the testing stage each of these directional and non-directional hypotheses has to be converted into null hypothesis as follows:

- There is no significant difference between the achievements in mathematics of boys and girls (non-directional null hypothesis).
- The achievement in mathematics of boys is not higher to that of girls (directional null hypothesis).

▲ Necessity of Null Hypothesis

A question is, generally, asked: 'Why is it necessary to have a null hypothesis?' It is an admitted fact that the use of null hypothesis is unavoidable in case of experimental research and desirable in case of other kinds of researches. The reason is that there is no statistical method or technique, which can directly test the research hypothesis. All statistical tests are tests of null hypotheses. Only, indirectly, by rejecting or accepting the null hypothesis one arrives at the conclusion about the research hypothesis. The argument follows the same theory, which is operative in the courts of law. If a plaintiff makes an allegation against some person, the court does not accept that and says, 'no' he has not done that crime. Then, the burden of proof lies on the plaintiff who has to disprove the court's no-hypothesis. Only by disproving court's null hypothesis the plaintiff can prove his allegation.

In historical research, for example, if the question to be answered is 'Did Shahjahan build the Taj Mahal?' the researchers will have a null hypothesis 'Shahjahan did not build the Tajmahal'. Then, the researchers will have to collect evidence which rejects this null hypothesis. If they succeed, their original question is answered in the affirmative.

▲ Criteria for Judging the Value of a Hypothesis

While formulating hypothesis the researchers must evaluate how good or appropriate are their hypotheses. Van Dalen (pp. 167–73) describes following criteria for judging the value of a hypothesis.

- (i) *Plausibility of explanation*: This means that the hypothesis must be logically consistent, pertinent to the question under consideration and not in contradiction with laws of nature. For example, the hypothesis 'That the number of tables and chairs in a school determines the level of children's academic achievement' makes no sense. The explanation given has nothing to do with the problem. It is irrelevant.
- (ii) *Testability of explanation*: This means that the consequence deduced from hypothesis must be testable. A hypothesis cannot be tested if it is stated vaguely and whose terms or variables cannot be defined operationally. Involving such terms as 'good', 'bad', 'poor' and 'best' render a hypothesis untreatable many a time because it is difficult to say who is good or poor.
- (iii) *Adequacy of scope*: This means that a hypothesis must be capable of explaining and testing sufficiently a large number of consequences. If it explains just one or two aspects it is of no use. For example, the hypothesis 'that the reading interests of high school students of school-A are poor' is not only vague and untreatable, but has a very limited scope of generalization. Nothing can be said on the basis of its findings about the reading interests of school-B. A hypothesis is of greater value if its findings can explain many areas of the problem and can be applied in many fields of knowledge.
- (iv) *Roots in existing theories*: This means that the relationship that is assumed between the independent and dependent variables involved in a hypothesis must be supported by some scientific theory, i.e., the relationship visualized must be rational. It must be reasonable based on some theory or discovered truth. For example, 'the kind of food that a man eats determines his philosophy of life' is a hypothesis that is not backed by any psychological or biological theory. The relationship between the kind of food eaten and the philosophy of life of man has no rational underlying. No theory supports this hypothesis.
- (v) *Simplicity of explanation*: This means that the hypothesis should explain the phenomenon with the least complex theoretical structure. The hypothesis must explain the existing data in as simple terms as possible, i.e., it must explain the most in simplest terms. It must be stated as simply and concisely as the complexity of the concepts involved.

■ Criteria for a Good Hypothesis

A good hypothesis should meet the following criteria:

- *It should be stated as far as possible in simple terms:* Stating the hypothesis in simple terms not only makes their meaning clear to others, but also helps in their testability. Moreover, the simplicity of statement provides a basis for a clear and easily comprehensible report at the completion of the study.

A hypotheses should not make use of the vague terms or constructs. It is quite useless to formulate a hypothesis that makes use of the terms or constructs which do not convey the intended meaning to the reader. The researcher should make use of such terms that are generally accepted for naming a phenomenon.

- *It should be consistent with most known facts:* A hypothesis should not be inconsistent with a substantial body of established facts. They should be grounded in the well-established theories and laws. Consider the hypothesis: 'There is no relationship between the self concept of adolescent male students and their rate or physical growth.' This hypothesis is not worth testing because the preponderance of evidence supports the relationship between self-concept and rate of physical growth.

A hypothesis, however, cannot be consistent with all known facts because in so many areas the facts themselves contradict one another. In such cases it is worthwhile to formulate hypotheses that resolve the contradiction.

- *It should be limited in scope:* Hypotheses of global significance are not usable as they are not specific and simple for testing and drawing conclusions. The beginning researchers, however, are overly ambitious in their initial efforts and formulate hypotheses of global significance. It is partly because of their earnestness and partly because it takes maturity of viewpoint to realize how little can be accomplished in a specified period. It is desirable to formulate hypotheses that are simple to test, yet are highly significant. Sometimes it is of course possible to state a rather broad research hypothesis and derive a number of operational hypotheses from it.
- *It should be amenable to testing within a reasonable time:* The researchers should not select a problem which involves hypotheses that are not amenable to testing within reasonable specified time. They must know that there are problems that cannot be solved for a long time. These are problems of immense difficulty that cannot be profitably studied because of the lack of essential techniques or measures.
- *It should state the expected relationship between variables:* A satisfactory hypothesis should state explicitly an expected relationship between the variables. Let us consider two hypotheses:

- (i) High-school students who attend NSS programmes show greater moral growth than students who do not.
- (ii) Extraversion, as measured by the Maudsly Personality Inventory, will be related positively to achievement in social studies of VII grade students, as measured by standardized test.

The first hypothesis is not usable because the term 'greater moral growth' does not refer to a variable that is measurable at the present time, or likely to be measured in the near future (Koul 1997: 77). On the other hand, the second hypothesis refers to the variables 'extraversion' and 'attainment in social studies' that can be measured by Maudsly Personality Inventory and the standardized tests, respectively. Moreover, the relationship posited in that the personality variable and the attainment variable will be related positively.

- *It should be testable:* A hypothesis should be formulated in such a way that they can be tested or verified. Such hypotheses enable the researcher to determine, by observation, whether those consequences that are derived deductively, actually occur or not. If the hypotheses are not testable, it would be impossible either to confirm or contradict them and therefore they do not help the researcher to draw conclusions. For example, the hypothesis: ‘The NCC programme promotes the all-round adjustment for the high-school students would be hard to test because of the difficulty of defining and measuring all round adjustment.’ Moreover, it would be difficult for the researcher to isolate other factors that might contribute to the adjustment of high-school students.

Since hypotheses are predictors of the outcome of the study, they must relate variables that are capable of being measured. It is essential that the tools of instruments should exist (or can be developed), which will provide measures of the involved variables. If no tools or means are available for measuring the variables, then it would be impossible for the researcher to collect the data necessary to test the validity of the hypotheses. A hypothesis, therefore, should define the variables operationally by stating the operations or procedures necessary to measure them. For example, the hypothesis: ‘There is a negative relationship between neuroticism and achievement in mathematics of fifth grade students’ meets the criterion of testability because the variables involved in the statement can be defined operationally. Neuroticism might be defined as ‘the scores made on the neuroticism stability scale of “Maudsly Personality Inventory” and achievement in mathematics defined as “marks obtained in mathematics by the fifth grade students in their annual examination”’.

- *It should be clearly and precisely stated:* When hypotheses are clearly stated they usually avoid the use of general terms such as personality, intelligence and social class in their statements. On the other hand, the researcher may use ‘personality as measured by the Sixteen Personality Factor Questionnaire’, ‘intelligence as measured by Raven’s Progressive Matrices’ or ‘social class as defined by socio-economic status scale by Jalota et al.’ The clear statement of hypotheses generally involves concise technical language and definition of terms that are better defined than those in common language.

Evaluate Yourself

- (i) Define hypothesis.
- (ii) Discuss the importance of hypothesis.
- (iii) Describe various types of hypotheses. Give one example of each type.
- (iv) What are the characteristics of hypothesis? Illustrate your answer with the help of examples.

Testing of Hypotheses

A good hypothesis is amenable to testing within a reasonable specified time. Hypotheses are tested empirically as well as logically. A simple hypothesis can be tested directly. However, hypotheses of complex nature cannot be tested directly. Such hypotheses are tested in terms of their deduced consequences. Once all the deduced consequences come out to be true, the hypotheses are confirmed. If some of the consequences are true and certain others untrue, then the hypotheses need to be examined afresh. All the factual evidence collected through tests or other means should correspond with the deduced consequences. The consequences are logically deduced from the hypotheses.

After formulating a hypothesis, the researchers have to test the hypothesis. This is to be done step by step. First, they deduce its consequences, then conduct experiment or collect evidence to show that the consequences actually occur, and then test, i.e., prove or disprove the hypothesis by applying some statistical test in case of experimental research or using internal–external criticism in case of historical research or critically analysing the data in case of qualitative research. It must be remembered, however, that a hypothesis is never proved; it is merely sustained or rejected (Mouly 1963: 93). If rejected, it may be modified or replaced. The confirmation of hypothesis is always tentative and relative. It is always a matter of probability rather than of certainty.

Hypotheses are generally tested indirectly. First, the consequences are deduced and then, experiment is conducted or data are collected to test whether the consequences actually occur or not. For example, if the hypothesis is ‘effective teachers have a high morale’ this cannot be tested as it is. So consequences are deduced as follows: Ineffective teachers should have low morale, effective teacher should have higher level of morale as compared to that of the ineffective teachers. Hence, for the purpose of testing the hypothesis will be stated as: ‘The morale level of effective teachers will be significantly higher to that of the ineffective teachers.’ This can be tested directly. Van Dalen (p. 160) said: ‘Empirical support merely confirms, strengthens, or substantiates the hypothesis: it does not prove that something is absolutely true for all times.’

The null hypothesis asserts that there is no difference between the means. But some differences can always occur by chance. Hence, only when the obtained differences are greater than what might be accounted for on the basis of chance can the researcher assume that the real differences caused by the independent variable exist. That is the meaning of significant difference. How much can be the differences due to chance, an estimate of that is provided by the values given in the statistical tables. If the obtained difference is such as under the conditions given it is very improbable, then the null hypothesis is rejected. It is accepted if the obtained difference is found to have sufficiently small probability of its occurrence. Two types of errors, however, are always involved in the rejection or acceptance of the null hypothesis: type-I or alpha errors and acceptance of the null hypothesis, respectively. These two errors are so related to each other that if efforts are made to minimize the one the chances of other’s increase. Keeping both at the optimum minimum level is a difficult job and calls for a lot of insight on the part of the researcher.

After the hypotheses are formulated, they are subjected to testing. The purpose of testing a hypothesis is to determine the probability that it is supported by fact or not. When hypotheses are simple, they can be tested directly. But when they are complex, it is not possible to test them directly.

In such situations, we test them in terms of deduced consequences. For this, it is necessary to collect evidence by selecting or developing data collecting instruments, to analyse the data and then to interpret results in the light of the hypothesis and its deduced consequences. Any hypothesis then will be confirmed if the evidence agrees with the deduced consequences.

The absence of conflict with the other satisfactorily proved generalization lends support to the correctness of a hypothesis. A hypothesis is also confirmed to be correct if the predictions made on its basis prove to be successful. Let us explain this with an example, how a hypothesis is formulated on the basis of deduced outcomes.

For example, in the research problem mentioned in the first step, i.e., ‘A comparative study of engineers and doctors belonging to different socio-economic status in relation to their creativity’, it can be easily seen that if there is difference in creativity of engineers and doctors belonging to different socio-economic status, there will be a significant difference in the mean scores of engineers and doctors belonging to different socio-economic status in creativity and then the hypothesis pertaining to this difference will be stated as follows: ‘There is significant difference in the mean scores of engineers

and doctors belonging to different socio-economic status in creativity? This is only one of a number of hypotheses that will have to be formulated for the research under reference. This hypothesis is also known as researcher's hypothesis.

▲ Collection of Data

We have learnt that the hypothesis shows the way for deciding the nature of data needed. But collection of data needs appropriate instruments/tools and the sample whose members have to be measured. In research situations, usually the researcher comes across unmanageable populations, where in, large numbers are involved.

In these situations, researchers have to use different sampling methods such as random, systematic, stratified, cluster, judgement, purposive or quota sampling depending upon their requirements. Here, the researchers should be well informed about the scope and limitations of these sampling methods before they think of their own sample in the research, because sample determines the applicability of generalizations arrived at after the investigation.

These generalizations are applicable only to the population, which has been sampled and that too only when the sample chosen is a fair representative of the population. Hence, the external validity depends largely on the correct sampling of the population.

In order to collect data, different tools, both testing and non-testing, are used. These tools are intelligence tests, aptitude tests, achievements tests, personality inventories, observation, interview, questionnaire and rating scales.

The researchers must be well versed in the use of these tools and fully aware of their merits and demerits. All the worthwhile tools, besides some specific requirements for the particular purposes and which they are used, should have general qualities like validity and reliability. The reliability and validity of these standardized tools should find a place in research proposal.

If the researchers are developing their own tools, they should outline the procedure to be followed in their development. It may be noted here that in historical and philosophical researches, the nature of the data and their treatment is different from other types of researches. When data is collected, the next task that lies before the researcher is how to organize, analyse and interpret data.

▲ Analysis of Data

The data collected from sample and through administration of various tools do not lead to interpretation, unless the data is edited, classified and tabulated in the form needed for testing of hypothesis and consequent interpretation and generalization.

Organization

The first step in treatment of data is its organization, which includes editing, classifying and tabulating the information. Editing implies checking of gathered raw data for accuracy, usefulness and completeness. Classification refers to dividing the data into different categories, classes, groups or heads. Tabulation refers to the recording of the classified data in quantified terms, which not only facilitates its manipulation but also increases the precision.

Analysis

The second step in the treatment of data is its analysis. Analysis of data means studying the organized material in order to discover inherent facts. This requires an alert, flexible and open mind. Statistical

techniques contribute a lot in gathering, organizing, analysing and interpreting data. The data are first made to yield 'statistic' descriptive of the salient features of the sample and then from these the parameters of the population are inferred.

The processing of data through statistics calls for competence in the use of statistical methods. The strengths and weaknesses of the statistical methods should be known to the researchers so that they may not be misled by them.

Interpretation

After collection and analysis of the data, the researchers interpret the results. Interpretation is not a routine and mechanical process. This last step in treatment of data requires a careful, logical and critical examination of the results obtained after analysis, keeping in view the limitation of the samples chosen, tools selected and used in the study.

Generally, in research we try to find out whether the differences in statistic of the different samples are only due to sampling chance or something else. This is called testing the significance of the differences. As we have already learnt in the third step of research process, i.e., formulation of hypotheses, the research hypothesis is converted into null hypothesis for the purpose of testing.

If null hypothesis is rejected, a level of significance is appended to it. Let us say that null hypothesis is rejected at 0.05 per cent or 0.01 per cent. What does it mean? It means that the behaviour of the variables mentioned in the hypothesis, which was converted into null hypothesis for being tested, may be taken to hold good, with a risk of 5 or 1 per cent. It means that this prevents the researcher from making 100 per cent sure assertions. If the null hypothesis is not rejected, the researcher's hypothesis becomes doubtful.

It is safer to say that null hypothesis cannot be 'rejected' instead of declaring that null hypothesis being correct in doubt, while the latter accepts it. Accepting a hypothesis may be wrong, e.g., the null hypothesis may be wrong still we may accept or retain it. So the non-rejection of null hypothesis leaves the issues simply in doubt. The null hypothesis may or may not be correct.

Conclusion

If the hypothesis is tested and upheld several times, it may be possible for the researcher to arrive at generalization, i.e., to build a theory. As a matter of fact, the real value of research lies in its ability to arrive at certain generalizations. These generalizations derived from a study are applicable only to that population from which the sample is taken and not beyond it. The suggestions for the applications of research findings in practical settings and for further research may also be provided with conclusions and generalizations.

In this chapter, we have learnt about the process of research. It involves various steps, which require hard labour and critical thinking. All the steps of the research process are dependent on one another.

We have learnt that before selecting the problem, the researchers fix up their field of research according to their ability and interest and look for a specialist in that field to guide them. Then with the help of a guide, the researchers locate the problem, of which the solution still seems to be wanted.

We also noted that the researchers complete the definition and identification of the problem in three steps:

- (i) By writing the topic, which is called statement of the problem

- (ii) By giving the operational definitions of the main terms in the topic
- (iii) By formulating hypotheses. Hypotheses should be formulated in such a manner that they can be tested. Hypothesis shows the way for deciding the nature of the data needed, their collection, analysis and also for the interpretation of the results of the analysis.

Further, we noted that in research process null hypothesis is used by the researcher for testing research hypothesis. It says that the results obtained from a sample are not significantly different from those expected on the basis of some attributes of the population. If the hypothesis is tested and upheld several times, it helps the researcher to arrive at generalizations or in other words help in building a theory which is the basic requirement of any research process.

If we critically analyse all the steps of the research process, we will realize that they are dependent on one another and have virtually to be considered together. It is necessary for a researcher to demarcate the steps of research for lucid exposition, yet the beginning, the middle and the end are all tied together.

Summary

- Research starts with a felt difficulty. It takes place when there is a problematic situation and a need to solve the problem.
- The research process is based on scientific method to solve the problem.
- The process of research involves various steps: identification and definition of the problem, survey of related literature, formulation of hypotheses, collection of data, analysis of data, and conclusion and generalizations.
- The hypothesis is a tentative solution of a problem.
- The research activities are planned to verify the hypothesis and not to find out the solution of the problem or to seek an answer to a question.
- Generally hypotheses are classified into two types: directional and non-directional.

Key Words

- *Hypothesis*: It is a tentative statement about the solution of a problem.
- *Deduction*: It is the process in which the researcher extracts a specific truth from the general truth.
- *Introduction*: It is the process in which the researcher extracts a general truth from the specific truth.
- *Index*: It identifies the source of the article or of the book.
- *Abstract*: It include brief summaries of the contents of the research study.

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Sampling 6

Most of the educational phenomena consist of a large number of units. It would be impracticable, if not possible, to test, interview or observe each unit of the population under controlled conditions in order to arrive at principles having universal validity. Some populations are so large that their study would be expensive in terms of time, money, effort and manpower. Sampling is the process by which a relatively small number of individuals or measures of individuals, objects or events is selected and analysed in order to find out something about the entire population from which it was selected. It is often desirable in order to reduce expenditure, save time and energy, permit measurement of greater scope or produce greater precision and accuracy. Sampling provides generalizations on the basis of a relatively small proportion of the population.

The representative proportion of the population is called sample. To obtain a representative sample, the researcher selects each unit in a specified way under controlled conditions.

▲ Purpose of Sampling Technique

‘Sampling’ is the process of inferring something about a large group of elements by studying only a part of it. Generalization based on the part of a large group is not a new procedure. It is an everyday process in one way or the other. For example, a trader examines a handful of grains from the bag before making a deal or a housewife checks a few grains of rice from the pan to determine whether the entire lot has been cooked or not. They are all using sampling technique to draw a conclusion.

This sampling technique becomes fundamental to research purposes where sample is selected from a population for accomplishment of the research objectives. Therefore, sampling can be defined as selecting participants for a research project. At this stage, before going into the details of sampling, it will be worthwhile to acquaint ourselves with some basic concepts like sample, population, statistics and parameter, sampling frame and sampling error.

▲ Meaning and Concept of Sampling

Statistical methods, like much of scientific methods, consist of mainly organized common sense. So is with sampling. H.J. Butcher of the University of Manchester explains the meaning and importance of sampling as ‘when we turn over the top layer of apples on a barrow or outside a green grocer’s, when we dig a spadeful of soil to see if it is heavy or light, when we set an examination paper to test the progress of a class ... in all these cases we are practicing a rudimentary kind of sampling and drawing conclusions about a population from information provided by a sample.’

Scientific research aims at generalizations; and generalization, where it is not dependent on pure deductive logic as in mathematics, is usually based on samples. No botanist or zoologist has examined every plant or animal of a particular species, nor has any child psychologist examined every human child. Even the most scholarly historian cannot examine every relevant document. Yet generalizations are made, and all these subjects have progressed by the examination and analysis of sample data.

Bloomers and Lindquist have stated the importance of sampling in these words: 'A large majority of the research studies in education and psychology or for that matter, in many other fields, are of a type known as sampling studies. In such studies, measurements or observations are made of a limited number of samples of individuals or objects in order that generalizations or inferences may be drawn about still larger groups or populations of the individuals or objects that these samples are supposed to represent.'

Imagine the difficulty of conducting a reading experiment with all Indian fifth-grade children as subjects. The study of population of this size would require the services of lakhs of research workers, the expenditure of crores of rupees and hundreds of thousands of class hours.

Fortunately, the process of sampling makes it possible to draw valid inferences of generalizations on the basis of careful observation of variables within a relatively small proportion of the population.

By studying the samples of a defined population, educational research aims at making generalizations, which can be applied to the population. Borg W.R. outlines the importance of research design as, 'perhaps the most important factor in determining the generalizability of research results is the selection of the sample used in collecting the research data.' There will be wastage of time, money and energy if the research data are not generalizable to some degree beyond the sample used in the research.

Sampling Theory

According to W.G. Cochran, 'sampling theory attempts to develop methods of sample selection and of estimation that provide at the lowest possible cost estimates that are enough for the purpose'. Sampling theory is the underlying factor of all types of sampling methods and techniques. The theory enables prediction of the characteristics of population.

▲ Bases of Sampling

The choice of the sample as representative of the whole group is based on the following assumptions:

- (i) *Homogeneity and complexity*: Fundamentally speaking, the students are similar in many respects so that a study of some of them will throw significant light upon the whole group. Beneath the diversity and complexity of the nature of students, there is an underlying similarity and homogeneity.
- (ii) *Possibility of representative selection*: It has been observed that if a certain number of units are selected from a population or universe on purely random basis, each unit has an equal opportunity of being included in the sample as the representative of the whole group.
- (iii) *Cent per cent accuracy not essential*: In large-scale studies, the research workers have to depend upon averages and estimates, which are considered as fairly significant in an enquiry. The results of sampling studies turn out to be fairly significant in an enquiry and accurate to permit valid generalizations.

Need for Sampling

Sampling is used in most of the researches due to following reasons:

- It saves time and money. A sample study is usually less expensive than a census study and produces results at a faster speed.
- It enables to get more accurate measurements and is generally conducted by trained and experienced investigators.
- It remains the only method when populations contain infinite members.
- It is the only choice when a test involves the destruction of the item under study.
- It enables to estimate the sampling errors and assists in obtaining information concerning some characteristics of the population.

Evaluate Yourself

- (i) Define Sampling. What is the need for sampling?
- (ii) Clarify the bases of sampling.

Characteristics of a Good Sample

A good sample has the following characteristics:

- It reproduces the characteristics of the population with the greatest possible accuracy, of course within restrictions imposed by its size.
- It should be free from error due to bias or deliberate selection of the unit of sample.
- It should be free from random sampling error.
- It should be selected by a procedure where there is no connection between the method of selection and the characteristics under consideration.
- It should be free from incomplete coverage of the units selected for study, i.e., it should not ignore the failures in the sample in responding to the study.
- Properly selected small samples may be relatively much more reliable than large samples poorly selected.
- It is adequate in size so that it can become really reliable.
- Only such units should be included in the sample, which, as far as possible, are independent.
- In the selection of a good sample, measurable or known probability sample techniques are used.

Uses of Sampling

The main use of sampling is as follows:

- A large population can be satisfactorily covered through sampling.
- Sampling saves a lot of energy, money and time.
- When the data are unlimited, this method becomes very handy.
- Sampling technique is very useful when the units are relatively homogeneous.
- The use of this method becomes inevitable when cent per cent accuracy is not required.
- Sampling makes intensive study possible when the number of individuals to be studied is manageable.

Steps in a Sampling Procedure

W. C. Cochran has suggested the following principal steps in the sampling procedure:

- Formulation of the clear statement of the objectives of the study
- Clear demarcation and definition of the population to be sampled
- Use of appropriate tools and devices of measurement
- No overlapping in the choice of a sampling unit
- Selection of adequate size of the samples
- Supervision of the work
- Collection of samples
- Tabulation and analysis of samples
- Dissemination of the information obtained

Advantages of Sampling

The following are the main advantages of sampling:

- *Reduced cost*: Sample is a fraction of the population. Hence it is economical. If the data are collected from the entire population, cost will be very high
- *Greater speed*: Sampling is less time-consuming than the census (official numbering of populations)
- *Greater scope*: Sampling simplifies matters relating to collection and tabulation of data
- *Greater accuracy*: Since sampling reduces the volume of work, careful analysis of field work is possible
- *Convenient organization*: On account of small numbers, it does not require elaborate facilities and paraphernalia
- *Exhaustive and intensive data*: Since the number is limited, it is possible to collect exhaustive and intensive data
- *Suitable in limited resources*: The method enables the research worker to work even with limited resources
- *Better rapport*: In a manageable sample, it is possible for the investigator to establish meaningful rapport with the respondents

Disadvantages of Sampling

The following are the major disadvantages of sampling:

- *Biased selection*: Sampling may involve biased selection of respondents on the part of the research worker.
- *Difficulty in selection*: Selection of a truly representative sample is very difficult. A large number of factors stand in the way of selecting good samples.
- *Specialized knowledge needed*: Sampling method needs a specialized knowledge and in its absence, the investigators may commit serious mistakes.
- *Problem of cooperation*: The subjects of the sample may be widely dispersed. Some of them may even refuse to co-operate with the researcher.
- *Less accuracy*: Sampling is not suitable where a higher standard of accuracy is expected.
- *Limited nature*: Sometimes the universe is so small or heterogeneous that it is not possible to derive a representative sample. In such a situation census study is the only alternative.

▲ Important Concepts Related to Sampling

- *Population*: Population in a research project means the aggregate or totality of objects, subjects or individuals regarding which inferences are to be made. A population is any group of individuals that have one or more characteristics in common that are of interest to the researcher.
- The notion of a population implies a wider group from which the sample is drawn. This wider group is usually referred to by statisticians as the 'population' (occasionally as the 'universe'). The statistical concept of population is, therefore, more general than the common usage. In ordinary speech we talk of the population of a country or of a town, but more rarely of the population of a school.
- *Sample*: A sample is a small proportion of a population selected for observation and analysis. By observing and analysing the sample, research workers make certain inferences about the characteristics of the population from which it is drawn.
- *Statistics*: A measured value based upon sample data is statistics.
- *Parameter*: A population value inferred from a statistics is a parameter.
- *Sampling error*: By sampling distribution we mean the relative frequency distribution of infinity of determinations of the value of this statistics. Each determination is based on a separate sample of the same size and selected independently by the same presented procedure from the same population.
- *Sampling bias*: If the mean of the sampling distribution of a statistics coincides with or equals that of the corresponding parameter it (the statistics) is said to be unbiased. On the other hand, if the mean of its sampling distribution does not coincide with the parameter it is said to be biased.
- *Standard error*: The standard error of any statistics is the standard deviation of its sampling distribution.

Sample

The selected part, which is used to ascertain the characteristics of a large group is called sample. Alternatively, sample is a sub-section or cross-section of the larger group. It may be rightly called as a representative of a larger whole.

Population

The large group from which a sample is selected for any research project is known as population. All possible units or elements that make up a large group make up the population. The population, therefore, comprises of all people, animals or objects that have at least one common characteristic, e.g., all graduates represent one population.

Statistics and Parameter

It is clear from the preceding discussion that inferences drawn from sample are applied to the population. We are basically interested in measuring some characteristics of the population.

The measures of sample are known as statistic and the measures of population are termed as 'parameter', e.g., mean, standard deviation (SD) and coefficient of correlation of sample observation are known as statistic. On the other hand, mean, SD and coefficient of correlation of a population are called parameter. In sampling, some population parameters are inferred by studying only a part of the population.

Sampling, therefore, refers to the process of choosing a sample from the population so that some inferences about the population can be made by studying the sample. Figure 6.1 shows the concept of population and sample.

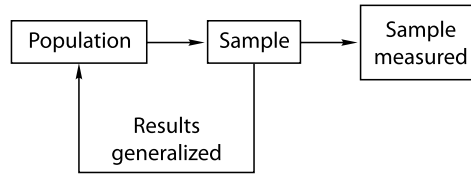


Figure 6.1 Concept of population and sample

Census

Sampling is not the only process available for making inferences about a population. For small population, it is sometimes desirable to examine every member of the population. This process is referred to as census or complete enumeration of the population.

Sampling Frame

As discussed earlier, a sample is a portion of a population. Technically, it is not selected from a population but from a sampling frame. A sampling frame is a concrete listing of all the elements or units in a population. As such, this frame is either constructed by the researchers for the purposes of their study or may consist of some existing lists of population.

Some of the examples of existing sampling frames are telephone directories, list of publishers of books, list of schools and colleges in a state and so on. Can we suggest some other existing sampling frames? Whatever the frame may be, it should be a good representative of the population.

Let us explain all these concepts with an example.

Example

Suppose a researcher wants to study the attitude of college towards cultural activities. Let us say that the total strength of students is 500. What is the population here? Whether complete enumeration is possible? Obviously 500 students constitute the population. Complete enumeration is not possible as it is not feasible to study 500 students. Here, population is numbered in order from 1 to 500. This order is sampling frame. From this sampling frame, 100 students are selected for the study, which will form the sample. Thus, generalization drawn from the sample will help in knowing the attitude of 500 students of the college towards cultural activities.

Sampling Error

Sometimes data collected from the sample may not be a true representative of the population. This possibility is due to certain amount of inaccuracy in the collection of information. This inaccuracy may be termed as 'sampling error'. Sampling errors are those errors which arise on account of sampling. They generally happen to be random variations in the sample estimates around the true population values. Sampling error is inversely proportional to the size of the sample. The larger the size of sample, the less will be the sampling error. The formula for sampling error is:

where N is the size of the sample and s is the standard deviation.

If N , the size of the sample, increases, the sampling error or standard error of mean decreases. If it tends to infinity, the sampling error will be zero. Sampling error can be easily understood with the help of a Venn diagram shown in Figure 6.2.

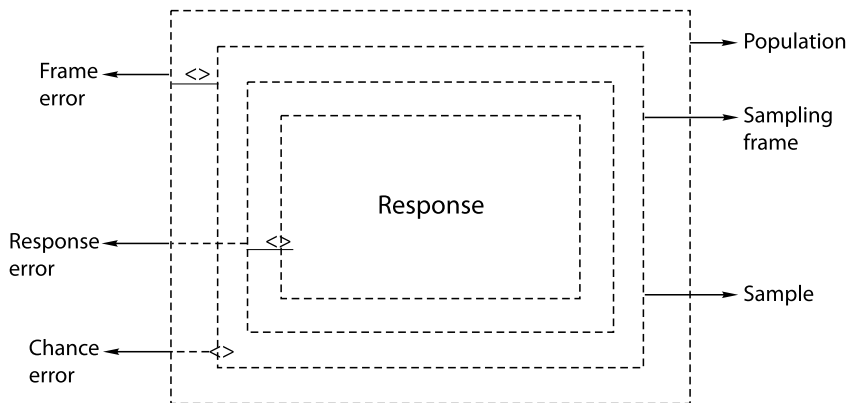


Figure 6.2 Venn diagram of sampling error

Contrary to sampling error, there is also a non-sampling error. This error creeps in during the process of collecting actual information. This occurs in all surveys. As compared to sampling error, which can be studied and calculated, non-sampling error cannot be measured.

▲ Advantages of Sampling over Complete Census

Let us discuss the various advantages of choosing a part or small portion of the population for collecting data, because collecting data from each and every unit of a population, i.e., complete enumeration or census, is neither feasible nor advisable.

Reduced Cost

Expenditure will be less if we collect data on a small portion or fraction of the population. That is why manufacturers of the new product first collect the response of consumers through sample survey before marketing a product.

Less Time-consuming

Sampling is less time-consuming than census. Suppose the researchers are interested in studying the reactions of the inhabitants of a particular city towards the rising prices of essential commodities. A detailed study to get the questionnaire filled by every person of the city is likely to take more time and therefore, the researchers will depend on the sampling technique. They will select a smaller sample from the population.

Greater Speed

The volume of the data to be collected will be smaller, which can be tabulated and analysed more quickly and easily with a sample than with the total population, e.g., a population consists of 500 units. Taking a sample of 100 units from this population will be easy to handle and tabulate.

Greater Accuracy

With the help of sampling technique, the volume of work gets reduced. With its reduction, personnel with higher expertise and training can be employed. At the same time, direct supervision of fieldwork and processing of data is also possible. Hence, we see that sampling may produce results, which are more accurate than those which could have been obtained through a complete census. Let us consider an interview study.

Sampling not only saves money and labour, but also allows the interview to be conducted in a relatively less time. Thus, the distorting effects of the passage of time are minimized. At the same time, it also permits greater depth in analysis and greater accuracy in processing due to less number of units.

Types of Sampling

In general, there are two basic types of sampling depending upon who or what is allowed to govern the selection of the sample.

These two sampling types are as follows:

- (i) Probability sampling
- (ii) Non-probability sampling

Probability Sampling

The word 'probability' refers to the study of likelihood of events, e.g., what are the chances of winning a toss? What are the chances of winning a lottery being drawn today? It is a quantitative discipline in the sense that we must be able to count events and possible outcomes.

Probability sampling is the technique in which every element or unit in the sampling frame has an equal and independent chance of being included in the sample. Obviously, selection of one element or unit will not influence the selection of others.

In this technique, the selection of elements or units is made through chance procedures such as flipping a coin or drawing a number out of hat or any urn. This process of selecting elements or units is called random selection.

Now, probability sampling can be defined as a technique that ensures random sample, i.e., a sample, which is a representative of the population from which it is drawn.

Non-probability Sampling

Non-probability sampling is the sampling technique in which the subjects or elements are not chosen at random. Therefore, the likelihood that any particular element of the population will be selected is not known and cannot be calculated.

In this case, elements are chosen on the basis of how they look, where they live or some other criteria. With the result, we are limiting the chances of those elements who do not meet the above criteria. Here, samples may be picked up on the basis of judgement or convenience of the enumerator. Usually, the complete sample is not decided at the beginning of the study but it evolves as the study progresses. Both types of sampling and their forms can be seen in Figure 6.3.

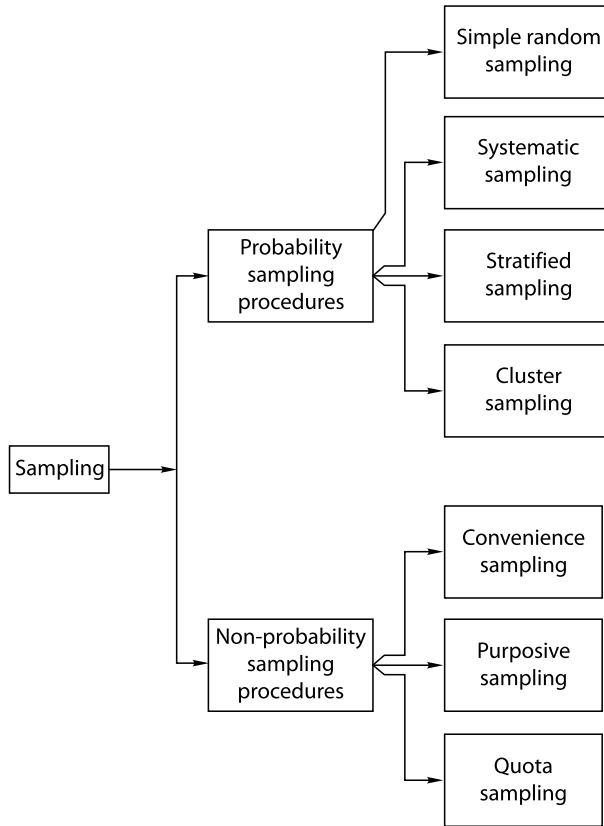


Figure 6.3 Types and forms of sampling procedures

▲ Probability Sampling

It is also known as random sampling or chance sampling. Under this design, each item of the universe has equal chance of inclusion in the sample. It is a lottery method in which units are picked up from the whole group by some mechanical process. The results obtained from such a sample can be assured in terms of probability, i.e., we can measure the errors of estimation or the significance of results obtained from a random sample. That is why probability sampling techniques are considered superior to deliberate sampling techniques. Some other sampling techniques under probability sampling are the following:

- Simple random sampling
- Systematic sampling
- Stratified sampling
- Cluster sampling
- Multistage sampling
- Sequential sampling

- Multiphase sampling
- Double sampling

Simple Random Sampling

We have already learnt that a sample in which each element of the population has an equal and independent chance of being included is a random sample. A sample selected by randomization method is known as simple random sample and this technique is known as simple random sampling. Let us now enumerate the different steps involved in drawing a random sample:

- Define the population
- List up all the units in the population and number them from I to N
- Decide upon the size of the sample or the number of elements or units to be included in the sample
- Use either of the following methods for the selection of a sample:
 - (i) Lottery method
 - (ii) The use of table of random numbers
 - (iii) The use of computers.

All these methods are independent of human judgement and hence ensure randomness. Different steps of drawing a random sample from the population are shown in Figure 6.4.

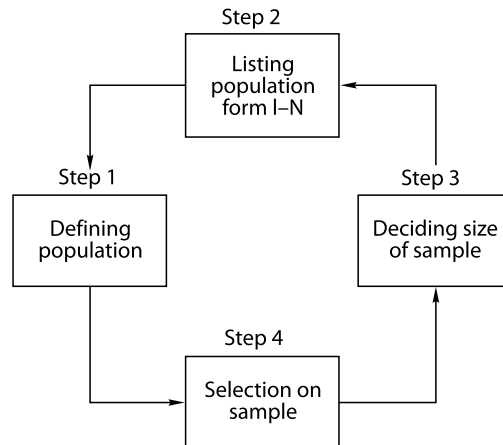


Figure 6.4 Illustrating simple random sampling

In lottery method, each member of the population is represented by a disc, which are placed in an urn and mixed well. Then the sample of the required size is selected.

The second method, i.e., the use of table of random numbers, is generally regarded as superior and the most objective method of random selection.

As the population increases, it becomes more and more difficult to work with the lottery method. Nowadays, this method can be done directly by using computer. We can instruct the computer to pick a number from I through N using its pseudorandom number generator. This ensures that every number from I through N has an equal probability of getting picked up.

Let us explain how table of random numbers help in picking up a simple random sample. A random number table is exactly what its name denotes: a table containing random numbers, or numbers arranged in no particular order.

A table of random sampling numbers is given in Table 6.1.

Table 6.1 Random sampling numbers

82308	73580	84828	89252	64760
32893	42779	02789	48072	95170
59909	22076	65703	21811	50465
05551	64931	35873	68960	44968
50035	54365	62603	99069	93005

Example

Suppose we have a population of size 35 and we want to pick a simple random sample of size 5. We proceed by defining a procedure. First of all, we will number the units in some order from 1 to 35 so that each student is identified uniquely by a serial number. Since the total number of students 35 is a two digit number, we take numbers in groups of two. We must decide, then, which two of the five digits in a column (Table 6.1) we will consider to be valid.

In this example, we will use the two right-most digits in each column of Table 6.1. Next step will be, how we will move through the table: down the columns, up the column or across the rows. Any direction will suffice, but one must be consistent in one’s direction. We will move down the columns, when we come to the bottom of one column, we move to the top of the next.

However, once a starting position has been selected, we should continue to choose numbers. For example, let us start from column 2, row 3 of the table. In column 2, row 3, two right-most digits are 7 and 6. Already, we have a problem, 76 is too large. Whenever we encounter a number outside the range of our sampling frame, we simply ignore it and move on to the next number. The same thing is done with any repeat number. Table 6.2 contains selection of a sample of size 5 by using Table 6.1.

Table 6.2 A simple random sampling procedure using Table 6.1

Row	Column	Number	Comments
3	2	76	Discard outside range
4	2	31	Selected, n = 1
5	2	65	Discard outside range
1	3	82	Discard outside range
2	3	89	Discard outside range
3	3	03	Selected, n = 2
4	3	73	Discard outside range
5	3	03	Discard, already selected
1	4	52	Discard outside range
2	4	72	Discard outside range
3	4	11	Selected, n = 3
4	4	60	Discard outside range

Table 6.2 (Continued)

Row	Column	Number	Comments
5	4	69	Discard outside range
1	5	60	Discard outside range
2	5	70	Discard outside range
3	5	65	Discard outside range
4	5	68	Discard outside range
5	5	65	Discard outside range
1	1	08	Selected, $n = 4$
2	1	93	Discard outside range
3		09	Selected, $n = 5$
Sample complete with students 31, 3, 11, 8, 9			

Here we see that serial number 3 has been selected twice. So one number 3 should be discarded. The process in which already selected element is not replaced in the population is termed as sampling with replacement. It means that if an element is picked up once, it is not available to be picked up again. While in sampling with replacement, the selected element is replaced in the population so that it can be picked up again.

Systematic Sampling

In systematic sampling, elements or units of population are arranged in some systematic manner. Then the sample is drawn. Systematic sample is a sample where the units are selected at equal intervals.

The mechanics of taking a systematic sample is very simple. Suppose the population consists of ordered N units (arranged in order from 1 to N), a systematic sample of size n is to be selected from this systematically arranged population. Sample is selected in such a way that $N/n = P$ (rounded to nearest integer). Here P is called sampling interval. Now from first P of the units, a unit is selected randomly.

Example

Let sample size $n = 5$ and population size $N = 40$

Sampling interval P will be $N/n = 40/5 = 8$.

Now every ninth unit will be selected in the sample, i.e., among first 8 units, one unit is selected randomly. Suppose this number is 3, then we select unit number 11, 19, 27, ... in our sample at equal intervals till the requisite sample size has been reached.

This is a simple method of selecting a sample, but sometimes it may prove to be an inefficient method when there is some hidden periodicity in the population. Suppose, in the above example, if most of the eighth unit is defective, then sample will consist of large number of defectives, and representativeness of the sample cannot be ensured.

Stratified Random Sampling

Sampling requires a list of sampling frame. In simple random sampling, the elements or units in the sampling frame are relatively alike, i.e., homogeneous. But sometimes, sampling frame is not homogeneous and contains subgroups, i.e., heterogeneity occurs. These subgroups are also known as strata. The strata are the partition of the population, which is more homogeneous than the complete

population. The members of a stratum are similar to each other and are different from the members of another stratum in the characteristics that we are measuring.

The stratified sampling is used whenever these strata are necessary for research purposes. This is a technique in which the entire population is divided into strata and then sample is selected from each strata by randomization.

For example, our sampling frame is university students. It consists of juniors, seniors and so forth. Here the sampling frame (of university students) would involve random sampling in senior class, in junior class and so on until all classes are represented in the sample.

Let us explain stratified sampling symbolically also. Suppose we have a population of N units. Now what we will do to get a stratified sample. First of all, we will divide the whole population into strata by fixing some criteria (e.g., statewise, classwise, agewise, and sexwise). Let us divide the whole population of N units into P subgroups or strata on the basis of sex, the i th subgroups having N_i unit ($i = 1, 2, \dots, P$). These subgroups which are non-overlapping will comprise the population such that

$$N_1 + N_2 + N_3 + \dots + N_p = N$$

A simple random sample is then drawn from each strata independently. Thus, the total sample size is

$$n = n_1 + n_2 + n_3 + \dots + n_p = np$$

as shown in Figure 6.5.

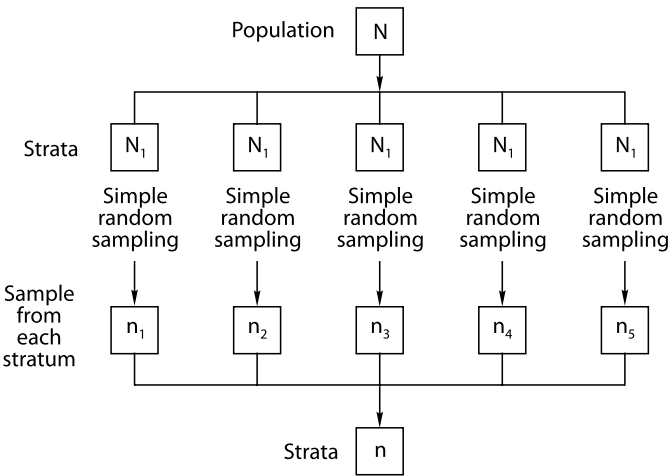


Figure 6.5 Illustrated stratified sampling

The main advantage of stratified sampling is that the sample is a good representative of the population. But when the researcher is not able to decide the relevant criterion for stratification, it may lead to misleading generalization.

Cluster Sampling

When the selection of individual members of the population is impractical or too expensive, it may be possible to select groups or clusters of members for the sample. Cluster sampling is a procedure of selection in which the unit of selection, called the cluster, contains two or more population members. Each member of the population must be uniquely contained in one, and only one, cluster. Cluster

sampling is useful in situation where the population members are naturally grouped in units that can be conveniently used as clusters, e.g., a class and a school building.

Example

Suppose we are interested in doing a survey of fourth-grade achievement in mathematics by using a standardized achievement test in a city having 33 elementary schools. Suppose there are 85 fourth classes in the city, with an average enrolment of 30 students per class. A sample size, suppose grade approximately of 600 students is required.

So here what we have. We have:

Elementary schools = 33

Total number of fourth-grade classes in the city = 85

Average enrolment per class = 30 students

Then what we will do is select 20 classes, which will be used as clusters. Now all members or students of these 20 classes will be tested on mathematics achievement. The sampling design can be diagrammed as shown in Figure 6.6.

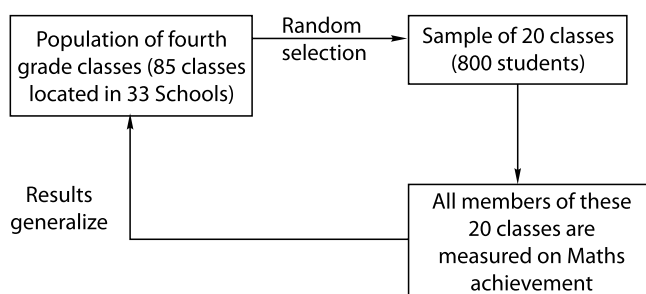


Figure 6.6 Illustrating cluster sampling

Cluster Versus Stratum

We can now compare cluster sampling with stratified sampling. Stratification is done to make the strata homogeneous within and different from other strata. Clusters on the other hand should be heterogeneous within and different clusters should be similar to each other. In cluster sampling, random selection occurs not with the individual members but with the clusters. The clusters, which form the sample, are randomly selected from the larger population of clusters; once a cluster is selected for the sample, all the population members in that cluster are included in the sample.

While in stratified sampling, individual members within strata are randomly selected. Convenience of data collection is usually the basis for cluster definitions. On the other hand, the criterion used for stratification is a variable, which is closely associated with the characteristic we are measuring.

Multistage Sampling

In multistage sampling, the material to be sampled is regarded as composed of number of first-stage sampling units, each of which is made up of a number of second-stage sampling units, and so on, until we reach the ultimate sampling unit in which we are interested. At the first stage, the first-stage sampling units are suitably sampled. Similarly at second stage, a sample of second-stage unit in the selected cluster,

one can think of obtaining better and more efficient estimators by concentrating on sub-sampling within the cluster. This technique is called multistage sampling. In general, it refers to a sampling technique which is carried out in various stages with population as primary units in the first stage. For example, to get a sample of crop fields growing wheat in Punjab, get a sample of districts, then a sample of villages from each selected district and finally a sample of crop fields from each selected village. Multistage sampling is more flexible. It enables existing divisions and subdivisions of the material to be taken as sampling units at different stages. The construction of a second-stage frame is meant only for those units which are selected in the first-stage sampling and this obviously leads to a great saving in operation cost. However, multistage sampling is generally less efficient than a suitable single-stage sampling of the same size.

Sequential Sampling

The sampling design in which a particular lot is to be accepted or rejected on the basis of a single sample is known as single sampling. When decisions are to be taken on the basis of two samples, it is known as double sampling and in case the decision rests on the basis of more than two samples but the number of samples is certain and decided in advance, the sampling is known as multiple sampling. But when the number of sample is more than two, but is neither decided nor certain is called sequential sampling. In this type of sampling, one can go on taking samples one after the other as long as one desires to do so.

Multiphase sampling

Sometimes certain items of information are collected from a sample constructing only a part of the original sampling. This sampling plan is at times convenient and economical. Multiphase sampling may be employed if the number of units required to give the desired accuracy in different items is widely different or if the cost of collection of data for different items is different. The information gathered in earlier stages is utilized as basis of sampling in subsequent phases. In multiphase, the sampling unit remains the same in all phases. For example, in drawing a random sample of household take a sample from all households to classify the households into middle class or non-middle class groups. In the second phase, we may draw a sample out of the sample class household obtained in the first phase for the family budget enquiry.

Evaluate Yourself

- (i) What are the different types of probability sampling techniques?
- (ii) When we have a list of 200 schools and out of this 14 schools are to be selected, the researchers select one school from the first 28 schools and then second school from the next list of 28 schools and so on because $14 \times 28 = 392$. If they select schools at serial number 6, 20, 34, 48, 62, 76 and 90, 140, 169, 186, 210, 224, 391, 294, which type of sampling is this?

▲ Non-probability Sampling Procedures

Non-probability samples are used when the representativeness is not particularly the primary issue. From these samples, one cannot estimate sampling error. Hence these are also called 'uncontrolled sampling methods'. This sampling procedure does not afford any basis for estimating the probability that each item in the population has a chance of being included in the example. This type of sampling is also called as deliberate sampling, purposive sampling and judgement sampling. In other words, under

non-probability sampling the investigators purposively choose the particular units of the universe for constituting a sample on the basis that the sample will be a typical or representative of the whole. In such a design, personal element has a chance of entering into the selection of the sample.

The investigators may select a sample which shall yield results favourable to their point of view and if this happens, the entire enquiry may get vitiated. There is always the danger of bias entering into this type of sampling technique. But if the investigators are impartial and take sound judgement, the results obtained from the analysis of deliberately selected sample may be reliable. Quota sampling also is a non-probability sampling. Here, the interviewers are simply given quotes to be filled from different strata, with some restriction on how they are to be filled. Actually, the selection of the items for the sample is left to the interviewer's discretion. This type of sampling is very convenient and relatively inexpensive, but they do not possess the characteristic of random samples. Quota samples are judgement samples and inference drawn are not amenable to statistical treatment in a formal way.

Major forms of non-probability sampling procedures are as follows:

- Convenience sampling
- Purposive sampling
- Quota sampling

Convenience Sampling

As the name implies, in this type of non-probability sampling, the samples are selected at the convenience of the researchers. This results into biased estimates and there is no way to quantify the possible errors. Therefore, it is suggested that convenience sampling should not be used in both descriptive and casual studies. This method is useful in testing of questionnaire.

Purposive Sampling

In convenience sampling, any member or element of the population can be included in the sample without any restriction. When some restrictions are imposed on the possible inclusion of an element in the sample, the sampling is called purposive.

In purposive sampling, the investigators purposively draw a sample from the population, which they think is a representative of the population, e.g., if the investigators wish to take a sample of Class IX boys belonging to different socio-economic status in the population, they may choose Class IX of one or more schools in which they think all the elements of the population are represented well.

The main disadvantage of this sampling is that the personal bias of the investigators has a great chance of influencing the sample. If the investigators choose a sample to give results, which favour their viewpoints, the entire study may be biased. On the other hand, if personal biases are avoided, a relatively representative sample can be drawn from the population on the basis of relevant experience and acquaintance of the investigators.

Quota Sampling

Quota sampling is a procedure where the sample is selected according to a number of key characteristics. Certain basic parameters such as age, sex, income, occupation and educational level that describe the nature of the population form the basis of selection of the sample. First of all, in this sampling the entire population is classified into different categories on the basis of judgement or the previous knowledge. The second step is to decide the proportion of population falling into each category. Then the sample is selected from each category so as to make it a representative of the population. Finally, quota of cases are drawn from each proportion.

Example

Suppose we are conducting a survey to study the attitude of campus students towards Hindi as national language. Let sex be our criterion for dividing the population into strata. The proportion of the students falling into each category, i.e., male (M) and female (F) is 40 per cent (M) and 60 per cent (F), respectively. Now we have to decide the size of the sample. Suppose we decide to select a sample of 200 students from the population, samples of size 80 Males and 120 Females should come from males and females, respectively.

Next task is to fill the specified quotas. There are no constraints on the method of doing it. The sample selected from this procedure may or may not be a good representation of the population because selection of sample is left totally to the investigators' discretion.

Suppose in the above example if we go to the campus early in the morning and approach the students gathered. This freedom actually goes against the basic requirements of a good sample, i.e., representativeness.

Sometimes, we may approach only those subjects who appear most friendly and co-operative. Bad weather may also force us to complete our quota without covering the entire campus. There can be other reasons also that may affect representativeness of quota sample.

Quota sampling, at the outset, might look similar to stratified sampling but difference occurs between the two. The main difference lies in the selection of sample. In stratified sampling, a random sample is selected from each cell of the population, whereas in quota sampling it is not random and is left to the discretion of the investigators.

Distinction Between Probability and Non-probability Sampling

After knowing different sampling procedures It possible to draw the differences existing between two procedures of sampling, i.e., probability and non-probability. Some of the important ones are as follows:

- Probability sampling is the technique in which each unit of the population has an equal and independent chance of being selected in the sample. But, in non-probability sampling neither each unit of the population has equal chance nor the chance of its being included in the sample is known.
- In non-probability sampling, the sampling error is not measurable and the error in the estimator tends to increase sharply because the representativeness of the sample members is questionable. But we can measure the errors of estimation or significance of results obtained from a random sample.

This chapter explains that sampling is an important consideration in any research study designed to generalize from a sample to a population. Here the sample drawn is a complete replica of the population. Sampling is less time-consuming, less expensive and more accurate as compared to complete enumeration. It is also noted that there are two basic methods of sampling: probability sampling and non-probability sampling.

In probability sampling, every element of the population has an equal and independent chance of being included in the sample, whereas in non-probability sampling this assurance is not there. Among the probability sampling methods, simple random sampling is used when the population is homogeneous. A simple random sample attaches equal probability to each unit of the population to be selected in the sample. Operationally, sample is selected from the sampling frame containing a list of all the units of population by using random number tables. Systematic sampling starts with a random start and picking up members after a fixed interval.

When the population is heterogeneous and contains many strata, stratified sampling is used. When the population of interest is very large and to select subjects randomly one by one becomes a costly affair, cluster sampling can be used. It involves the random selection of clusters from the larger population.

All the population members of a selected cluster are included in the sample. Non-probability sampling such as convenience sampling, purposive sampling and quota sampling are sometimes used although representativeness of such a sample cannot be ensured.

▲ Sample Size

The problem of sample size arises especially in case of SRS. A general rule is that the sample should be large. But, it should not be unnecessarily large. It should be neither too large nor too small. It should have the optimum size. An optimum sample is one which fulfils the requirements of efficiency, representativeness, reliability and flexibility. It should be small enough to avoid unnecessary expenditure. It should be large enough to avoid sample errors beyond the limit of tolerance. It should yield desired information with required level of reliability at a minimum cost.

The choice of the size is affected by several factors: (i) nature of population (heterogeneous population calling for a larger sample), (ii) complexity of tabulation (larger number of categories requiring a larger sample) and (iii) data collection and resources of the researcher including time and money available, length of the questionnaire, collection of data individually or in groups, number of field workers, location and spread of units, refusal rates, mortality rates, type of sampling method of statistical analysis, number of statistical analysis, number of uncontrolled variables (large sample needed if there are many uncontrolled variables) and anticipated effects (large sample needed when small effect is anticipated).

Calculating Sample Size

In case of probability sampling, it is possible to calculate the size of the sample using approximate formulae based on the criterion of population variance and the confidence limit preferred. At the same time, it should be remembered that the criterion of representativeness is more important than the size of the sample. According to Sidhu K. Singh (1973) if the size of the population is 10, the sample size also should be 10. Similarly for N s equal to 15, 30, 50, 100, 200, 400, 500, 600, 800, 1000, 1500, 3000, 5000, 10,000, 50,000 and 1,00,000, respectively, sample size should be equal to 14, 28, 44, 80, 132, 196, 217, 234, 260, 278, 306, 341, 357, 370, 381 and 384.

While determining the sample size, two things are to be considered: (i) degree of precision wanted and (ii) some estimate of standard deviation of the population. This may be known or estimated on the basis of researches if already made or some pilot study or one's own experience. If the range of variation of the attribute in the population is known or can be estimated, it may be divided by six and this will give the rough estimate of the standard deviation. Degree of precision means limit of accuracy or the margin of error, which is acceptable in a situation (say 5 or 2 per cent). It depends upon how exact or accurate results one wishes to obtain. For example, if one is testing the effectiveness of a drug for heart disease a very small error (say 1 per cent) will be acceptable; if it is the effectiveness of two methods of teaching a larger error may be tolerated.

Standard error (probability of confidence level) is the measure, which explains the chances of a sample studying within the acceptable limit (decided to be tolerated). Ninety five per cent samples fall within ± 2.0 SE if the confidence level is set at 0.95. It means that the sample should be one that has an SE of $1/2$ of the margin of error.

If the precision is to be doubled, its size should be multiplied by 4; and if it is to be increased by three times, its size should be multiplied by 9 and so on.

Parton (1965) gives two formulae for determining roughly the required size of the sample—one for percentage and another for averages, as follows:

- (i) $N = \frac{PC(100 - PC)Z^2}{2}$ for percentages in which PC means preliminary estimate of the percentage of the universe, Z means SE units and T means margin of error to be tolerated.
- (ii) $N = \left(\frac{\sigma \times SE \text{ Units}}{T} \right)^2$ or $\left(\frac{\sigma Z}{T} \right)^2$ for means in which σ = SD.

Population (estimated), Z means SE units of significance level, 1.96 or 2.58 and T means margin of error to be tolerated (as 5 or 2 per cent)

For example, if estimated σ (SD) is 16, error to be tolerated is 2.0 at 1.96 SE level of confidence, then

$$1.96 \times \frac{\sigma}{\sqrt{N}} = 2 \text{ or } 1.96 \times \frac{16}{\sqrt{N}} = 2 \text{ or } \frac{1.96 \times 16}{2} = \sqrt{N} \text{ or } \left(\frac{1.96 \times 16}{2} \right)^2$$

Thus, $N = 246$.

From the above expression, it should not be taken for granted that this will generate a desired precision. This is true only when one has an ideal random sample, which is hardly possible in research. This, however, does not mean that the calculation of sample size from probability formula should not be done. It is in fact, the best bet, unless practical considerations make it inexpedient.

Another strategy to improve the precision is the stability test of sampling in which they go on adding more and more alike samples till the desired result is obtained. Still another method is to add more and more cases to the sample and test the significance and stop at a point where desired outcome is reached. This is known as sequential sampling. But, both these approaches are short of the qualities that SRS has.

Evaluate Yourself

- (i) Differentiate between stratified sampling and stratified random sampling?
- (ii) Clarify cluster and purposive sampling.

Summary

- Sampling is an indispensable technique of behavioural research. The research work cannot be undertaken without the use of sampling.
- The research design is based on the sampling of the study.
- The concept of sampling has been introduced with a view to making the research findings economical and accurate.
- Sampling is fundamental to all statistical methodology of behavioural and social researches.
- Sampling, a deliberate rather than haphazard method of selecting subjects for observation, enables the scientist to infer conclusions about a population of interest from the observed characteristics of a relatively small number of cases.

- Simple random, systematic, stratified random, area of cluster and available (non-probability) samples have been described. Methods of determining the size of an appropriate sample are suggested and the sources of sample bias are considered.

Key Words

- **Sampling:** It is the process of inferring something about a large group of elements by studying only a part of it.
- **Sample:** It is a subsection of the whole.
- **Population:** It is the larger whole from which sample is selected.
- **Sampling Frame:** It is a concrete listing of all the elements in a population.
- **Sampling Error:** It is the error, which arises on account of sampling.
- **Simple Random Sample:** It is a sample in which each element of the population has an equal and independent chance of being included in the example.
- **Systematic Sample:** It is a sample where the units are selected at equal intervals.
- **Stratified Random Sample:** It is a sample collected by dividing population into strata and selecting a sample from each subgroups or strata by randomization procedure.
- **Cluster Sample:** It is a sample where intact groups or clusters are selected randomly.
- **Convenience Sampling:** It is a process of selecting a sample based on convenience.
- **Purposive Sampling:** It is a procedure where the sample is selected through judgment.
- **Quota Sampling:** It is a method of selecting elements on the basis of categories assumed to exist within the population.

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Method is a way of conducting research work, which is determined by the nature of the problem. It is more general and includes techniques also. The research techniques are the ways of implementing a method. Different techniques may be employed within the same method. According to M. Verma, 'method is only in the abstract as logical entities that use can distinguish between matter and methods, reality, they form an organic whole and matter determines method, analogously as objective determines means and content and spirit determines style and form in literature.' Method refers to the formal structure of the sequence of acts commonly denoted by instructions. It is also defined as 'orderliness and regularity or habitual practice of them in action'. With reference to research, methodology means a type of inquiry.

In the previous chapters, we have learnt about the meaning and areas of educational research, and the various stages that the researchers have to undergo while planning and conducting a research study.

The researcher first selects the area of research; they identify and define their problems; review the literature to acquaint themselves with the recent developments in knowledge related to the problem, state hypotheses and define specifically the objectives of their study; finalize their research plan; and then start working actively on the problem itself according to the plan. At the planning stage, the researchers have to decide about the research method that could be used in solving their research problem.

Research methods are of utmost importance in a research process. They describe the various steps of the plan of attack to be adopted in solving a research problem, such as the manner in which the problems are formulated, the definition of terms, the choice of subjects for investigation, analysis and interpretation of data, and the processes of inferences and generalization. This chapter discusses various methods of educational research, namely historical method, survey method, causal-comparative method, genetic studies and the experimental method, in detail.

▲ General Methodology Classification

Basically, research methods are categorized as follows:

- Historical research
- Survey research
- Causal-comparative research
- Experimental research

Historical research: This provides a method of investigation to discover, describe and interpret what existed in the past.

Survey research: This provides a method of investigation to study, describe and interpret what exists at present.

Causal-comparative research: This provides a method of investigation to study variables as they occur in a natural setting, because they have already occurred or cannot be manipulated.

Experimental research: This provides a method of investigation to derive basic relationships among phenomena under controlled conditions or, more simply, to identify the conditions underlying the occurrence of a given phenomenon.

The discussion of research methods in this chapter will be organized according to the basic categories outlined above. The selection of an appropriate method and the specific design within that method in investigating problem will depend upon the nature of the problem and the kind of data that the problem entails. In any specific study, although it is a common practice to use any one of the above methods, yet, there is no reason why two or more methods cannot be applied effectively in combination in certain research situations.

The researchers must have a thorough understanding of all research methods, which will help them to carefully plan the steps in the research process and describe the method clearly before they actually start working on the solution of the problem. A pre-planned and well-described method will provide the researcher a scientific and feasible plan for attacking and solving the problem under investigation.

The classification of research by methodology is summarized in Table 7.1.

Table 7.1 Classification of research by general methodology

Type	Characteristics	Questions Asked
Historical	A description of past events or facts is developed.	What was or what happened?
Survey	The incidence, relationships and distribution of variables are studied.	What are the characteristics of the variables?
Causal-comparative	Variables are studied as they occur in a natural setting, because they have already occurred or cannot be manipulated.	What are the relationships and possible effects among the variables?
Experimental	At least one variable is manipulated to determine the effect of manipulation.	What is the effect of the experimental variable?

▲ The Historical Method

We know that history is a meaningful and organized record of past events. It is not merely a list of events arranged chronologically, but a valid integrated account of social, cultural, economic and political forces that had operated simultaneously to produce a historical event. Education also has a history of its own, which has progressed under the influence of such forces.

Nature of Historical Research

Historical research attempts to establish facts so as to arrive at conclusions concerning past events. This is usually accompanied by an interpretation of these events and of their relevance to present circumstances and what might happen in the future. Therefore, the main purpose of historical research is to arrive at an accurate account of the past so as to gain a clear perspective of the present. This knowledge enables us, at least partially, to predict and control over future existence.

Historical research, as any other type of research, includes the delimitation of a problem, formulating hypotheses or tentative generalizations, gathering and analysing data and arriving at conclusions or generalizations based upon deductive–inductive reasoning. However, the historians face greater difficulties than researchers in any other field. According to Ary et al. (1972), they lack control over both treatment and measurement of data, have relatively little control over sampling, and have no opportunity for replication.

Historical research is not based upon experimentation, but upon reports of observation, which cannot be repeated. The historian handles a data of unique type. They are mainly traces of past events in the form of various types of documents, relics, records and artefacts having a direct or indirect impact on the event under study.

The jobs of the historians become more complicated when they derive truth from historical evidence. The major difficulty lies in the fact that the data on which historical research is based are invariably relatively inadequate and often the study is conducted with all of the independability that the data may entail. According to John W. Best (1977), ‘the historian must depend upon the reported observation of others, often witnesses of doubtful competence and sometimes of doubtful objectivity.’

These obviously pose a difficulty in matters of objectivity of interpretation. The data of occurrence of a certain historical event is another difficulty. It may be difficult to determine it partly because of changes brought out in the system of calendar and partly due to incomplete information.

Value of Historical Research

Historical research has great value in the field of educational research because it is necessary to know and understand educational achievements and trends of the past in order to gain perspective on present and future directions. For instance, knowledge of the history of schools and other educational agencies is an important part of the professional training of the teacher or the school administrator.

Knowledge of the history of education enables an educational worker to bring about reform in education. Only in the light of their origin and growth can the numerous educational problems of the present be viewed sympathetically and without bias by the teacher, the school administrator or the public.

History of education shows how the functions of social institution shift and how the support and control of education have changed from very simple and local arrangements to those that are now somewhat centralized and complex. Finally, it inspires respect for sound scholarship and reverence for great teachers.

Historical research is useful for predicting future trends. There is an old adage that those who are unfamiliar with the mistakes of history are doomed to repeat them. Thus, historical research can provide information necessary to avoid previous mistakes.

Types of Historical Research

There are at least four types of historical studies that may be conducted in the field of education:

- Legal research
- Studying the history of ideas
- Studying the history of institutions and organisations
- Bibliographic research

Legal Research

Legal research aims to study the legal basis of educational institution run by different religions and castes, relation between central and state governments with regard to education, legal status of teachers

and students, administration of private aided schools, school finance, participation of students in the administration of universities and so on. However, legal research needs special training in the field of law, and anyone without this training is not competent to do this type of research.

Studying the History of Ideas

It involves training in the major philosophical or scientific thought from their origin through different stages of their development. It also aims at tracing changes in popular thoughts and attitudes over a given period of time. The evolution of current concepts like systems approach and mastery learning strategy provides important topics for historical research.

Studying the History of Institutions and Organizations

It also provides numerous problems for significant historical research. For example, one may study the history of the growth and development of Banaras Hindu University

Bibliographic Research

It aims at determining and truthfully presenting the important facts about the life, character and achievements of famous educators. For example, one may study the contributions of Gandhi or Tagore in educational practice and thought.

Steps of Historical Research

In general, historical research involves the following five steps:

- Selection of the problem
- Formulation of hypotheses
- Collection of data
- Criticism of data
- Interpretation of data and reporting of findings

Step 1: Selection of the Problem

The researchers should exercise due care in selecting and delimiting the historical problem for investigation. They should check that the problem selected should not only be of historical and current significance, but also answerable by available methods of research and available sources of data.

The researchers may select a problem pertaining to the history of educationists, institutions curriculum, administration and teacher education. They may delimit their study to an era of events in a local, regional or national setting, or may study the trend of events in different eras or different cultures. They may discover new knowledge, which when interpreted will provide answers about the past events, or may sometimes doubt an old interpretation of the existing data and then attempt to provide a satisfactory explanation of past events.

Step 2: Formulation of Hypotheses

While formulating hypotheses, researchers may formulate questions that are most appropriate for the past events they are investigating and then direct their research towards seeking answers to these questions with the help of evidences.

The hypotheses that the researchers formulate for historical research are useful in explaining events, conditions or phenomena of the historical period in question. Sometimes in such studies, the researchers

are merely interested in concrete events in their singularity; they have to merely check the validity and authenticity of facts about the past events and arrange them in a chronological sequence.

Therefore, the researchers may not formulate any hypotheses in such investigations. However, the findings based on unstated hypotheses are ambiguous and do not explain or describe the structural interrelation of the phenomena under study. So, hypotheses for historical research may not be formal hypotheses to be tested. Rather, they are written as explicit statements that tentatively explain the occurrence of events and conditions.

Step 3: Collection of Data

In order to verify the hypotheses thoroughly, the researchers have to collect all the data available, which is a time-consuming process. The researchers have to go through the vast materials of human activities that testify past events, and from these identify and select data that are relevant to their problem. These data are classified as primary and secondary sources.

Primary Sources

These are eye-witness accounts and are the only solid bases of historical enquiry. Goode, Barr and Scates (1941) have called them as the 'first witnesses of a fact'. The original documents or remains come under the category of primary sources. They are available in written, pictorial and mechanical forms as follows:

Personal records: Certificates, diaries, autobiographies, affidavits, declarations, letters, wills, deeds, contracts and original drafts of speeches, articles, books and pamphlets

Official records: Legislative, judicial or executive documents prepared by central or state governments, municipalities, panchayats or other local bodies, such as constitutions, laws charters, court proceedings and decision, the information compiled by central or state education departments, special commissions, professional organizations, school boards, such as the minutes of meetings, reports of committees and commissions, school surveys, annual reports, attendance records, cumulative records of dramas, games, musical and athletics events, and examinations

Oral testimony of traditions and events: Myths, folk tales, family stories, ceremonies, spoken account of a witness of an event, interviews with administrators, teachers, students, parents or guardians, school patrons and prominent educationists

Pictorial records: Photograph, movies, micro-films, drawings, paintings, coins and sculptures

Mechanical records: Photographic records of events and tape recordings of interviews, meetings and speeches

Remains or relics: Fossils, skeletons, tools, weapons, clothing, buildings, furniture, utensils, art objects, teaching materials, samples of examination question papers, samples of student work and murals

The remains or relics are more trustworthy than the records, reports or words of others, because the researchers can examine them personally. However, they have to search for clues in reports made by men in the past and then make any valid interpretations. Remains and relics sometimes reveal the events and conditions better than official documents. For example, the remains of an ancient burial place may impart more information about the food, tools, religious beliefs, customs and means of livelihood of a particular community.

Secondary Sources

These are the accounts of an event provided by a person who did not directly observe the event, object or condition. The person might have directly contacted an actual observer and talked with him or read an

account by an observer. Since the testimony of the person is not that of an actual participant or observer, secondary sources are subject to an inherent danger of inaccuracy and distortion. For this reason, the researchers should rely as much as possible on primary sources and use the secondary sources only to bridge the gaps between the various pieces of primary data.

However, it is not always possible to obtain primary data and in such situations the researchers may have to rely on secondary sources. These situations are frequent in education where only fragmentary reports concerning the processes of education are available.

Secondary sources serve many useful purposes, if used carefully. They may acquaint the researchers to major theoretical issues in their field and the work that has been done in the area under study. They may suggest possible solutions of the problem and working hypotheses, and may introduce the researchers to important primary sources.

The card catalogue, periodical indexes, bibliographies, historical reviews, dissertations and research journals provide helpful guides in locating source materials in historical research. It may be noted that historical studies involve more intensive bibliographical work and library usage than any other type of research, and, hence, the researchers should be careful to assemble full bibliographical information in their note-taking system to facilitate problem documentation.

Step 4: Criticism of Data

After the data have been identified, the researchers must establish the authenticity of the source and also the validity of its contents. The process of establishing the authenticity of the data is termed as external criticism and that of establishing the validity of their content is termed as internal criticism.

External Criticism

It also called as lower criticism. It checks the genuineness and authenticity of the source material. It helps to determine whether it is what it appears or claims to be and whether it reads true to be original so as to save the researchers from being the victim of a fraud. According to Moulay (1963), the purpose of external criticism is not so much 'negative', that is the detection of fraud as it is the 'establishment of historical truth'.

To determine the genuineness of the historical data, the researchers must possess a rich fund of historical and general knowledge. According to Van Dalen (1973), they also need a 'good chronological sense, a versatile intellect, good common sense, an intelligent understanding of human behaviour and plenty of patience and persistence.' The problem of establishing age or authorship of a document may involve such techniques as authentication of signatures, handwriting, script and type; chemical analysis of paint, carbon dating of artefacts, ink, paper, cloth, stone, metal or wood.

The researchers, therefore, must be familiar with chemistry, archaeology, cartography, art, literature, philology, anthropology, paleography or various modern and ancient languages. If they do not possess knowledge of these fields, they may acquire special training in the fields that are most closely related to their historical problem or may seek the help of competent experts in the field.

Internal Criticism

After the authenticity of the historical data has been established, the researchers proceed to internal criticism. It is also called as higher criticism and is concerned with the validity, credibility or worth of the content of the document. Besides textual criticism, it also involves factors such as competence, good faith, bias and general reputation of the author.

Internal criticism is positive in nature when the researchers seek to discover the literal and the real meaning of the text. It is negative when the researchers try to seek every possible reason for disbelieving the statement made, questioning critically the competence, truthfulness or accuracy and honesty of the author. According to Good, Barr and Scates (1941), 'both positive and negative criticisms are essential in historical research but the researchers should not go so far as to be cynical and hypercritical.'

The competence and accuracy of an author is evaluated in relation to his status as a trained eye witness and in terms of the time period that has elapsed between the event and its recording by the author so as to ascertain whether the author was able to remember accurately the account of the event. In some instances, the author of a document may know the truth, but for certain reasons he may report the evidence only in part or in a distorted form, resulting from the author's motive, bias or prejudice or some vested interests.

According to Good C.V. (1966), 'the test of truthfulness and honesty include evaluation of the author's characteristics and statements in relation to personal or vested interests, race, nation, party, region, sect, social level, economic group, profession, conventional formulas rather than true sentiments, vanity or boasting, attempt to please some individual or group exaggerations, and embellishments.'

Step 5: Interpretation of Data and Reporting of Findings

After the data have been collected and criticized, the researchers turn themselves to the task of interpretation of these data in the light of their problem. Because of the unique nature of the historical data, the task of interpretation becomes complicated and acquires special significance. It requires greatest ingenuity and imagination on the part of the researchers.

The researchers in the historical type of investigation must be very cautious while dealing with 'cause and effect' relationships. Since history is actually a record of the chain of related events, it becomes very difficult for the researchers to interpret that one event in the chain was caused by the previous event in the chain. Furthermore, many conditions and circumstances interact and become responsible for a particular event. This makes the task of the researcher difficult, to assess accurately the influence of a particular event and to identify clear-cut cause-effect relationships.

The historical researchers must also be very cautious in their use of analogy in the interpretation of data. While drawing comparisons between one historical event and any number of others, they must carefully make use of similarities as well as differences. The ultimate goal in the historical type of research is not only to establish facts, but also to determine trends that the data may suggest and to draw the inferences from the data.

The researchers must show an understanding of the sequence of events and must draw a vertical relationship of proceeding facts with succeeding ones along the timeline. Their main goal should be synthesis and interpretation rather than mere summation. After the data have been interpreted, the researchers have to write a well-organized report of the study. A detailed discussion of the process involved in report writing has been presented in previous Chapter 6.

The writing of historical research report needs the highest level of scholarship on the part of the researchers. This is a matter of expository strategy, which calls for creativity in addition to the qualities of imagination and ingenuity. The presentation of the report should be objective and systematic and should not hide or distort the truth. The historical research report must be presented in the logical and chronological order. It should neither be dull and unattractive nor too flowery and ornamental. They must follow precision, continuity, clarity and dignity in their style to give a sense of design and completeness.

The methodology of historical research is presented diagrammatically in Figure 7.1.

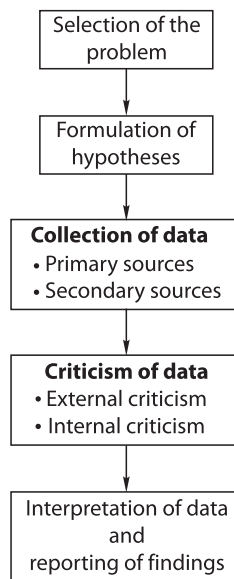


Figure 7.1 Methodology of historical research

▲ Descriptive Research

A descriptive research describes and interprets. It is concerned with conditions or relationship that exist, opinions that are held, processes that are going on, effect that are evident or trends that are developing. It is primarily concerned with the present, although it often considers past events and influences as they related to current conditions.

Descriptive method is concerned with the present and is oriented towards the determination of the status of a given phenomenon. It is based on large cross-sectional samples. Surveys are relatively less scientifically sophisticated than most other research techniques. According to *Webster's New Collegiate Dictionary* a survey is a critical inspection, often official, to provide exact information.

The survey approach to educational problem is one of the most commonly used approaches. It is followed in studying local as well as state, national or international aspects of education. It involves interpretation, evaluation and generalization directed towards a proper understanding and solution of significant educational problems. It brings into the focus our attention for the existing educational problem and also suggests ways of meeting them. The worthwhile studies collect three types of information: (i) what exists, (ii) what we want and (iii) how to get there.

Meaning of Descriptive Research

Descriptive research studies the current phenomena and its status. The main goal of descriptive research studies in education is to tell 'what is', and to establish a clear description of materials and phenomena under investigation.

This is entirely reverse to the experimental research, as far as control of treatment is concerned. It is directed towards determining the nature of situation as it exists at the time of study.

Descriptive studies may include present facts or current conditions concerning the nature of a group of persons, a number of objects, or a class of events and may involve the procedures of induction, analysis, classification, enumeration, or measurement.
—Good (1963)

The ultimate aim of descriptive research is to classify events, so that later research can employ an unequivocal terminology and to lessen the confusion coming from ad hoc definitions. But purpose of descriptive research is to establish a clear description of materials and phenomena under investigation.
—Gephart and Ingle (1969)

A descriptive study describes and interprets what is. It is concerned with the conditions or relationships that exist, opinion that are held, processes that are going on effects that are evident or trends that are developing. It is primarily concerned with the present, although it often consider past events and influences as they relate to current conditions.
—Best (1983)

The word descriptive as, 'having the quality of describing, characterized by description'.
—Webster's New Collegiate Dictionary (1989)

Describe researcher studies the present status of the phenomena, determining the nature of prevailing conditions, practices and attitudes.
—Daben and Meyer (1962)

Descriptive research does not involve the experiments per se. It seeks to discover the nature of the factors involved in a given situation, it seeks to determine the degree in which they exists, and it attempts to discover the links or relationship which exist between the factors.
—Lovell and Lawon (1970)

Descriptive research is nearly self-explanatory; it occurs when the researcher wants merely to characterize the behaviors of an individual or a group. For example, survey of the students of a high school to ascertain the level of alcohol use.
—International Encyclopedia of Psychology (1996)

To conclude, we can say that descriptive research studies the relationship between variables that exist at present in their natural setting. It also tests the hypotheses, develops generalizations, and results in some prediction.

Evaluate Yourself

The type of research that is concerned with the present and is oriented towards the determination of the status of a given phenomena is called as follows:

- (i) Ideational research
- (ii) Clarify the types of historical research
- (iii) Descriptive research
- (iv) Status research
- (v) Phenomenological research

Value of Descriptive Research in Education

The descriptive research method has, undoubtedly, been the most popular and the most widely used research method in education. It helps to explain educational phenomena in terms of the conditions or relationships that exist, opinions that are held by the students, teachers, parents and experts, processes that are going on, effects that are evident or trends that are developing. Because of the apparent ease and directness of this method, a researcher can gather information in terms of individual's opinion about some issue, by a simple questionnaire. Often, descriptive survey is the only means through which opinions, attitudes, suggestions for improvement of educational practices and instruction and other data can be obtained.

The problem in education directly involves people, and the situations precipitating these problems are constantly in a state of change. To keep abreast of changes, descriptive studies conducted at different intervals with representative groups of people will be immensely helpful.

The descriptive type of research is useful in the development of data-gathering instruments and tools like checklists, schedules, questionnaires and rating scales. It also provides the background ideas and data from which many more refined or controlled studies of causal relation are made.

Evaluate Yourself

Descriptive research reveals the current status of any educational phenomenon, which helps in evolving data-gathering tools and provides background ideas and data for consideration.

- (i) Further research of experimental nature
- (ii) More refined causal relationship studies
- (iii) Ideational studies
- (iv) In-depth phenomenological investigations

Steps in Descriptive Research

The process of descriptive studies is not different from other forms of research. Since such studies describe and interpret what conditions or relationships exist at present, the researchers may adopt the following steps:

Selection of the problem: Researchers may be concerned with conditions or relationships that exist, practices that prevail; belief, points of view or attitudes that are held; processes that are going on; effects that are being felt or trends that are developing and may select the problem accordingly from the area or field in which they are interested.

Statement and definition of the problem: The researchers must state the problem clearly as done in case of other types of research. The statement must identify the variables involved in the study. It should specify clearly whether the study is merely seeking to determine the present status of these variables or whether it will also explore relationships between the variables.

Identification of data: After stating and defining the problem, the next step is to list the data to be collected for the study. They have to specify whether the data are of qualitative or quantitative nature and whether the data will be collected in the form of counts, test scores, responses to questionnaires, interviews and so on.

Selection or development of tools: The nature of the data to be collected helps the researchers to select the appropriate tools for the study. If the ready-made tools are not available, the researchers have to develop their own tools. Questionnaires, interviews, psychological tests, rating scales, schedules

and attitude scales are the most frequently used tools for descriptive research. If the researchers use readymade tools, they should satisfy themselves about their reliability, validity and suitability for sample chosen for the study. If the researchers develop their own tools, they should try them out with a small group in order to evaluate them and make modifications, if necessary.

Selection of the sample: The researchers must select the sample about which they wish to seek information using appropriate sampling techniques. The samples selected should adequately represent the population.

Collection of data: The researchers should specify the practical schedule for gathering data from the sample selected for the study with the help of appropriate tools.

Analysis and interpretation of data: The data collected is quantified in the form of counts, test scores, responses to questionnaires and so on. These are analysed and interpreted with the help of appropriate parametric or non-parametric statistical basis.

Writing of the research report: It is the last stage in the descriptive research as in any other form of research. The researchers should exercise extreme caution in generalizing conclusions and reporting them with all the limitations of the study.

Evaluate Yourself

How many steps are generally involved in conducting a descriptive research?

- (i) Five
- (ii) Seven
- (iii) Nine
- (iv) Eight

Purpose of Descriptive Research

The main purposes of descriptive research are as follows:

- Educational surveys are particularly versatile and practical, especially for administrators, in that they identify present conditions and point to present needs. By providing the basis for decisions for improvement, they can be decided practically.
- Surveys must do more than merely uncovering data; they should interpret, synthesize and integrate these data and point to implications and inner relationships. As the fact-finding aspects of the survey are occasionally semi-clerical in nature, there is ample opportunity for the investigators to display ingenuity and scholarship in interpretation of the data and understanding of their strengths and weaknesses, their inter-relationships and especially their implications.
- Descriptive research, like all other researches, must begin with a definite problem and be oriented towards the eventual derivation of valid generalizations. The survey makes its maximum contribution when it originates from a problem existing within the framework of the theory and when it is oriented towards the identification of factors and relationships worthy of investigation under more rigorously controlled conditions.
- The survey constitutes a primitive type of research in that the investigations of any problem must begin with a survey of its nature before it can move into the mere structured and rigorous phases. At its most elementary stage, the survey is concerned with determining the immediate status of a given phenomenon. This classification of the problem helps in the development of further

insights and eventually in the derivation of hypotheses to be incorporated into more adequate investigations at the experimental level; thus, its purpose is both immediate and long range.

- Descriptive studies also serve as the direct sources of valuable knowledge concerning human behaviour. As surveys of the reactions of inmates of orphanages or blind homes might provide definite insight in the psychology of the human personality under conditions of psychological stress.

Evaluate Yourself

The purpose of descriptive surveys is to know the immediate status of the following:

- (i) Previous relationship
- (ii) Existing phenomenon
- (iii) Future trends
- (iv) Provision for art history

Features of Descriptive Research

The following are the characteristics of descriptive research:

- It gathers data from a relatively large number of cases.
- It is essentially cross-sectional, mostly of 'what exists' type.
- It is concerned not with the characteristics of individuals but with generalized statistics of the whole population.
- It is an important type of research involving clearly defined problems and definite objectives. It requires an imaginative planning, a careful analysis and interpretation of the data and a logical and skilful reporting of the findings.
- It does not aspire to develop an organized body of scientific laws, but provides useful information to the solution of local problems. It may, however, provide data to form the basis of research of a more fundamental nature.
- Surveys vary greatly in complexity; some are concerned only with frequency count of events, while others seek to establish relationships among events.
- Surveys may be qualitative or quantitative. Qualitative—naming and defining constituent elements of various phenomena, e.g., qualities of a good teacher. Quantitative—ascertaining the amounts of constituents of characteristics.
- Description may be either verbal or expressed in mathematical symbols.
- It fits appropriately into the total research scheme or the stages in exploring a large field of investigation. It may serve as a getting-acquainted stage of research in a new area.

Evaluate Yourself

Descriptive surveys provide information about the following:

- (i) Individual cases
- (ii) Generalization about whole population
- (iii) Limited ideas concerning sample
- (iv) Broad leaks about individual problems

Significance of Descriptive Research

Scientists do not generally regard the normative survey investigation as a research of high order. But the type of information the survey method provides is in much demand and is capable of providing important service as follows:

- It determines the present trends and solves current practical problems.
- It secures historical perspective through a series of cross-sectional pictures of similar conditions at different times.
- It suggests the course of future developments. It focuses on needs, reveals practices, which are well above average, and gives pertinent data to persons who are forward looking and engaged in planning for future.
- It also helps in fashioning many of the tools with which research is conducted, e.g., in the development of instruments for measuring many things in quantitative research as well as various data-gathering instruments like checklist, schedules, score and rating scales.
- It contributes to advancement of knowledge because it affords penetrating insight into the nature of what one is dealing with, e.g. by studying children of various age levels one can differentiate according to age and obtain some picture of the trend of development.
- It provides the background ideas and data from which many more refined laboratory or controlled studies or causal relations are made.

Types of Descriptive Research

Descriptive research has been classified differently by various writers. Some have classified them on the basis of the purposes they achieve, some on the basis of the geographical areas they cover and some on the basis of the techniques they employ. These classifications mostly range from the survey, which describes the status quo of educational variables, to the correlation study, which investigates the relationships between variables. There are three types of descriptive research three categories: (i) survey studies, (ii) interrelationship studies and (iii) development studies.

Survey-type Research

Meaning and Nature of Survey Research. According to Kerlinger (p. 410), the purpose of survey type research is to discover the relative incidence, distribution and inter-relations of sociological and psychological variables. Survey-type studies, by and large, describe the current status of a phenomenon, some group of people, an institution, some existing practice, policy or event. Sometimes, they compare the status with some available standards and make suggestions for improving the status. Survey research as being used in social sciences is, however, different from the status survey and is considered scientific if looked from the point of view of methodology.

In most of survey-type researches small samples are studied and on that basis, inferences are drawn about the whole or at least larger populations. They emphasize that for this purpose, the sample should be drawn randomly. These are, generally, called sample surveys.

Types of Survey Research. A lot of things can be studied through survey research. Hence it is very difficult to classify them into clear-cut types. However, they can be categorized as (i) institutional surveys, (ii) job surveys, (iii) population surveys, (iv) documentary surveys, (v) public opinion surveys, (vi) community surveys, and (vii) sociological and psychological surveys. Documentary surveys are also known as 'content analysis', 'activity analysis' or 'informational analysis', which are quite akin to

historical research. Sociological surveys focus on sociological facts, opinions, attitudes, social habits and social customs. Psychological surveys describe the status and distribution of psychological variables like intelligence in the group or larger population.

Methodology of Survey Research. The methodology of survey research emphasizes using rigorous sampling methods and sampling designs like specification of objectives, hypotheses and plan of collecting information. The methodology uses various kinds of tools such as questionnaires, interviews, personal visits, inspection of records and use of standardized psychological tests. It specifically stresses on the preparation of some sort of flow chart, which tells the researchers the following: (i) What are the objectives? (ii) What kind of information is to be collected to achieve these objectives? (iii) From whom or where this information has to be collected? and (iv) How this information or data has to be tabulated and analysed?

In no way survey type of research should be considered inferior to any other research.

Steps of Survey Research. The researchers, to begin with, must decide and describe the following points.

- What is the purpose of the study—descriptive or explanatory?
- Is a survey appropriate for this question?
- What is the question or hypothesis to be tested?
- What is the population of interest?
- What method of data collection is appropriate given the purpose, question and population?
- What method of data analysis is intended and appropriate, given the purpose, population, question and data?

Sampling Phase. The research must decide and describe the following points:

- What is the intended size of the sample?
- What is the type of sample—cross-sectional or longitudinal?
- What is the intended universe, that is, what does the sample purport to represent?
- What kind of sampling procedures are appropriate, given the sample size, type and intended representativeness?

(i) *Data collection:* The researcher must decide and describe the following:

- What is the basic mode of data collection—interview (personal or telephone) or questionnaire (individual or group)?
- How can questions be asked or concepts of interest be accurately measured, given this mode of data collection and this population?
- How long is the interview, questionnaire or phone call?
- How will scales be constructed?
- What checks are there on the validity and reliability of the data collected?

(ii) *Data analysis:* The researcher must decide and describe the following:

- How will data be made ready for computer processing—transcriptive data entry or automatic data entry?
- How will data be edited and cleaned?

- How will it be possible to show that a given explanation is tenable? Are there ways to test competing alternative hypotheses?
- What data analysis procedures will be used? Are they consistent with the purpose of survey and the quality of the data?
- What procedures will be used for documenting data files and data procedures? What will be the survey designs?

Surveys are primarily conducted to answer ‘What’ of the research question. When the researchers are interested to know what has happened, they use the survey research design. For example, you may be interested to know how many children are enrolled in a primary school at the block district level, what is the dropout rate, what is students/teacher ration in a district, what is the level of achievement of students of a specific grade in a specific subjects, what is the impact of a training programme, what is the level of participation of students in school activities and so on. Thus, survey method is used to obtain descriptive and evaluative information in education. Using this method almost every area of education can be surveyed.

In survey design, information is collected through various techniques. Although use of questionnaire and its derivatives (such as opinionnaire, checklist, rating scales and tests) are more commonly used, the information is also collected through structured interviews and observation schedules. It is perfectly possible to collect qualitative data within a survey. Even physiological measures (e.g., heart beat, blood pressure, breathing rate and cholesterol level) can be collected using survey approaches, of course, with different instruments.

Surveys are of different types such as cross-sectional and longitudinal surveys. These types have been discussed in greater detail under developmental studies.

Normative Survey Method. While historical studies discover, describe and interpret what existed in the past, there are other kinds of investigations which study, describe and interpret what exists at present. They are concerned with conditions or relationships that exist, practices that prevail, beliefs, points of view or attitudes that are held, processes that are going on, effects that are being felt or trends that are developing. The literature of such investigations includes expressions like descriptive survey, normative, status or trend.

The terms ‘survey’ and ‘status’ suggest the gathering of evidence relating to current conditions. Normative implies the determination of normal or typical conditions or practices and the term ‘normative survey’ is generally used for the type of research that we intend to consider here—the research which proposes to ascertain what is the normal or typical condition or practice at present.

Nature of Normative Survey Research. Survey is the single most popular and most widely used approach in educational research. It involves study of events that have already taken place and are related to a present condition. Survey research is a method of collecting and analysing data, obtained from a large number of respondents representing a specific population collected through highly structured and detailed questionnaire or interviews. The researchers are usually interested in describing the population they are studying.

This approach is followed in studying local, as well as, state, national and international aspects of education. It goes beyond mere gathering and tabulation of data. Rather, it involves interpretation, comparison, measurement, classification, evaluation and generalization all directed towards a proper understanding and solution of significant educational problems.

Worthwhile survey studies collect three types of information as stated below:

- What exists by studying and analysing important aspects of present situation?
- What do we expect by clarifying goals and objectives possibly through a study of the conditions existing elsewhere or what experts consider to be desirable?
- How to get there through discovering the possible means of achieving the goals on the basis of the experience of others or the opinions of experts?

Surveys vary greatly in complexity; some concern themselves only with the frequency count of events, while others seek to establish relationship among events. A survey is usually not concerned with the characteristics of individuals, but with generalized statistics of the whole population. There are clearly defined problems and definite objectives. It requires an imaginative planning, a careful analysis, and skilful and logical reporting of findings.

Value of Normative Survey Research. Survey has been the most widely used research method in education. It helps to explain educational phenomena in terms of the conditions or relationships that exist, opinions that are held by the students, teachers, parents and experts, processes that are going on, effects that are evident or trends that are developing. Because of the apparent ease and directness of this method, a researcher can gather information in terms of one's opinions about some issue, by a simple questionnaire.

Many times, survey is the only means through which opinions, attitudes, suggestions for improvement of educational practices and instruction, and other data can be obtained. These investigations, which are descriptive in nature are of immense value in solving problems about children, school organization, supervision and administration, curriculum, teaching methods and evaluation.

The problems in education directly involve people and the situations precipitating these problems are constantly in a state of change. To keep abreast of changes, surveys conducted at different intervals with representative groups of people will be of immense help.

Further, this type of research is useful in the development of data-gathering instruments and tools like checklists, schedules, questionnaires and rating scales. It contributes to the advancement of knowledge because it helps to develop an insight into the nature of what one is dealing with.

Types of Normative Survey Research. Survey studies are conducted to collect detailed description of existing phenomena with the intent of employing data to justify current conditions and practices or to make more intelligent plans for improving them. The objective is not only to analyse, interpret and report the status of an institution, group or area in order to guide practice in the immediate future, but also to determine the adequacy of status by comparing it with established standards. Some surveys are confined to gather all the three types of information:

- Data concerning existing status
- Comparison of existing status with the established status and standards
- Means of improving the existing status

Surveys may be narrow or broad in scope. Some surveys encompass several countries, states or regions, or they may be limited to one country, state or region. Survey data may be collected from every unit of a population or from a representative sample. Survey studies describe and specify the properties of educational phenomena. They include the following:

- School surveys
- Job analysis

- Documentary surveys
- Public opinion surveys
- Social surveys
- School surveys

Surveys are comprehensive studies of existing conditions. Their main purpose is to determine the overall effectiveness of the school programme and suggest improvement where necessary. The first formal survey of the schools of Boise, Idaho (USA) was conducted in 1910, which was mainly of an inspectional nature. But now the emphasis is on comprehensive surveys designed to evaluate the school as a functional unit.

According to Good C.V. (1966), the comprehensive school survey usually covers the following aspects of the school system: aims, outcomes, pupil achievement, curriculum, method and instructional aids; administrative problems and procedures of the schools; financial policies and procedures; pupil transportation; staff personnel; operation and maintenance of the school plant and related factors.

School surveys may be conducted at the local, state, regional or national level. They can also be undertaken at various levels of instruction—elementary, secondary or higher. The scope of school surveys is large and varied. A single comprehensive school survey may comprise various parts or constituent surveys. These include: survey testing, school appraisal, status studies, financial studies, curriculum studies and building surveys. These are briefly described as follows:

Survey testing: Tests are intended not only to measure maximum capability, such as achievement, aptitude and intelligence, but also describes typical behaviour such as personality traits, interest and attitudes. This is mainly concerned with achievement, intelligence and personality testing.

Achievement testing: Survey testing of educational achievement has become an important aspect of school surveys. Achievement tests of objective type are used for these surveys. They are used to compare attainment of present pupils with that of the previous years, to compare the performance of different schools, to enable assessment of curricular strengths and weakness, to identify particular groups of students who are weak so that appropriate remedial measures could be introduced for them and to determine whether an innovative programme has been better or poorer than the conventional one in facilitating the attainment of specific curricular objectives.

Intelligence testing: It is a very useful tool for educational researchers. In large group studies of the survey type, the researchers invariably make use of verbal or non-verbal group tests of intelligence, or both intelligence testing surveys are helpful for identifying gifted children, for studying mental growth, for measuring general readiness for learning at different levels of schooling, for making relatively homogeneous sections, for estimating more accurately the degree of mental retardation among children, for studying socially and educationally maladjusted children and for indicating the extent of differences of I.Q. among the children of the same chronological age.

Personality testing: Among the desired educational outcomes, modification of behaviour and formation of desirable attitudes are given an important place. Personality testing includes: behaviour studies (centred around measuring such traits as self-reliance, initiative and cooperation) and attitude studies (centred around the attitudes of pupils, parents or teachers towards courses of study).

School appraisal: Appraisal is a form of classification or scaling according to subjective values. School appraisal is concerned with administrative provisions and practices of an educational institution and the educational attainments of its pupils. It aims at an evaluation of all the conditions and outcomes in a school system. Besides checklists, rating scales or score cards, the researchers frequently employ other types of evidences such as academic achievement and subsequent success of the people.

Status studies: These are undertaken for determining the personal and professional status of teachers and other school officials. Studies to investigate the problems of selection and placement of teachers, their work load, their status in relation to the service conditions, health, law, supply and demand all provide useful subjects for research. Questionnaires, schedules and official records are used for collecting data.

Financial studies: These are conducted to identify the problems relating to the financial position of a school in terms of the sources of finance, items of expenditure, the deficit, expenditure per student and salaries of teachers form important aspects of school studies. Official records and questionnaires are the main sources for collecting data.

Curriculum studies: The analysis of the existing curriculum in a school system and its comparison with the one existing elsewhere may be a part of a school survey. The curriculum analysis usually includes an analysis of the principles on which the curriculum is based, the needs of the pupils and the community it fulfils and its limitations. Questionnaires, schedules and checklists are generally employed in these studies.

Building surveys: The surveys of school buildings are undertaken to gather information about their sites and location, the accommodation they provide and the arrangements they have for various classes, subjects, activities or staff. Questionnaire, checklist, score card and observation are usually employed as tools for collecting data in such studies.

■ *Job analysis*

It is generally used in business and industry. In education, it is employed to gather information about the general duties and responsibilities of the teaching, non-teaching and administrative personnel, the specific duties that they perform, their working conditions, the nature and type of their facilities and their status and relationship in the administrative organization.

The data about the education, specialized training, experience, skill habits, health standards and behavioural traits of these personnel are also collected. These data help researchers, to get knowledge about the existing practices and conditions of employment, and the competencies and behavioural traits that the personnel posses or should possess to carry out their work effectively and efficiently.

■ *Documentary surveys*

It is closely related to historical research, as here also existing records are studied. Since documentary analysis is concerned with the classification, quantification and comparison of the content of communication, it is sometimes referred to as 'content', 'activity' or 'informational' analysis. Researchers may analyse textbooks, syllabi, course of study, lesson plans of pupil teachers, and prospectus of various universities and colleges. They may analyse the contents of reference works, newspapers, periodicals and journals. Sometimes, study of personal documents, such as diaries, letters and notes, provide valuable information to the researchers.

■ *Public opinion surveys*

In order to make some important and crucial decisions, industrial, political, educational and other leaders seek knowledge of the public opinions, attitudes and preferences. Educationists, for example, conduct public opinion surveys to find out how people feel about school issues, and make use of questionnaires, schedules or interviews to gather data from the selected group or groups following appropriate sampling procedures.

■ *Social surveys*

These are called community surveys, and are generally conducted to study health services, employment conditions, causes of juvenile delinquency, housing problem or caste discriminations.

Such surveys may be conducted by the state or local government and research tools like questionnaires, schedules, interviews, rating scales and direct observation may be used for the same.

Steps in Normative Survey Research. The process of normative survey research is not different from other forms of research. Since such studies describe and interpret what conditions or relationships exist at present, the researchers may adopt the following steps:

- (i) *Selection of the problem*
Researchers may be concerned with conditions or relationships that exist, practices that prevail, beliefs, points of view or attitudes that are held, processes that are going on, effects that are being felt or trends that are developing, and may select the problem accordingly from the area or field in which they are interested.
- (ii) *Statement and definition of the problem*
The researchers must state the problem clearly as it is done in case of other types of research. The statement must identify the variables involved in the study. It should specify clearly whether the study is merely seeking to determine the present status of these variables or whether it will also explore relationships between the variables.
- (iii) *Identification of data*
Next, the researchers list the data to be collected for the study. They have to specify whether the data are of qualitative or quantitative nature and whether the data will be collected in the form of counts, test scores, responses to questionnaires, interviews and so on.
- (iv) *Selection of development of tools*
The nature of the data to be collected helps the researcher to select the appropriate tools for the study. If readymade tools are not available the researchers have to develop their own tools. Questionnaires, interviews, psychological tests, rating scales, schedules and attitude scales are the most frequently used tools for descriptive research.
If the researchers use readymade tools, they should satisfy themselves about their reliability, validity and suitability for sample chosen for the study. If the researchers develop their own tools, they should try them out with a small group in order to evaluate them and make modifications if necessary.
- (v) *Selection of the sample*
The researchers must select the sample about which they wish to seek information using an appropriate sampling technique. The sample selected should adequately represent the population.
- (vi) *Collection of data*
The researchers should specify the practical schedule for gathering the data from the sample selected for the study with the help of appropriate tools.
- (vii) *Analysis and interpretation of data*
The data collected are qualified in the form of counts, test scores, responses to questionnaires and so on. These are analysed and interpreted with the help of appropriate parametric or non-parametric statistical tests.
- (viii) *Writing of the research report*
It is the last step in survey research as in other forms of research. The researchers should exercise extreme caution in generalizing conclusions and reporting them with all the limitations of the study. Figure 7.2 summarizes the steps in the methodology of conducting a survey.

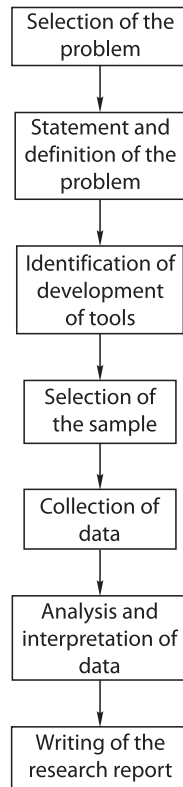


Figure 7.2 Flow chart showing steps in conducting a survey

Interrelationship Studies

These are studies, which aim at going a step further instead of stopping at just describing the phenomenon like the survey type studies. Three types of such studies have been described by Van Dalen (p. 218). These are: (1) case studies. (2) causal-comparative studies and (3) correlational studies, which are explained as follows.

Case Study. A typical case study is an intensive investigation of a social unit. The social unit may be an individual, a family, a school, a group of delinquents, dropouts or any teenage gang.

In a case study, the researchers attempt to examine an individual or unit in depth. They gather pertinent data about the present status, past experiences and environmental forces that contribute to the behaviour of the individual or social unit, and how these factors are related to one another. The analysis of the factors and their interrelationships help the researchers to construct a comprehensive and integrated picture of the unit. Actually, a worthwhile case study can rarely be completed by a single individual. It usually requires a team of experts.

Nature of Case Studies. The case study method was originally used in medicine to examine the patient's precious development, his health and physical state from the beginning and many other factors

in the past besides making a careful study of the patient's present condition and symptoms. Sigmund Freud used case study method to assist his subjects in solving their personality problems. The published accounts of Freud's interviews with patients provide excellent examples of case studies.

Guidance counsellors and social workers conduct case studies for diagnosing a particular condition or problem and recommending therapeutic measures. They gather data from a carefully selected sample of individuals so as to derive valid generalizations about the population that the sample represents.

In education, exceptional children, the blind, the deaf, mentally defective, delinquent and the truant, are studied through a similar approach. A case study is not different from a survey, but instead of collecting information about few factors from a large number of units, the researchers make a deep and intensive study of a limited number of representative cases.

It is narrower in scope, but more exhaustive and informative in nature than a survey. To provide more qualitative data, the case study is often used to supplement the survey method. The basic assumption underlying this method is that the present state of the individuals, their behaviour patterns and attitudes are developed from the manner in which they deal with some significant experiences and events in their life.

Sometimes, case studies are also conducted for the purpose of hypothesis testing and take the form of experimental research. Many case studies, for example, were conducted to investigate the effects of operant conditioning on human behaviour. In a typical study, the researchers identify a specific behaviour in their subjects and systematically record the frequency of this behaviour. Then, they introduce an operant conditioning treatment and record the frequency of the specified behaviour during treatment.

Significance of Case Study Method. The case study is concerned with everything that is significant in the history or development of the case. The case may be an individual person, a family, a group, a social institution or an entire community. In a case study a deep probe is made into the interaction between the factors that produce change or growth. Case study is intensive in nature. It aims at staying 'everything about something'. The case is some phase of the life history of the unit of attention or it may represent the entire life process.

Definitions of Case Study. It is the method of exploring and analysing the life of a social unit. P. V. Young states that case study is a method of exploring and analysing the life of a social unit, be that a person, family, an institution, cultural group or an entire community.

It is an approach, which views any social unit as a whole. According to Goode and Hatt, 'case study is a way of organizing social data so as to preserve the unitary character of the social object being studied. Expressed somewhat differently, it is an approach which view any social unit as a whole.'

It is small, inclusive and intensive study. According to Yang Hsin Pao, 'case study method may be defined as small inclusive and intensive study of an individual in which investigator brings to bear all his skills and method or as systematic gathering of enough information about a person to permit one to understand how he or she functions as a unit of society.'

Case study is a very careful and complete observation of a unit. According to Biesabz and Biesang, 'the case study is a form of qualitative analysis involving the very careful and complete observation of a person, a situation or an institution.'

Characteristics of Case Study Method. Case study methods have the following characteristics:

- (i) It should be based on adequate and complete data.
- (ii) Data of the study should be valid.

- (iii) Data should have continuity in it.
- (iv) Data should be scientifically synthesized.
- (v) Synthesis of the data should be as much prognostic as diagnostic.
- (vi) Data should be kept confidential.
- (vii) Follow-up work must be taken up.

Uses of Case Study. Case study methods are useful for the following reasons:

- (i) A case study method is a useful mode of investigation into the casual relationships of complex educational phenomenon.
- (ii) It is frequently employed in studying cases of problem children, maladjusted students and students showing academic and other difficulties.
- (iii) It is also employed in finding out the general characteristics of phenomenon of a given class or an area, for example, case studies of truant students in slum areas or learning difficulties of students in mathematics.
- (iv) Sometimes case study method is employed in studying the teaching difficulties of beginning teachers.
- (v) Recently, case study method has been extended in the investigation of normal and gifted children also.
- (vi) It is also employed to find out the factors, which are responsible for successful institutions and groups.
- (vii) Case study had been extended for the investigation of ideal teachers.
- (viii) It forms the basis of preventing maladjustment.
- (ix) It is obviously an important source of educational programmes and reforms.

According to Thorne, 'an adequate case history clarifies ethnological relationships, resolves controversial points, uncovers illogical thinking and misinformation and aids in the differentiation between functional and organic complaints. The client derives reassurance from the fact that such a careful study is being made of his difficulties and benefits from desensitization, catharsis and aberration. As the details of the case history are elicited and brought into perspective, the client perceives causal relationship and gains new insights concerning the total problem of the organism meeting the environment.'

Types of Case Studies. Case studies are classified as follows:

- (i) Case studies of individuals
 - (a) A biography of child development
 - (b) An autobiography of an evolving philosophy and psychology of teaching
 - (c) Autobiography of a mental patient or of a criminal
 - (d) A personal account of psychoanalysis
- (ii) Case studies of institutions
 - (a) Case study of family
 - (b) Case study of an institution of learning
 - (c) Case study of a hospital clinic
- (iii) Case studies of communities or cultural groups
 - (a) Case study of a rural village
 - (b) Case study of an industrial community
 - (c) Case study of a factory setting

The study of Rothney and Roens revealed that there was need for preparing case histories of the following:

- (i) Children of exceptionally high achievement
- (ii) Children who show exceptionally high ability in art
- (iii) Children who show exceptional skill in practical arts or painting
- (iv) Children who are very persistent in striving for success
- (v) Children trying very hard against great obstacles
- (vi) Children who show exceptionally high ability in music
- (vii) Children who constantly present behaviour problems in class
- (viii) Children who do not seem to be able to do the work of the grade
- (ix) Children whose behaviour makes them appear to be 'model'

An Illustration of Case Study

- (i) Initial status or symptoms—reading disability of a child
- (ii) Collection of explanatory data—factors associated with learning disability: physical, intellectual, pedagogical, emotional, social or environmental
- (iii) Diagnosis or identification—defective vision
- (iv) Developmental treatment—correctly fitted glasses
- (v) Follow-up programme

The case study of the history of an individual: It is an intensive analysis of many important aspects of the individual person. Many techniques are employed to prepare a case study. The material for the case study is gathered through the use of many techniques, e.g., test of intelligence and achievement, self-reports, interviews, observations and home visits.

A case study is essentially more than an expanded cumulative record. It contains interpretations, recommendations and reports in follow-up work. The person who prepares a case history must have a broad background of psychology and sociology, and must avoid bias.

Writing the Case Study. According to Jane Warters, 'whether long or short, written in formal manner or in free description and narrative style the case study should present as accurate and as objective an account and as complete and dynamic a picture as possible.' The writers should, as a rule, avoid technical terminology; and they should make it a rule to shun loose generalizations. Every possible care should be taken to avoid such common sources of inaccuracies as errors in perception, especially as to what is seen and heard; falsification of memory; unconscious omissions; tendency to dramatize; projection of one's own ideas, attitudes, values and the like into the report; inclination to pay special attention to unusual and striking incidents and to neglect the common place and small details that may have special significance in the light of the whole—interpretations, recommendations for treatment for developmental and preventive purpose as well as for remedial purposes, and reports on efforts to carry out recommendations and to provide treatment should be included in the case study.

Allport suggests that successful case study seems naturally to fall into three sections as shown in Table 7.2.

Table 7.2 Sections related to a successful case study

Present	Past	Future
Problem	History of problem	Educational plan
Educational status	Educational history	Prediction of ultimate level
Intellectual status	Intellectual development	

(Continued)

Table 7.2 (Continued)

Present	Past	Future
Health and physical status	Health and physical history	Prediction of future health
Maturity level	Development history	Vocational plans
Personality	Personality development	
Social relations	Social history	
Vocations	Vocational history	Vocational plans
Family relationship	Family history (including home and neighbourhood)	

For conducting case history the following data should be called:

- Name of the child, date of birth, age, class, sex
- Name of the father, occupation, address

Statement of the problem

The different types of problems are shown in Table 7.3.

Table 7.3 Different types of problems

In school	Out of school
Scholastic	Delinquency
Conduct	Recreational needs
Health	Home conditions
Emotional	
Attendance	

Nature of case study data

Data may be collected under the following main heads:

- Psychological
- Medical
- Mental
- Temperamental
- Academic history
- Family history
- Social history
- physical history
- Educational testing history

Limitations of Case Study Method. Case study methods have the following limitations:

- A generalization drawn from a single case or a few casually.
- It is very difficult to select subjects on units for a study that are representative or typical.
- Sources of data may not be very reliable.
- Sources of data may be reliable but data may suffer from over-emphasis on unusual events or distortion.
- Subjective bias is a constant threat to objective data gathering and analysis.

- Effects may be wrongly attributed to factors that are merely associated rather than cause and effect related.
- For using this method effectively the researcher must be thoroughly familiar with the existing knowledge of the field of enquiry and should be skilful in isolating the significant variables from the irrelevant variables.

Value of Case Studies. The case study attempts to understand an individual or a unit in depth. It tries to understand the whole 'case' in the totality of his environment. It analyses not only the present status of an individual, but also his past. The case study often provides an opportunity for the researchers to develop insight into basic aspects of human behaviour.

The case study helps the researchers to observe events both within and outside the educational setting in their totality. They note events in terms of their location in space and time, and interpret results in the light of the relationships and interdependence of events.

A case study may provide insights that will help a researcher to formulate fruitful hypothesis or a set of hypotheses. Freud, for example, when attempted to probe deeply into the dynamics of his patient problems, reasoned that the relationships that he observed between them and their environments might also be the characteristics of other individuals with similar problems.

Steps of case study: The following steps are involved in the conduct of case study:

(i) *Determining the present status of the case*

The first step is to determine the present status of the individual or the social unit under investigation through direct observation or measurement. Here, the researchers go far beyond casual observation or superficial description. In addition to a physical examination of the subject, a psychological evaluation designed to determine the general ability level and the emotional maturity of the case is necessary. There are numerous standardized tools that are useful to the researchers in this assessment process like, direct observation, intelligence, aptitude and personality tests.

(ii) *Formulation of the hypothesis*

Through the knowledge of similar cases, the researchers, for example, can formulate a hypothesis that the occurrence of delinquent behaviour in a child is due to inadequate home environment, poor teaching in the school, low mental ability or any other factor.

(iii) *Verification of the hypothesis*

The case is then checked for the presence or absence of the antecedents supposed to apply to the situation under investigation. Here, the researchers make use of the knowledge of the present status and the history of the case. They should not over-emphasize observational methods and neglect other methods. Van Dalen (1973) suggests that a multi-method approach may serve as a more valid test of a hypothesis.

The researchers may ask the case to recall past experiences or to express present wishes in interviews or questionnaires. Personnel documents, such as diaries and letters, and various physiological, psychological or sociological measurements may provide valuable information. Data may be obtained from teachers, friends, parents, brothers, sisters and other family members.

(iv) *Validation of the diagnosis*

After verification of the hypothesis, next step is directed towards further validation of the diagnosis. Some remedial measures in the light of the causes found are suggested. Case is checked for the presence or absence of the antecedents and steps are taken to remove the causes of the problem.

(v) *Follow-up of the case*

This is the last step of the case study. The case under study is re-examined to ascertain whether any changes have been produced by the treatments introduced. If the change is positive and significant, the diagnosis is taken to be correct.

(vi) *Reporting the case study*

Facts of a case study must be reported precisely and objectively, and judgements must not be made until adequate evidence supports a conclusion. The researchers must exercise every possible precaution to detect data that are the product of 'family perception, deliberate deception, a poor memory, unconscious biases, or reporter's or subject's desire to present the right answer'. They should avoid the tendency to over-emphasize unusual events or to distort them for dramatic effect.

Causal-comparative Studies

This is another types of research, which has been categorized under interrelationship studies, which are of descriptive nature.

Meaning of Causal-comparative Studies. Basically, the purpose of these studies is to find out whether there is any causal relationship between a phenomenon and certain other factors, or conditions hypothesized to be related to it. Hence they are called causal studies. They are also called comparative for the reason that, in most cases, the causal relationship is established on the basis of comparisons of similarities and differences among phenomena. From the point of view of purpose to be achieved causal-comparative studies are very close to experimental studies as in both it is the causal relationship that is aimed to be established. But, from the point of view of methods they are much different from one another. In case of an experimental study the researchers manipulate the independent variable and then observe its effect on the dependent variable, while in case of the causal-comparative study the researchers get the dependent variable as a naturally occurring phenomenon; and from this point they proceed to identify the various antecedents, which may have been related to its occurrence. For example, the researchers come across a group of children with negative attitudes towards teachers. They meet the phenomenon of negative attitudes of children as it has already been occurred naturally. This is a dependent variable. Now, they proceed to find out the factors that are related to children's negative attitudes. This is done by comparing various personal, social and environmental characteristics of these children with those of the children who do not have negative attitudes.

One the basis of this kind of comparison, they describe why the said group of children had developed negative attitudes towards teachers. This method had emerged from Mill's method, which says: 'If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree is the cause (or effect) of the given phenomenon' (Mill 1846: 244).

Importance of Causal-comparative Studies. The importance of these studies lies in the fact that the true experimental method of identifying causal relationship is not applicable in actual situations of life. In these situations, it is not possible to manipulate the independent variable and conditions, which can deliberately develop less negative and more negative attitudes in children. Hence, in these situations only methods such as causal-comparative studies are useful. These types of studies are more practical, feasible and meaningful for this reason. All the investigations in which differences between groups are studied are of this kind and are considered important.

Disadvantages of Causal-comparative Studies. Although very useful, causal-comparative studies have their own limitations. Lack of control of variables and lack of possibility of manipulation of

independent variables render them of limited value, as their results cannot be generalized to any larger population. The results obtained cannot be considered to be very reliable. The precision of these studies to establish which is the cause and which is the effect. They cannot have high internal validity.

According to Kerlinger, 'causal-comparative research or ex-post facto research may be defined as that research in which the independent variable or variables have already occurred and in which the researcher starts with the observation of dependent variable or variables. The independent variables are those variables whose effects are being examined and the dependent variables are those that are being predicted or those that are affected by the independent variables.'

It is a systematic, empirical enquiry in which the scientists do not have direct control on independent variable because their manifestations have already been occurred or they are inherently not manipulable.

In some investigations, the researcher attempts to explore not only what a phenomenon is like, but also how and why it occurs. In such cases, the aim of the researcher is to compare the likeness and differences among phenomena to discover what factors or circumstances seem to accompany or contribute to the occurrence of certain events, conditions or practices.

The relation between the events and circumstances is studied in this type of research. Nowadays, it is also called ex-post facto research. Inferences about relations among variables are made without direct intervention, from concomitant variation of independent and dependent variables.

Nature of Causal-comparative Studies. The causal-comparative studies are based upon John Stuart Mill's method of discovering causal relationships. Mill's method of agreement states: 'If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstances in which alone all the instances agree, is the cause (or effect) of the given phenomena.'

Causal-comparative studies are employed when researchers cannot manipulate the independent variable and establish the controls that are required in experiments. In a laboratory experiment, the experimenters control all variables except the independent variable or variables which they manipulate to see what happens. But, because of the complexity and nature of the social phenomena, a researcher while studying educational phenomena cannot always select, control and manipulate the factors necessary to study cause-effect relationships.

If the researchers, for example, want to study emotional stability, they cannot manipulate the home background, socioeconomic status or intelligence of children and cannot place children in a situation where all factors are kept constant except for one variable, which is manipulated to determine what causes a particular type of emotional instability.

Rather, they select children who, according to a criterion, are emotionally unstable and compare them with a group of emotionally stable children. After analysing the data, they may be able to identify the factors or conditions associated with the group of emotionally disturbed children and, therefore, present a possible explanation of the underlying causes of the emotional instability.

Value of Causal-comparative Method of Research. Causal-comparative method is especially useful in the situations when the experimental method is impractical or costly in time, money and effort. In some situations, ethical considerations may prevent a researcher to use experimentation as a method of investigation. Van Dalen (1973) states that, respect for living things prevents an investigator from inflicting unnecessary pain, hardship or harm on others, or from interfering in any way with the normal growth and development of an individual.

This method provides a means of tackling problems that cannot be probed in laboratory situations. Furthermore, they yield valuable information and clues concerning the nature of phenomena and are admirably suited to many types of field studies seeking to establish causal relationships.

Guidelines for Causal-comparative Research. The steps for conducting a causal-comparative study are similar to the one for conducting a survey that has already been discussed in previous chapter 6.

This type of study may be of any magnitude, from a single classroom to an entire school or schools of a district. A study could be international in scope, involving several countries, such as the International Study of Achievement in Mathematics.

Causal-comparative studies can be improved by adhering to some relatively simple guidelines. Hypotheses should be stated and tested whenever possible. The interpretation of the results of a causal-comparative study, as with any type of research results, should be supported by knowledge of the independent and dependent variables—their possible relationships and effects.

A potential weakness of this type of research is lack of control, but this should not be interpreted as a reflection on the value of ex-post facto research. Many educational research problems, especially those involving social and psychological variables, such as aptitude, teacher characteristics and school climate, are causal-comparative in nature.

Types of Causal-comparative Designs. The causal-comparative designs are of two types:

- (i) Correlational design
- (ii) Criterion group design

Correlational designs: It serves a useful purpose of determining the relationship among variables and suggesting possible bases for causality. Although correlation does not necessarily imply causation, in this design causation necessarily implies correlation. Simply stating, the correlational design involves collection of two or more sets of data from a group of subjects with the attempt to determine the subsequent relationships between those sets of data.

Criterion group design: Criterion group design is used when the researchers are working in an ongoing environment particularly one based on an interest in formulating some hypotheses about what causes a particular state or condition. It is often helpful in such studies to begin by contrasting the characteristics of a state with the characteristics of its opposite state using the criterion group design.

For example, when the researchers are interested in studying the interaction patterns of effective teaching they have to begin by identifying the two criterion groups: effective teachers and ineffective teachers; and then discover what may 'cause' only some teachers to be effective.

Correlational Studies

The purpose of these studies, like the causal-comparative studies, is to find out relationship between variables. But, while the other methods explain only about the fact of relationship, i.e., the relationship exists or not, correlational studies go a step further and also explain how much is the relationship. In case of these studies, it is possible to find out the magnitude of relationship in the form of a mathematical quantity known as the coefficient of correlation. They also explain whether the relationship is positive or negative. The magnitude of relationship varies between +1.0 and -1.0. The coefficient of correlation of +1.0 indicates perfect relationship in the positive direction and that of -1.0 indicates perfect correlation in the negative direction. In between these, there are high and low relationships on the continuum.

Correlation studies use statistical methods for finding out coefficients of correlation. These are used in studying more complex relationship such as studies of predictive nature and multivariate analysis.

One great disadvantage of correlation studies is that they do not explain which is the cause and which is the effect. In the kind of relationship that is discovered between the variables, causal relationship cannot be established on their basis. This makes correlation studies different from experimental studies.

Developmental Studies

This is another type of descriptive study. This type of study aims at describing the change that takes place in the growth and development of an organism or an institution or some social process over a determined period of time. It also describes what factors and conditions in what manner brought about the change.

Van Dalen (p. 28) discusses two types of researches: growth studies and trend studies.

Growth Studies

Growth studies can be made in any field. But, most common are the studies of human growth and development. They describe how the human organism develops, what characteristics develop at what stage of life, and which forces and factors are responsible for these developments. These studies are of two types: longitudinal and cross-sectional.

In case of longitudinal studies the same child or the same group of children is measured on several variables at different age levels with the result that the study stretches over a number of years bringing out most critical changes taking place at a critical age level. For example, a group of children is measured on intelligence, social habits, emotional stability, self-concepts, interests and other personality characteristics at the age levels of five, six, seven, eight, nine, ten and eleven years. By comparing these measures, the researchers are in a position to describe the developmental change that takes place.

The cross-sectional research measures several different groups of children of different ages simultaneously on certain variables of interest and compares the groups among themselves to find out how they differ and what dominant characteristics are shown at different age levels. Such studies are completed within a short duration of time. For example, simultaneously at one point of time, the researchers administer their tools for measuring a few variables of five-, six-, seven-, eight- and nine-year-old children. They calculate the mean scores on each variable for all the age groups and compare them. On the basis of this comparison, they describe which traits are dominant at which age level, or which dominant characteristics define a particular age group.

It is difficult to say whether longitudinal or cross-sectional approach is better. Both have their own advantages and disadvantages. The longitudinal method is considered more appropriate as technique of studying human development. It has several advantages. But at the same time it has certain weaknesses also. It gives, no doubt, more accurate assessment of the developmental change. But, that may not be true about all individuals as the group of children studied may not be a representative of any larger population. Another weakness is that it is difficult to keep all the subjects within the study over a long period of time. Several of them may be lost to the investigation for several reasons. It is also time-consuming. It is difficult to wait for a long time for the results. On the other hand, the cross-sectional study is considered to be handy and adequately manageable. Hence, they are more popular. They have the advantage of being completed within a short duration. They reveal the status of the children of different age groups on several variables simultaneously. But, they, too, have several weaknesses. One of these is that the groups that are compared are not, many a time, comparable.

Both types of studies are, however, considered quite useful if the purpose is to understand growth and development.

Children grow very fast. They also learn very quickly. If one observes a child admitted in grade I for some time, one finds many changes in the child's behaviour. The researchers who want to know changes in behaviour over time can apply cross-sectional or longitudinal designs for their study.

Suppose a researcher is interested to know the changes in height and weight of the child after every six months for a period of three years. Another researcher may be interested to know how many words

children can recognize when they are at the age of 4, 4½, 5 and 6 years. In these types of studies one can either employ a cross-sectional design or a longitudinal design.

A cross-sectional design is relatively simpler. It involves collection of information from different groups of pupils (varying in age) at one time. For example, you want to know the number of words children can recognize. You select four groups of children at the age of 4, 4½, 5 and 6 years. In other words, in this design, the researcher attempts to study the impact of age on behaviour or learning. The design is simple and consumes less time and money; time periods cannot be considered equal in terms of their cultural and historical experiences.

Longitudinal design, in contrast, involves study of same group of children over a number of times. For example, in the above example, children, who are 4 years old will be tested on the first occasion. Thereafter, the researcher will wait for 6 months and only after the children attain the age of 4½ years they will be subjected to testing. The same group of children will be tested when they are 5 and 6 years old. It is evident that this method is more time-consuming and costly. It is also characterized by the problem of attrition. Considering the current high dropped out, only less number of pupils will be available. The same group of children is tested on several occasions, which enhances the possibility of carry over of learnt material from one occasion to another. The advantage is that it helps in understanding the processes involved in learning.

Trend Studies

Trend studies also constitute a sort of development type of research as they also observe and assess what characteristics are emerged prominently and consistently at different times. But, they do not stop only at this point describing only these consistently dominant characteristics. They are also future-oriented in the sense that on the basis of these consistently dominant characteristics or trends they also predict what will be the future status of these trends, how will they affect the institution, the people, the environment, the output and other various aspects. For example, the study of the rates of enrolment at primary level of education for the past 10 years may enable the researcher to predict what will be the situation in the next 5 or 10 years, how many schools will have to be opened, how much financial allocation will be required per year, and so on.

This kind of research uses methods and techniques like other research strategies such as historical research, survey techniques and content analysis. Studies of school enrolments, population changes, employment opportunities, and specific social changes may be considered belonging to this category of research. For certain purposes, they may be considered very useful.

Clinical Research and Case Studies

Clinical Research

Clinical methods are different from the experimental and differential methods, which are more concerned with normal mental phenomenon; but in educational psychology we come across certain deviations in behaviour, which generally are called mental disorders. These mental disorders also require methods of not only diagnosis of the causes, but also of the treatment of those disorders. The methods used for diagnosis and treatments of mental problems or symptoms of a milder or more severe nature are called clinical methods. The word clinical is something pertaining to a bed, which means dealing with the sick persons, just as in a hospital or in a health clinic, the doctor deals with the patient on the bed. The clinical method is directed towards the individual and is concerned with the diagnosis of the mental

illness of that individual and secondly with the treatment of the illness, just as the doctor first diagnoses the nature of the illness and the causes thereof and then prescribes the line of treatment, which may be medical and surgical or concerned with psychotherapeutics.

Some of the methods, which constitute the treatment or clinical methods are the following:

Advice, Enlightenment and Suggestion

Sometimes, the mental problem or difficulty is a timely setback and more at the surface level. It is not very chronic or deep seated, but is transitory and temporary. A youth, for example, was saved luckily by being run over by the train, as he wanted to commit suicide. The case was brought to the psychiatrist for advice and help. It was discovered that the young man had taken fancy for his cousin and wanted to marry her after he had seen her in a family wedding. Ordinarily in a Hindu family thinking of marrying a cousin or near relations is something not only condemnable but also taken as sinful, wrong and even abominable. The same idea formed the part of the super-ego of the specifically being rather rigid rebuked the self or the ego very severely that he was such a hateful rascal and such an inexcusable sinner that he had such learning towards his cousin sister who was like a sister. It was better for him to draw himself somewhere and not to show his bloody face to anybody as he had such mean, dirty and shameful thoughts about his cousin. His ego or self was not very strong and he was not very bright also.

Ordinarily mental illness is caused when the ego is weak, as the ego is easily assailed by doubts and is easily confused, frightened, subdued and threatened by the stronger super-ego. The situation was quite clear to the psychiatrist after studying his case history and the nature of symptoms. Here, the illness was not deep seated needing long analysis but it was a simple case of confused thinking with poor ego strength to decide the issue. The boy was told that if he was so set and was so fond of the girl, he could ask her to go with him far away from his home to find a job to maintain her and to fend his way. He should have guts and courage to take her away and not legal for him to continue living with her, his super-ego was also corrected and it was strongly suggested that there was nothing sinful or immoral to marry his cousin sister as among Muslims, Parsis and other communities cousin marriages are quite common. If it was not a sin against God in these cases, why should it be a sin or something immoral in his case? He was also informed that in history there have been nations where, not only cousin marriages but marriages among brothers and sisters were also common.

In Germany, for instance, up to seventh century AD when some missionaries went there, marriages among brothers and sisters were so common. Cleopatra, the queen of Egypt had her husband Ptolemy who was her real brother. In some such manner of enlightenment the young man was strongly suggested that he was not committing a sin in marrying his cousin. Knowing that the young fellow was not so strong to take that step it was further suggested that although there was nothing wrong and sinful in marrying his cousin sister, first he should think of completing his education. Then there would be so many offers for him of girls even better than her. She was after all not the only girl for him in the world and there actually were many more girls to choose from, who were even better than her in many respects. There was no hurry for him and could decide after he would get employed.

This was a guidance for his marital problem; by the way of building up or correcting his super-ego and giving him some ego strength with a specific purpose or motive in life the patient felt much relieved and fairly normal. The result was that he took his studies very seriously and stood first in the examination. After getting the degree he dropped the idea of getting so much involved in that girl as he did not have ego or strength enough to take her away and there was a possibility of getting some better girl. Thus, the tangle was resolved. This was a simple case of enlightenment of the whole situation at the conscious level without going deep into therapy.

Similarly, some counselling or suggestion given to young people in such personal problems gives them a new start in their life as without proper information they feel confused and distressed and sometime severe conflict, which undermines their achievement in work, and leads, in some cases, to more severe personality problems. There was a confirmed young masturbator who came to psychiatrist for advice and went away with a smiling and beaming face after he had been enlightened about the habit of masturbation, and that there was no so-called loss or harm arising therefrom. He was told that he was not the only condemned sinner. He was told of the well-known statement of the great authority Norman Haire who wrote in his book, *Encyclopedia of Sexual Knowledge*, that 99 per cent of the people, both boys and girls or men and women, had sometime or the other in their life, and in one way or the other, masturbated and the 100th as the Pure was either a liar or an impotent. The patient was told emphatically that he had committed no sin and that no harm has been done to him, as the seminal discharge is a normal process. According to the statement by an authority tears from the eyes, saliva from the mouth and nasal secretions from the nose were the same as seminal fluid from the sex organs. He was told that if drop-by-drop water falls in a cup it is bound to overflow after sometime, so was the case with the nocturnal discharge. In fact, it was good to have such occasional discharges to release tension. Such information given to the young boy enlightened him and the spark in his eyes showed that he grasped the whole; however, he was told not to indulge in the habit voluntarily because nature had made sex function for the enjoyment of both the sexes and to get joy by self-stimulation or masturbation was more a selfish act and that is why one feels guilty, shameful, inferior and not quite adequate. In this youth who had sometimes suicidal fantasy also, simple enlightenment on the functioning of the sex urge was enough to restore him his normal health.

Psychoanalysis

Psychoanalysis as a clinical method was evolved by Sigmund Freud. This method was of giving hypnotic suggestions to the patient when he was in a hypnotic trance and hypnotism. In this method the patient is made relaxed in a couch and by tiring his eyes is made to look at a spot in front. The patient could be put in a state of drowsiness or artificial sleep, which was called hypnosis. In this state, the therapist instilled or suggested forcefully a mode of behaviour, but it was only for a temporary relief. Freud was disappointed that hypnotism was not the sure cure of mental symptoms. Before leaving Paris one day he noticed that a patient who was very keen to talk to him felt a great relief after she had finished conversation. This episode served a turning point in psychotherapy, as Freud hit upon the idea that real cure lay in allowing the patient to talk about the symptoms and the illness. He left Paris and came to Vienna and used 'talking cure' technique with his patients. Freud called this technique as psychoanalysis, which, in fact, consisted of free association and dream analysis. Through these two techniques Freud claimed that the unconscious mind, in which the causes of the symptoms in the form of repressed desires lay, was understood. The cure was said to consist in digging up the unconscious and to make it as part of the conscious self so that the patients could have a clear idea of the nature and the causes of their symptoms. A patient, for example, was suffering from 'washing mania', when she would wash everything in the home. With a mop in hand she would go from room to room, to doorsteps and again to the bathroom to wash the mop, which she thought had become dirty and started the process again, as she felt that day even washed the sofa, carpets and furniture in the drawing room. Her husband was much worried. He was tired of this behaviour on her part. She would not allow him to enter the house when he came from outside without taking off his shoes, as she argued that he would make the floor dirty.

Although it was a common symptom of washing mania, as found in many cases in one form or the other, this unusual behaviour was a case for psychoanalytical treatment. In the consultation room of the psychoanalyst this lady, as a patient, was allowed to talk all about herself, her family, early childhood, her

marriage and about children, which she had none. In the data revealed by her during the psychoanalytical sessions, it was made out that the lady thought herself dirty and all things around her to be dirty and had to be cleaned again and again. This mania about dirt to be wiped away was, in fact, her feeling of dirt, guilt and so bad as she had proved so ignoble, bad, ugly, dirty, guilty and useless as she had failed to fondle a child. Her guilt feeling, leading to washing mania, was made out to be caused by her failure to be a mother as every woman's greatest desire was to be a mother. It seemed as if her super-ego was rebuking that she was such a dirty, ugly, bad and immoral a woman who had not delivered a child. This reprimand of the super-ego made her feel so guilty and dirty that she began washing her hands and other things around her so much so that washing became an obsession with her, which resulted in the washing mania.

Sometimes, to have a detailed picture of the causes, interview sessions are also arranged and then the task becomes more easier to analyse the content into a new synthetic whole of the personality of the patient with a new direction or orientation. Patients to have the understanding and insight into their problems to be able to control and solve it.

Psychoanalysis is not so effective with children because there are certain prerequisites or treatment through this method, which is more applicable to adults than children. First, for getting some benefit from psychoanalysis the patients must feel that they need psychological help. But children are not so aware of the problem nor do they seek the help of anybody. In their case the parents feel more worried and think of seeking help for the child. Second, the children are not able to control their behaviour outside and inside the analysts room nor to express themselves in verbal forms. Third, they cannot have insight or understanding of their own conflict nor do they have the will to get well by co-operating with the analyst. Fourth, they cannot establish the transference situation with the analyst, which means that they cannot identify themselves with the analyst and transfer their problems to him. So for children play therapy is used.

▲ Genetic or Developmental Studies

It is important for educators and teachers to have reliable information about physiological, intellectual and emotional growth of children at various ages; how they differ from one another within certain age levels and how they change as a result of certain treatments. Such types of information are useful in making decisions about the type of curriculum, textbooks and teaching methods.

Genetic studies are used for investigating the characteristics of children and the ways in which these characteristics change with growth and development. Such studies are concerned not only with the present status and interrelationships of phenomena, but also with changes that take place as a function of time. Genetic studies are also called developmental studies.

Today's developmental methodologies have their origin in the nineteenth century with its advances in science and the emergence of the field of psychology and psychoanalysis and the developments in measurement and statistics.

Developmental studies provide reliable information about the present status (development) and interrelationships of phenomena as well as the changes, which occur with the passage of time. It also describes various emerging characteristics and significant course of their development over a period of months or year. How children grow, differ from others, develop physically, intellectually, emotionally and socially, may be made the object of probe through such studies. How the characteristics of children change with growth and whether changes are a result of some interrelated factors are also studied through developmental research. According to Mouly (1970), 'developmental or genetic research is strictly not an educational research technique'.

Developmental research resembles with many research techniques—historical experimental—but it is still unique, as it is different from all these in purpose. It is not interested in the present or its historical background, not even in the present or in the ways in which phenomena can be modified through the environmental conditions but simply in the patterns (Mouly 1970). Developmental studies are also called genetic studies.

Value of Genetic Studies

The teachers must have the knowledge of the nature and rate of changes that take place in the children in order to teach them effectively. They must have an understanding of the interrelated factors that effect the growth of children at various stages of development and how the duration, intensity and timing of such factors in the developmental period effect growth.

Genetic studies are used to seek knowledge of the nature and rate of changes that take place in human organism. They are helpful in studying when various aspects of growth among children are first observable, accelerate further, remain rather stationary, attain optimal development and decline.

Types of Genetic Studies

Genetic studies can be divided into two types:

- Longitudinal studies
- Cross-sectional studies

Longitudinal Studies

It follows the same subject a group of subjects, or an institution over a relatively long period of time. It is a kind of extended case study as it involves a long lifespan of the same subject, group or institution. For example, the researchers may test and measure the same student on a trait of personality when he is 10, 11, 12, 13 and 14 years and plot his individual growth patterns for this trait during these years. Therefore, they could assess the change in the trait over a period of time at different age levels of the student.

This type of research is mostly used in clinics and laboratories. However, its use in the field of education is not uncommon. Some studies are good examples of carefully planned and executed longitudinal investigations. Terman and co-worker (1925, 1947, 1959) made a comprehensive longitudinal investigation of gifted children. The findings of this study have made a significant contribution to the understanding of the growth of gifted children and also set the methodology for further research in this area.

In spite of the importance of this method it suffers from some limitations. Longitudinal studies have sampling weaknesses, as the data is usually obtained from a single individual or a limited number of individuals. In some cases, it becomes difficult to maintain the co-operation and track of the individual for a longer period.

Moreover, longitudinal studies may give accurate descriptions of the growth of the individuals studied, but these data are not necessarily representative of the total population from which the individuals are selected.

Another problem is that the researchers cannot make improvements in their measuring tools or instruments as their study develop without disrupting the continuity of the procedures. Further, these studies require extensive facilities, considerable amount of money and maximum perseverance on the part of research personnel over a number of years. Such studies, therefore, may be undertaken by research organizations in the form of projects and not by individual researchers.

Advantage of longitudinal studies: Longitudinal research is the best in developmental techniques. Dalen and Meyer (1966) gave an edge to longitudinal studies; the longitudinal technique is the most satisfactory method of studying human development.

Individual variability of growth and development is revealed better in longitudinal studies. For example, growth in height of a particular group of children or of an individual is measured through years. This technique provides significant picture of growth. Longitudinal technique will clearly depict the spurt in height or other individual fluctuations which are frequently of greater interest than the overall growth patterns itself. Shuttleworth (1939) found that late maturing and early maturing girls exhibited different growth curves, which were not apparent, when age cross-sectional data were used. Children mature at different age, and their growth patterns reflect the influence of illness and environmental experiences that they encounter. Hence, longitudinal technique accurately describes the individual growth than any other technique of developmental research.

Goodenough (1940) has enlisted certain difficulties of longitudinal research as follows:

- Difficulty in population sampling such as the selective elimination of many of the original subjects during the course of a long-term investigation. Maintenance of satisfactory working relationships among subjects, parents, schools and investigators, particularly as personal changes take place with the passing of time. Motivation of children to demonstrate rather than perfunctory performance is a real challenge in the case of repeated testing over a period of months or years.
- Systematic errors of measurements in the administration or scoring of tests, mental/physical non-comparability or uncertain psychological equivalence of tests used at different age levels, especially when the time span is from early childhood to adolescence. Unequal experience of groups in terms of factors affecting the results of measurements used, but not affecting the trait itself, e.g. variation from previous experience with standardized tests. Recording and manipulation of data, e.g. work of graduate students, are probably not as accurate and efficient as a highly trained permanent staff for skilled punch-card operators and statistical clerks. Mistakes of interpretation resulting from the failure to take account of the principle of regression, particularly in its effects on measurements of gain or loss.
- Baldwin (1960) also highlighted certain weaknesses of longitudinal research. Since subjects are children, we must know their language, characteristics and psychology. We are unable to control the environment of a child over any reasonably long period of time, which means that control over the events in the child's life are frequently inadequate in longitudinal studies. We face ethical problems, particularly if some deception of the child is necessary in the interest of research. Both ethical and practical problems are present in securing subjects, and in working with the homes and with schools and institutions.

Cross-sectional Studies

These studies overcome many of the limitations of the longitudinal method. When conducting cross-sectional study, rather than following the same group of individuals and taking their repeated measurements over a relatively long period of time, random samples of individuals of successive ages are selected and one set of measurements of different individuals from each age level is taken as the basis for developing growth norms. The statistics derived from the samples are compared and the conclusions are drawn about the growth of individual with respect to the variables studied.

In cross-sectional studies, the researchers select age-differing groups that are as alike as possible in respect to sex, intelligence, socio-economic status or any other variable that may significantly affect the growth factor being studied. But, they too have some limitations. The researchers cannot remove

all variations due to the variables other than age, in which groups differ and the differences due to extraneous variables may seriously affect the results.

Measurements taken from individuals at each age level may not be comparable because the groups may differ on variables other than age. Another serious limitation of cross-sectional studies is that chance differences between samples may seriously bias the results.

Cross-sectional studies are easier to fit into most of the research studies as it gives quick results. Most of the researches are cross-sectional in character, chiefly because it is less expensive and less time-consuming (Lovell and Lawson, 1970). According to International Encyclopaedia of Psychology (1996), 'in cross-sectional designs, data are collected on different cohorts at the same time. These designs, data are collected on different cohorts the same time. These design permits an examination of age differences in behaviour; however, they cannot separate out the effects of different life experiences between cohorts.'

In terms of data secured for each age group, cross-sectional technique resembles with the descriptive-survey method. But emphasis in developmental research is on growth sequences and forward movements.

Cross-sectional research includes relatively large sample, which may accurately represent the whole population. It gives clear picture of the great range of individual differences that exists among children, for instance, average age to learn second language, levels of maturity and so on.

Unpredictable problems such as death, illness or causality to the subjects, moving of families, changes in cooperation of children and parents are relatively lesser in cross-sectional technique.

Cross-sectional technique gives prompt findings by consuming lesser time and money. Researchers can make improvements in their techniques as their study develop. Even if they discover some new instruments for measuring a particular variable, they may use it.

Cross-sectional method is preferred, when we want to learn the characteristics of typical children at various stages because of greater possibility of obtaining large sample with this method.

Generally, longitudinal studies are considered more acceptable than cross-sectional studies because they have the advantage of continuity and permit the researcher to record individual fluctuations, which are frequently of greater value and interest to him than the overall growth pattern itself.

However, if the researchers want to learn the characteristics of typical children at various stages, the cross-sectional method is preferred because of the greater possibility of obtaining large sample with this technique. Moreover, the selection of taking large samples may in many cases outweigh the limitations of the cross-sectional method.

These rules served as useful guides in the design of early experiments and are now used chiefly as guidelines in the planning of experiments. Further, the causal-comparative studies are based upon John Stuart Mill's method of discovering causal relationships. Mill's Method of Agreement states: 'If two or more instances of the phenomenon under investigation have only one circumstances in common, the circumstances in which alone all the instances agree, is the cause (or effect) of the given phenomena.' The following example given by Van Dalen (1973) provides a concrete illustration of this principle.

Suppose that six students A, B, C, D, E and F went to a debating competition, and subsequently, three of them A, B, C became ill. To find out the cause of their illness, the doctor questioned A, B and C about what food they had eaten and discovered that each had selected different items except for strawberry cream pie.

In other words, the only food eaten by all those who became ill was the pie. In conformity with the Method of Agreement, the doctor concluded that the illness was caused by pie, for it was only this item on the menu that the students had experienced in common.

To confirm his diagnosis, the doctor could have employed Mill's Joint Method of Agreement and Differences which rules that, 'if two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in

common save the absence of that circumstance, the circumstance in which alone the two sets of instance differ, is the effect or cause, or necessary part of the cause, of the phenomenon.' To make use of this rule, the doctor would have had to find out that pie was the only food that all the students consumed.

Furthermore, he would have had to question members of the group who did not become ill—D, E and F. If he found the only item common to those who suffered no ill effects was the absence of pie, he would have confirmed his conclusion that strawberry cream pie was causally related to the illness of students.

Another of Mill's cannons, known as the Method of Difference, states: 'If an instance under which the phenomenon under investigation occurs, and an instance in which it does not occur have every circumstance in common save one, that one occurring only in the former, the circumstance in which alone the two instances differ is the effect, or the cause, or an indispensable part of the cause of the phenomenon.'

For instance, if two situations are similar in every aspect, and one element is added to the one but not to the other, any difference that develops is the effect of the added element; or, if two situations are alike in every aspect, and one element is added to one but not to the other, any difference that develops is the effect of the added element; if two situations are alike in every aspect, and one element is removed from the one but not from the other, any difference that develops may be attributed to the subtracted element.

The cause and effect relationship can be studied by applying the Law of Single Variable. A researcher wants to study the effectiveness of a new teaching strategy, i.e. mastery learning strategy. For this purpose, two equivalent groups are selected: one group will be taught through the new strategy or the mastery learning strategy and the other group is taught by the conventional method. Same content will be taught and same criterion or achievement test will be administered on both the groups.

If the results of experiment show that the performance of the mastery learning strategy group is significantly higher than that of the conventional method group, it may be concluded that the mastery learning strategy is more effective than the conventional method, because better performance of the former group is caused by the new teaching strategy, i.e., the mastery learning strategy.

Evaluate Yourself

Research studies often conducted by researchers on a very large sample in order to know the characteristics of the learners of a specific age group, e.g. adolescent, are termed as follows:

- (i) Longitudinal studies
- (ii) Cross-sectional studies
- (iii) Growth studies
- (iv) Development studies

Follow-up studies: Follow-up studies follow the method, which somewhat resembles the longitudinal method. Such studies aim at investigating the subsequent development of individual or individuals after a specified treatment or condition. In case study approach, the researchers may be interested to follow up a case in order to determine whether the treatment is successful. If the follow up of a case indicates that its progress is unsatisfactory, a new diagnosis of the problem or problems is made. The techniques of experimentation are employed to evaluate the success of treatment or condition.

Trend studies: Trend studies are used to obtain and analyse social, economic or political data to identify trends and to predict what is likely to take place in the future. Some educational or other

organizations conduct such studies in order to plan effectively and to meet the demands that will be made on them in the future. These studies are undertaken through documentary analysis or surveys at repeated intervals. Such surveys help the researchers to study the rate, the direction of changes and to use these trends to predict future status. Sometimes trend study may combine historical study also.

▲ The Experimental Method

After having learnt about the historical and normative survey research methods, we shall focus our discussion on another broad category of educational research that involves experimentation. It differs from descriptive studies, in that the researchers have some degree of control over the variables involved and the conditions under which the variables are observed. The researchers deliberately manipulate some aspects of the experiment in which they are interested. They cause certain things to happen, and observe how the condition is affected or changed.

Although experimentation is the classic laboratory method of psychology, physics, chemistry, biology and other sciences, it has been effectively used in non-laboratory educational settings such as the classroom. So, an experiment is a research situation in which at least one independent variable is manipulated. The second half of the nineteenth century saw the beginning of educational experimentation. Wundt set up a psychology laboratory at Leipzig in 1897 where he experimentally studied the learning process.

Nature of Experimental Research

Experimental method provides much control and establishes a systematic and logical association between manipulated factors and observed effects. The researchers define a problem and propose a tentative answer or hypothesis. They test the hypothesis and accept or reject it in the light of the controlled variable relationships that they have observed.

Features of Experimental Research

There are four essential characteristics of experimental research:

- (i) Control
- (ii) Manipulation
- (iii) Observation
- (iv) Replication

Control

It is the essential ingredient of experimental method. It refers to the extent to which different factors in an experiment are accounted for. Since more of the factors are accounted for with accuracy and more control is being enforced, the researchers have more confidence that their results are dependable. High degrees of control are much easier to achieve in the laboratory setting than in the situations outside the laboratory.

The main purpose of control in an experiment is to arrange a situation in which the effect of variables can be measured. Since human nature is complex, there are many variables present while dealing with human beings in an experimental setting. The attempt of a researcher to reduce educational problems to the operation of a single variable is, therefore, not only unrealistic, but also impossible.

In experimental studies in education, the researchers have to direct their effort towards controlling the variables, which are significantly related to the dependent variable. There are inter-subject differences and some situation variables that might operate in the experimental situation itself.

Methods for Controlling Inter-subject Differences

There are various methods for controlling inter-subject differences so as to increase equivalence among groups that are to be subject to various experimental conditions. The best technique of attaining experimental equivalence is the random assignment of subjects to groups. Similarly, the researcher could assign teacher, classrooms, equipment and class periods strictly on a random basis.

Another method that is used for assigning subject to groups is to match individual subjects on as many extraneous variables as a researcher can identify that might affect dependent variable and then apply some random techniques to assign one member of each matched pair to the experimental conditions. However, it is important to determine which variables are significantly related to the dependent variable and which of these to use as a basis for matching variables such as intelligence, socio-economic, status, sex, age, achievements motivation and pre-test scores on the dependent variable, which are commonly used as the basis for matching.

A problem that may be faced by the researcher is how closely to match the subjects with the variable or variables. Generally, three matching procedures are used in experimental studies: subject-to-subject matching, matching groups for mean and standard deviation and ranking of subjects on the matching variable and thus forming the control and experimental groups.

Another procedure that is used to make groups comparable on an extraneous variable is to select groups that are as homogeneous as possible on that variable. For example, by selecting only male students, the researcher would control the effects of sex as an extraneous variable.

Because of the problems of the matching procedures discussed earlier, the technique of analysis of co-variance is used to control variation within the groups. This technique analyses the differences between the two groups, subjected to different experimental treatments, on the dependent variable after taking into account initial difference between the groups on pre-test measures or any other relevant independent variable.

Finally, assigning the same subjects to two experimental treatments and then to obtain measurement of the subjects first under one treatment and then under the other. Although this method is an efficient method of control it is not feasible in certain circumstances.

Methods for Controlling Situational Variables

There are three methods commonly used to control situational variables. First, in the method of holding situational variables, constant, the researchers treat all the available subjects alike except for their exposure to the independent variable. For example, the group may be taught by the same teacher, at the same time of the day and in the same environmental conditions such as temperature, presence or absence of distracting noise, furniture in the room and the like.

Second, the researchers should try to balance situational conditions by randomization. They may divide the two major groups into two smaller subgroups and randomly assign half of the first major group and half of the second major group to each teacher.

Third, the situational variables can also be controlled by manipulating them systematically. The researchers can use a sequence of experimental and control conditions in order to control progressive effects, i.e., by controlling the order in which experimental conditions are presented through a counterbalancing; half the subjects may receive an AB order and the other half a BA order.

Manipulation

This variable is another distinguishing characteristic of experimental research. It refers to a deliberate operation of a pre-determined set of varied conditions by the researcher, referred to as the independent variable, the experimental or the treatment variable. Sex, methods of teaching, attitudes, socio-economic status, classroom environment and so on are some common examples of independent variables in educational research.

Observation

In experimental research, the researcher studies the effect of the manipulation of the independent variable on a dependent variable (e.g., learning some task). Since learning cannot be measured directly, the researcher can only estimate it through such measures as scores on a test or observations with respect to some characteristics of the behaviour of the subjects used in the experiment.

Replication

Replication means conducting a number of sub-experiments within the framework of an overall experimental design. This is essential as no matter how objectively and carefully a researcher attempts to control the extraneous variable through the rounds of randomization or other methods, still some discrepancies invariably remain and influence the results of the experiment. Such discrepancies may be taken care of through the replication of the study.

Value of Experimental Research in Education

According to Campbell and Stanley (1963), 'the experiment is the only means for setting disputes regarding educational practice, the only way to verifying educational improvements, and the only way of establishing a cumulative tradition in which improvements can be introduced without the danger of a faddish discard of old wisdom in favour of inferior novelties.'

Experimental research is used to determine and evaluate the adequacy and effectiveness of the educational and instructional objectives through the measurement of their outcomes. After evaluating the efficacy of objectives, the suggestions are made for the formulation, execution and modification of educational programmes and classroom practices. Effectiveness of certain learning experiences, teaching method and innovations in the evaluation techniques is also ascertained through experimental research.

Steps in Experimental Research

The steps of the experimental method are not different from those of a scientific method, about which we have already studied earlier. These steps are described as follows:

(i) *Survey the literature related to the problem*

For a worthwhile research based on experimentation, the researchers, like in any other type of research, need to acquire up-to-date information relating to their problem.

(ii) *Selecting and defining the problem*

Experimental research starts with selection of the problem, which is amenable to experimentation. It needs a rigorous logical analysis and definition of the problem in precise terms. The variables to be studied should be defined in operational terms clearly and unambiguously. It helps the researchers to convert the problem precisely into a hypothesis that can be verified or refuted by the experimental data.

(iii) *Stating of hypotheses*

This step is one of the distinguishing characteristics of the experimental method. Hypotheses are the heart of experimental research. They suggest that an antecedent condition or phenomenon (independent variable) is related to the occurrence of another condition, phenomenon, event or effect (dependent variable).

To test a hypothesis, the researchers attempt to control all the conditions except the independent variable that they manipulate. Then, they observe the effect on the dependent variable presumably because of the exposure to the independent variable. Therefore, the researchers should not only be concerned primarily with experimental plans and statistical procedures, but also give sufficient attention to the formulation of hypotheses.

(iv) *Constructing the experimental plan*

Experimental plan refers to the conceptual framework within which the experiment is conducted. According to Van Dalen (1973), it represents all elements, conditions or phenomena, and relation of consequences so as to identify all non-experimental variables that might contaminate the experiment and determine how to control them; select a research design; select sample of subjects, assign subjects to groups and assign experimental treatments to measure the outcomes of the experiment; outline procedures for collecting data and possibly conduct a pilot study to perfect the tools or design, and state the statistical or null hypothesis.

The identification of extraneous variables and the procedures for controlling them have already been discussed earlier in this chapter. In order to select a suitable research design for assigning the subjects to different experimental treatments to measure the outcomes of experiment, the researchers must be well acquainted with different types of experimental designs. On account of the importance of experimental designs in experiment, they have been discussed separately in Chapter 8.

(v) *Measuring the experimental results*

With the help of the tools constructed or selected by the researchers, the results of the experiment are measured.

(vi) *Classifying, analysing and interpreting findings*

The results of the experiment are classified, tabulated and analysed statistically. On the basis of the results, the hypotheses are rejected or retained. Next, the findings are interpreted leading to the conclusion of the research study.

(vii) *Writing the research report*

This step involves all the main factors that the reporting of results of any research study does. The steps involved in experimental research have been represented below in the flow chart in Figure 7.3.

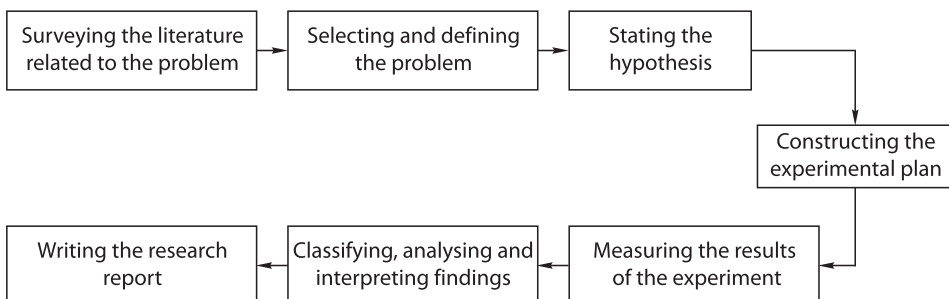


Figure 7.3 Flow chart showing steps in conducting experimental research

▲ Experimental Designs

An experimental design to a researcher is like a blueprint to an architect. It answers the valid research questions, objectively, truthfully and accurately, and presents an outline for studying the relationship between different variables. It provides an opportunity for the comparison of the hypotheses of the experiment and enables the researchers to make a meaningful interpretation of the results of the study with the help of statistical analysis of the data.

Criteria for Experimental Design

There are three important criteria, which the researchers must keep in mind while selecting an experimental design for conducting the experiment.

- Appropriateness
- Adequacy of control
- Validity

Appropriateness

It is the first criteria for testing the hypotheses of the study; otherwise, the results of the study will not be worthy of serious consideration. So, the researchers should select an appropriate design for a specific job, which will enable them to arrange the experimental conditions objectively to meet the requirements of the study.

Adequacy of Control

The design must provide adequate control so that the effects of the independent variable on the dependent variable can be measured. Adequate control of extraneous variables helps the researcher to get dependable answers to questions raised by hypotheses. The design with adequate control suggests what observations are to be made by the researchers, how to make them, what statistical tests are feasible, how to analyse the obtained experimental data and what results may be drawn from the statistical analysis.

Validity

It is essential for the purpose of testing particular hypothesis of the study.

Types of Validity

According to Campbell and Stanley (1963), there are two types of validity: internal and external.

Internal validity: One of the major objectives of the researcher in experimentation is to determine whether the variables that have been identified actually have a systematic effect on the dependent variable and whether the observed results are not affected by the extraneous or situational variables. The extent to which this aim is attained is a measure of internal validity of experiment, which is basically a problem of control.

Campbell and Stanley (1963) point out that there are eight extraneous variables that significantly affect the internal validity of a research design. They are of the opinion that these variables must be controlled or else they might lead to alternative interpretations of the results of the experimental study. They are as follows:

- History
- Maturation

- Pre-testing
- Measuring instruments
- Statistical regression
- Differential selection of subjects
- Experimental mortality
- Interaction of selection and maturation
- History

The researcher should try to control the specific events, other than the experimental treatment, that may occur between the first and second measurements of the subjects to affect the dependent variable.

■ *Maturation*

The time period that elapses during the experimentation may produce certain changes like biological or psychological in the subjects, e.g., fatigue, interest, age or motivation. Therefore, effects on the dependent variable as a result of the change in subjects due to passage of time could mistakenly be attributed to the experimental variable.

■ *Pre-testing*

It may serve as the learning experience and therefore it may affect their post-test performance.

■ *Measuring Instruments*

Different measuring instruments, scorers, raters, interviewers or the observers, used at the pre- and post-testing stages, which may also account for the observed differences in the scores or measures of the dependent variable.

■ *Statistical regression*

The groups chosen on the basis of extreme scores may cause statistical regression effect. It refers to the tendency for extreme scores to regress or move towards the common mean on subsequent measures. Such a tendency may operate to produce an effect that could be interpreted as an effect due to experimental treatment.

■ *Differential selection of subjects*

The groups may differ significantly on some important variables related to the dependent variable even before the application of the experimental treatment. For example, if the subjects in the experimental group are more intelligent than the subjects in the control group, the former may perform better on the dependent variable even if this group did not receive an experimental treatment.

■ *Experimental mortality*

The differential loss or dropping out of subjects from the comparison groups may affect the findings of the study. If, for instance, a low scoring subject in the experimental group drops out after the pre-test, this group will show higher mean on the post-test than the control group, not because of the experimental treatment but because the low scoring subjects are not present.

■ *Interaction of selection and maturation, selection and history*

When the two comparison groups have the same scores on the pre-test, some other differences due to interaction between variables, such as intelligence, motivation, interest and age rather than experimental variable, may cause one of the groups to get higher post-test scores. Such interaction occurs when subjects are selected into groups on the basis of factors extraneous to the purpose of the experiment.

■ *External validity*

It is concerned with the generalizability or representativeness of the experimental findings, that is, to what subject populations, settings, experimental variables and measurement variables can the results of the experiment be generalized. The extent to which this objective is attained is a measure of the external validity of the experiment.

Types of external validity: Bracht and Glass (1968) have classified external validity into two types: population validity and ecological validity.

- *Population validity*

It is concerned with the identification of the population to which the results of an experiment can be generalized. If the researchers select the sample randomly, then they can generalize the findings to this population with no difficulty.

- *Ecological validity*

It is concerned with generalizing experimental effects to other environmental conditions. For this, a design must provide assurance that the experimental effect is independent of the particular experimental environment. In order to achieve ecological validity, the researcher must pay increased attention to the following factors.

- (i) The researcher must furnish a complete description of the operations and the experimental settings involved in the experimental study. It helps a reader to judge to what extent the results can be generalized to other situations.
- (ii) Due consideration must be given to the experimental arrangements while generalizing the findings of the study. Presence of observers, experimental equipment and knowledge of participation of the subjects make them aware of the fact that they are receiving experimental treatments and, therefore, they may change their normal behaviour. Such a change is called Hawthorne effect. So, the researcher cannot claim that the effect of treatment variable is the same for subjects who are exposed to the treatment variable in non-experimental situations.
- (iii) Another factor is the question of the representativeness of the independent or experimental variables and dependent or criterion variables. Variable representativeness influences the generalizability of the findings of an experimental study.
- (iv) The tools or instruments used for the measurement of dependable variable also contribute to the ecological validity.

For instance, if the researchers use an essay-type test to measure academic achievement (dependent variable), Is it possible that the same effect would be observed if an objective type test was used as the measure of dependent variable?

The researchers must select a design that is strong both in internal and external validities. However, in certain educational experiments, one type of validity can be obtained at the cost of another one. In such cases, the researchers should attempt to reach a compromise between the types of validities, i.e. they should choose a design, within practical limits, that provides sufficient control to make results interpretable and generalize findings to the intended settings.

Types of Experimental Designs

There are various types of experimental designs. They vary in complexity and adequacy. The selection of a particular design depends upon factors such as the nature and purpose of the experiment, type of the variables to be manipulated, the nature of the data, the facilities or the conditions for carrying out the experiment and the competence of the experimenter. We shall here consider some of the major experimental designs:

One-group Experimentation

A one-group experiment involves the application of experimental factor or factors to an individual or a group in such a way that certain changes in the outcome can be determined. A group of subjects is

measured with regard to certain factors under study. All factors are kept constant except one which is the experimental factor or the independent variable that is applied for some definite period of time.

Finally, the group is measured again to determine the changes produced by the experimental factor in the dependent variable. Other factors may be introduced, one at a time, and their results are determined likewise. Although it is simple to plan and operate, it is the weakest basis for generalization, as there is no control group. For example, if 'A' denotes the group, 'X' the experimental factors and 'R' the initial result of measuring the particular factor in question, the one group experiment could be represented graphically thus:

$$\begin{array}{ccccc} & & X & & \\ A - & - & R & & R_1 \end{array}$$

The difference between the initial result (R) and the result achieved after the introduction of the experimental factor (R_1) can be attributed to the experimental factor (X).

Parallel or Equivalent Group Experimentation

This is perhaps the classical experimental design, more complex than the one-group experiment, but more accurate too. In this, two or more groups of subjects equivalent in all significant respects are selected. One of these parallel groups serves as the control group and the experimental factor or factors are applied to one or more of the other groups, known as the experimental groups, one by one for a specified period of time. The difference observed at the end of the period in the particular factor under study between the control and the experimental groups is expected to be due to the introduction of experimental factor.

For instance, if 'A' is the control group and 'B' is the experimental group, a parallel-group experiment carried out to determine the influence of one experimental factor could be represented graphically thus:

$$\begin{array}{l} A - R \\ B - R_1 \end{array}$$

R_1 is the result of X the experimental factor.

Rotation Group Experimentation

This experimental design may be looked upon as a variation of either the one-group or the equivalent-group method. If applied to a single group, it involves changing the time sequence of the experimental and control units in two or more cycles.

Cycle 1 would apply the control factor first, then the experimental.

Cycle 2 would apply the experimental factor first, then the control.

When applied to the equivalent groups it involves exchanging the factors between different groups cycle wise.

Cycle 1: Group A – experimental factor, Group B – control factor

Cycle 2: Group A – control factor, Group B – experimental factor

Thus, the rotational method involves the rotation of instructional factors of the experimental and control groups at equal intervals.

Simple Factorial Design of 2 by 2 (2×2)

The three designs that have been discussed so far are confined to classical single-variable designs, which require that an experimenter manipulates one independent variable to produce an effect on the dependent variable. R.A. Fisher overcame this difficulty when he had developed factorial designs and the statistical techniques like analysis of variance and covariance for the study of complex interactions. A factorial design enables the experimenter to evaluate or manipulate two or more variables simultaneously in order to study the effects of a number of independent factors singly as well as the effects due to interactions with one another.

The simplest factorial design is 2 by 2 (2×2). In this design, there are two independent variables and each of the independent variables has two values. The first independent variable, which is manipulated and has two values, is called the experimental variable. The second independent variable, which is divided into levels, is called the control variable.

For example, an experimenter is interested in comparing the effectiveness of programmed instruction and lecture method on the achievement in social studies of the sixth grade students. From the survey of related literature, the experimenter comes to believe that there may be a differential effect of these methods on different levels of intelligence of the students. On the basis of IQ, the experimenter divides the population into two groups: one group of high intelligence level and second group of low intelligence level.

In this experiment, there are two experimental treatments: teaching through programmed instruction and lecture method. Therefore, there are four groups of subjects within each of the two levels of intelligence and are randomly assigned to the two treatments. Thus, the factorial design is represented graphically in Figure 7.4:

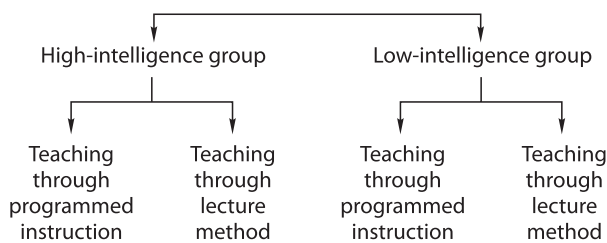


Figure 7.4 Factorial design—2 by 2

In this chapter, we have discussed different types of methods of research in education, i.e., the historical method, normative survey method, case study method, causal-comparative study, genetic studies and the experimental method.

Historical research, like any type of research, has some unique characteristics. It is a non-experimental research, where no variables are directly manipulated by the researcher. Historical research relies heavily on source materials from the past. External and internal criticisms are used to establish the authenticity and usefulness of the materials. Historical research is a systematic process of reconstructing what happened and interpreting the meaning of events.

Survey research is undoubtedly the most widely used non-experimental type of educational research. Questionnaires are commonly used in surveys. The normative survey type of research proposes to ascertain what is the normal or typical condition or practice at the present time, i.e., what are the conditions or relationships that exist; practices that prevail; beliefs, points of view or attitudes that are held; processes that are going on; effects that are being felt or trends that are developing.

This causal-comparative method aims at determining the causes of some educational phenomena through comparing factors associated with the occurrence and non-occurrence of the particular phenomena under study. This method differs from the historical, the normative survey and the experimental, respectively because it deals with the present phenomena, seeks to determine causal relationships and operates in normal field conditions.

The case study, through investigating the present as well as past history of 'cases' under study, establishes causal relationships among phenomena. It studies individual 'cases', abnormal behaviour of children as well as the behaviour of normal groups or individuals.

The genetic method of research aims at studying changes, growth and development occurring among individuals and groups, or institutions, over a considerably long period of time, in biological as well as psychological aspects. This method may take the longitudinal or the cross-sectional form.

Experimental research implies the type of scientific investigation in which the researchers control all significant factors during the period of enquiry and observe the results. The experimental designs provide the structure for the experiment in which the variables are deliberately manipulated and controlled by the researchers. An experiment must have definitely stated hypotheses, and the design should test these hypotheses, providing for the meaningful interpretation of results, whatever the pattern of the data.

Summary

- Research is a systematic and objective analysis and recording of controlled observations that may lead to the development of generalizations, principles or theories, resulting in prediction and possibly ultimate control of events. Education research seeks to develop scientific knowledge for the solutions to the educational problems.
- Research methods are of utmost importance in a research. They describe various steps of the plan of attack to be adopted in solving research problems.
- There are three basic categories: historical method, descriptive method and experimental method. Historical method implies an effort to recount some aspects of the past of an educational problem as principles of philosophy of education, elementary education, secondary, higher, rural education and so on. It follows five steps: selection of the problem, formulation of hypotheses, collection of data, criticism of data and interpretation and writing of a research report.
- A descriptive study describes and interprets what is. It is concerned with conditions or relationships that exist, opinions that are held, processes that are going on, effects that are evident and trends that are developing. Descriptive method is concerned with the present and is oriented towards the determination of the status of a given phenomenon.
- Descriptive research identifies present conditions and provides the basis for decisions for improvement. It must interpret, synthesize and integrate data, and point to implications and interpretations. It should begin with a definite problem. Its purpose is both immediate and long range. It also serves as the direct source of valuable knowledge concerning human behaviour.
- Descriptive research describes what is, by describing, recording, analysing and interpreting conditions that exist. It may involve some type of comparison or contrast and attempts to discover relationships between non-manipulated variables. It also includes survey studies, status studies, case studies, developmental studies, content analysis and comparative analysis.
- Descriptive method determines the present trends and also suggests the course of future developments. It also helps in fashioning many research tools, contributes to advancement of knowledge and provides background ideas and data from which many more refined laboratory or controlled studies are made. Trend or predictive study is based on longitudinal consideration of recorded data indicating what has been happening in the past, what the present situation reveals and on the basis of these data what will likely happen in the future. Follow-up study investigates individuals who have left an institution after having completed a programme, a treatment or a course of study. It is concerned with what has happened to them and what has been the impact of the institution and its programmes upon them.

Key Words

- *Control Group (in an experiment)*: A group of subjects who do not receive any experimental treatment. The group is included for comparison purposes.
- *Case Sectional Studies*: Studies in which the data are collected at one point in time from a random sample of a general population that contains two or more subpopulations with the intention of comparing the data from the subsamples or nothing trends across such subsamples.
- *Dependent Variable*: The variable being affected or assumed to be affected by the independent variable.
- *Experiment (in educational research)*: A research situation in which one or more independent variables are systematically varied according to a preconceived plan to determine the effects of this variation.
- *Experimental Group*: A group that is given some independent variable treatment.
- *Ex-post Facto Research or (Causal-comparative Research)*: Research in which the independent variables have already occurred and the research being observations on a dependent variable, followed by a retrospective study of possible relationships and effects.
- *Historical Research*: Research directed to the study of a problem in the past, using information from the past.
- *Hypothesis*: A conjecture or proposition about the solution to a problem, the relationships of two or more variables or nature of some phenomena.
- *Independent Variable*: A variable, which affects (or is assumed to affect) the dependent variable under study and is included in the research design so that its effect can be determined.
- *Intervening Variable*: A variable whose existence is inferred but cannot be manipulated or measured.
- *Longitudinal Studies*: Studies that involve measuring the same or different individuals two or more times during a period of time (usually of considerable length, such as several months or years), e.g., measuring the mathematics performance of the same students at yearly intervals as they progress from the fourth grade through senior high school.
- *Pre-test*: The test administered to the subjects after the independent variable is applied.
- *Population*: The totality of all elements, subjects or members that possess a specified set of one or more common characteristics that define it.
- *Sample*: A subset of the population under study.
- *Subject*: Also called as respondent and is the living organism that is studied.
- *Survey Research*: Research that deals with incidence, distribution and relationships of education, psychological and sociological variables in a non-experimental setting.

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The research methodologies can be divided into two major paradigms: logical positivism and phenomenological inquiry. Logical positivism dominates educational research and is based on the assumptions of the natural sciences. This is the paradigm elaborated upon in the description of the scientific method and hypothesis testing. There has been much confusion over just what qualitative research is. It is often described as a negative and non-quantitative research. The quantitative research is based on the logical-positive paradigm, which utilizes experimental research methodologies, while qualitative research is based on the phenomenological paradigm, which uses a variety of interpretive research methodologies. A variety of terms have been used for various forms of qualitative methods, including ethnographic, case study phenomenological, constructivist, participant observational and so on.

▲ Concept of Qualitative Research

Research methodology refers to the process, principles and produces by which we approach problems and seek answers. Our goals, assumptions and interests influence to a great extent which research method we choose. Two major theoretical or methodological perspectives which have dominated the social sciences are positivism and phenomenology. The origin of positivism can be traced back to the nineteenth and early-twentieth centuries, especially to August Comte and Emile Durkheim, who proposed that for a proper knowledge of society and human affairs from a scientific perspective, methods of physical and biological sciences be used for arriving at precise and exact description of social phenomena and causal explanation through empirical verification of hypotheses.

However, this approach was resisted by many German thinkers, such as Dilthey, who were of the view that the nature of social world is radically different from the natural world and the methods of natural sciences would not be appropriate for the study of humanities. Although the debate among the positivists and anti-positivist rotaries of hermeneutic approach remained inconclusive, the positivists succeeded in developing social sciences on the model of natural sciences. But during the last three decades and more, there has been a gradual disenchantment with the positivist approach and quantitative analysis.

There has been much confusion over just what qualitative research is. One of the problem is that qualitative research is often described by a negative connotation, i.e., it is a research that is non-quantitative. There are two reasons for the same. First, some qualitative research results in some quantification (e.g., counting the number of occurrences of a particular behaviour). Second, it represents a negative connotation, that is, quantitative research is based on logical positive paradigm, which utilizes

experimental research methodologies while qualitative research is based on the phenomenological paradigm, which uses a variety of interpretive research methodologies.

Another problem in understanding qualitative research methods lies with the misconception that qualitative research is a unitary approach, when, in reality, qualitative research is a variety of alternative approaches to the traditional, positivistic research most often found in the literature.

▲ Meaning and Definition of Qualitative Research

In Chapter 7, we have studied about a quantitative research; now you will be introduced to another important approach to research in which we gather data in the form of narratives. The main aim of this approach is to develop theory rather than to test a theory.

Qualitative research is defined as multi-method in focus, involving an interpretive, naturalistic approach to its subject matter (Denzin and Lincoln 1994).

Qualitative research can be characterized as the attempt to obtain an in-depth understanding of the meaning and definitions of the set presented by informants, rather than the production of a quantitative measurement of the characteristic or behaviour.

▲ Difference Between Quantitative and Qualitative Research

A better understanding of qualitative research is possible only if distinction between quantitative and qualitative research is made from each angle as explained in Table 8.1.

Table 8.1 Differences between quantitative and qualitative research

Quantitative Research	Qualitative Research
Objective	Subjective
Literature review must be done early in study	Literature review may be close as study progress or afterwards
Tests theory	Develops theory
One reality, focus is concise and narrow	Multiple realities, focus is complex and broad
Measurable	Interpretive
Research is behind the scene	Researcher is part of process.
Hypotheses	Research questions
Reasoning is logistic and deductive	Reasoning is dialectic and inductive
Establishes relation, causation	Describes meaning, discovery
Strives for generalization	Strives for uniqueness
Design-descriptive, correlative, quasi-experimental, experimental	Designs-phenomenological, grounded theory, ethnographic, historic, philosophical, case study
Sample size is large: 30–500 or more	Sample size is not a concern

Evaluate Yourself

- (i) Define qualitative research.
- (ii) What is qualitative research? How is it different from quantitative research?

▲ Features of Qualitative Research

Many authors have pointed out many different characteristics; but there are three main characteristics that are regarded as important, especially to research in social sciences.

- *Meaning from the inside:* Qualitative research attempts to understand the meaning that people give to their deeds or to social phenomena, i.e. see people from the inside.
- *Direct contacts:* Quantitative researcher may be able to do surveys without direct contact with research objects; they can collect data by using hired and trained interviewers or by mailing out questionnaires. Qualitative researchers, on the other hand, often enter into the natural fields of people whom they study and have face-to-face interviews with them. Because of this, qualitative research is sometimes called 'fieldwork' though this direct connectedness with people sometimes gives rise to several ethical problems.
- *Analytic induction:* Analytic induction is a major logic of qualitative research. The rule is to take one case and develop a working hypothesis to explain it. Then take another case and examine whether the hypothesis can explain the new case. If it fails, revise the hypothesis to explain both the cases. Then take the third case and repeat the same process of examining and revising the hypothesis. When you do not need to revise the hypothesis further and expect that the hypothesis will fit any new cases you might take, the hypothesis have been refined enough. Here the choice of cases to be examined has an important bearing on the trust worthiness of analytic induction and is related to the sampling procedures of qualitative research. All qualitative researches do not follow this approach, but the inductive approach to design, fieldwork and analysis is one of the most influential characteristics of qualitative inquiry.

▲ Themes of Qualitative Research

Patton (1990) proposes the following 10 themes that inculcate research:

- (i) *Naturalistic inquiry:* Qualitative research study real-world situations as they exists, without any manipulation, obstruction and control. It lacks predetermined constraints on outcomes.
- (ii) *Inductive analysis:* Qualitative research begins by exploring genuinely open questions rather than testing theoretically derived/deductive hypotheses.
- (iii) *Holistic perspective:* In qualitative research, the whole phenomenon under study is understood as a complex system that is more than its parts. It focuses on complex interdependencies not meaningfully reduced to certain discrete variables and linear cause–effect relationships.
- (iv) *Qualitative data:* It inquires in depth, capturing people's personal perspectives and experiences.
- (v) *Personal contact and insight:* Qualitative researcher has direct contact with and gets close to the people, situation and phenomenon under study.
- (vi) *Dynamic system:* It assumes that change is constant and ongoing.
- (vii) *Unique case orientation:* It assumes that each case is special and unique and study details of the individual cases.
- (viii) *Context sensitivity:* It places findings in a social, historical and temporal context.
- (ix) *Emphatic neutrality:* Qualitative researcher includes personal experience and emphatic insight as part of relevant data and takes neutral non-judgmental stance towards whatever content may emerge.
- (x) *Design flexibility:* It pursues new path of discovery as they emerge, avoids rigid designs that eliminate responsiveness.

▲ Strategies or Techniques of Qualitative Research

Quantitative approach to research makes use of psychological tests, educational tests, rating scales, attitude scales, and questionnaires using close-ended questions. These tools provide data in quantitative measures.

In case of qualitative research, Marshall and Rossman (1989) suggested three primary strategies that can be used to assist the researcher in designing appropriate data collection procedures, life histories, case studies and field studies.

In selecting the most appropriate strategy, the researcher must first determine what is to be studied. If one is interested in studying various teaching methods used in schools and which are perceived to be the most effective, some form of field study is probably most suitable. On the other hand, if the problem of study is a person with mental retardation who has a particular ability in drawing, the case study method would be more appropriate.

Another factor in determining the appropriate strategy is the time period under study. Again field study would not be possible if the event to be studied is historical in nature. Here, life history or document analysis will be more suitable.

The three main strategies used in qualitative research are: document or content analysis, case history and ethnography.

Document or Content Analysis

Documents are important source of data in many areas of investigation and the methods of analysis are similar to those used in historical research. The difference between historical research and qualitative research is that the former deals with past events and the latter with current events and issues. Here, the analysis is concerned with the explanation of some phenomena at a particular time or the development over a period of time. It adds knowledge to the field of enquiry and explains certain social events.

In document analysis, data is collected through records, reports, printed forms, letters, autobiographies, diaries, compositions, themes; other academic work, books, periodicals, bulletins; or catalogues, syllabi, court decisions, pictures, films and cartoons.

While using documentary sources, their reliability and validity must be verified and for this, every document used must be subjected to both external and internal criticism employed in historical research.

Case Study

Case study is a way of organizing social data for the purpose of viewing social reality. It examines a social unit as a whole. The unit may be a person, a family, a social group, a social institution or a community. It probes deeply and analyses interactions between the factors that explain present status or that influence change or growth. It is a longitudinal approach, showing development over a period of time.

The subjects of the case study should be selected very carefully in order to assure that they are typical or even a prototype of that category of individuals whom we wish to generalize. Here, the emphasis is on typicalness of subject rather than uniqueness as Bromley (1986) says: 'A case is not only about a person but also about that kind of person', e.g. for studying behavioural characteristics of alcoholic persons, select a typical alcoholic person to study instead of going for 200 or 500 alcoholic persons as done in quantitative research methods.

A case study involves variety of methods for collecting data such as:

- Observations, especially participant observation, by the researcher of physical characteristics, social qualities or behaviour

- Interview, both unstructured and structured with the subject, relatives, friends, teachers and counsellors
- Questionnaires, opinionnaires, psychological tests and inventories
- Recorded data from newspapers, schools, clinics, government agencies or other sources.

A single case study leads to in-depth analysis, but it is not directed towards broad generalization as one cannot generalize on the basis of one. The individual case study has been widely and extensively used in the field of medicine and medical research. Sigmund Freud was a pioneer in using case-study methods in the field of psychiatry, leading to psychoanalysis as a method of treatment.

Case studies are not confined to the study of individuals and their behavioural characteristics. It can be used to all types of communities and individuals like drug addicts, migrant workers, executives, industrial workers, and members of social classes. Institutions like colleges, reform homes, welfare agencies, and business groups are also studied as cases. These studies are conducted for the purpose of understanding the culture and development of variable relationships.

Although case study is a useful method of organizing research observations, certain precautions should be undertaken.

- The method may look very simple, which in fact is not. To use it effectively, the researcher must be thoroughly familiar with existing theoretical knowledge of the field of inquiry and skilful in isolating the significant variables from irrelevant ones.
- Subjective bias that may intervene is objective data gathering and analysis. The danger of selecting variable relationships based on preconceived convictions and the apparent consistency of a too small sample of observation may put question mark on the validity of the conclusions so drawn.
- Effects may be wrongly attributed to factors that are merely associated rather than cause-and-effect relationship.

Ethnographic Studies

Ethnography, sometimes known as cultural anthropology or more recently as naturalistic inquiry, is a method of field study observation that became popular in the latter part of the nineteenth century. It is being used for the study of behaviour in an educational situation. Primarily, it consists of participant observation, conversation and the use of informants to study the cultural characteristics of primitive people like Africans and American-Indian tribes by studying and analysing their language, customs and traditions, life style, religious beliefs and practices, social relations and rules of conduct and political institutions. The data-gathering techniques used were observation of patterns of action, verbal-nonverbal interaction between members of the tribe as well as between the subjects and the researcher, and the examination of records or artefacts available.

But these early studies were criticized on the ground that the anthropologists spend too little time among the people and get just superficial view of them and relied on their own cultural perspective, reaching ethnocentric, judgemental conclusions that resulted in stereotyped theories of the development of the primitive society. Later it has been realized that for valid ethnographic studies, the following steps must be taken by the researchers:

- The researchers must spend extensive period of time with the people whom they are going to study to the extent that they should become an integrated member of that social group.
- They must learn their native language in order to develop the sensitivity to think, feel and interpret observations in terms of their concepts, feelings and values.

- They must get themselves trained to systematically record field data in their own language and cultural perspective.

This refinement of participant observation resulted in more objective and valid observation and analysis. The classic study of adolescents of Samoa Island by Mead (1928) is an example of this kind of studies. The success of such studies lies in the observation of natural behaviour in a real-life setting, free from the constraints of more conventional research procedures.

As human behaviour is contextual, the researchers must understand the setting and nature of social structure, its traditions, values and norms of behaviour. They should observe and interpret as an outside observer and at the same time, observe and interpret in terms of the subjects—how they view the situation, how they interpret thoughts, words and activities of their own and those of others. The researchers must get inside the minds of the subjects on one hand and should interpret the behaviour from their own perspective on the other hand.

The relationship between the researcher and the subjects is based on trust and confidence in such studies. A position of neutrality is essential to objective participant observation.

Participant observation does not begin with preconceived hypotheses, rather build hypotheses in the process of observations and are subject to revaluation modification on the basis of new observations. Thus, this type of research has the characteristics of a series of consecutive studies. Here, interpretation is not deferred to the conclusion but is a constant ongoing process of testing tentative hypotheses against additional observations in a real situation.

Evaluate Yourself

- How does content/document analysis in qualitative research differ from historical research?
- Do you think that studying a typical person instead of a large group of that type of persons will give more relevant findings? Justify your answer.

▲ Data Collection Techniques in Qualitative Research

Buegess (1991a) has described three classic methods of collecting qualitative data: interview, participatory observation and document analysis. However, these older methods have been supplemented with newer arrivals as analysis of visual images and sound.

Interview

According to Rogers and Bouey (1996), 'without a doubt, the most utilized data collection method in qualitative research studies is the interview'. Many authors classify qualitative interviews into three types: structured, unstructured and semi-structured.

In structured interviews, sometimes also called standardized interviews, researcher asks the same set of questions, in the same order, using the same words, to different interviewees. It is convenient for comparing different interviewees' answers to the same questions and when a team of researchers is involved in conducting the interviews.

Unstructured interviews, also called informal conversation interviews, do not have any predetermined set of questions; instead researchers and interviewees talk freely (Burgess 1991b). These are often used in combination with participatory observation and though they may look easy to conduct, novices usually find them difficult because the researchers have to generate and develop questions according to what the interviewees say.

Semi-structured interviews, sometimes called guided interviews, are somewhat between structured and unstructured interviews in format. The researchers prepare interview guides that consist of a set of questions. The guides allow researchers to generate their own questions in interested areas of inquiry during the interviews. This type of interview is widely used in the qualitative research.

All the three types of interviews can be used in combination (Patton 1990).

Participant Observation

When observation is used in qualitative research, it usually consists of detailed notion of behaviours, events and the contexts surrounding the events and behaviours. Participant observation involves a period of intense social interaction between the researcher and the subjects in the milieu of the later and further during this period, data are unobtrusively and systematically collected.

Participant observation has been described as 'the most intimate and morally hazardous' form of social research. Lofland (1972) and Patton (1990) have mentioned five dimensions along which observations vary.

- The extent of the researcher's participation can vary from full participation to outlooker observation.
- The observer may conduct the observations covertly or overtly. In overt observations, people know that they are being observed, whereas in covert observations, they do not know this. One reason why covert observations are conducted is that people might behave differently when they know they are being observed. There is much ethical discussion about covert observations, in particular about the difficulties in deciding the extent to which the observation should be overt or covert.
- Those being observed may be given full explanations, partial explanations, no explanations or a false explanation.
- The observations may take place over the course of an entire school year (or even long) or could be as brief as an hour.
- The breadth of focus may vary from quite broad (e.g., entire school's curriculum) to quite narrow (e.g., how students in a particular class respond to a substitute mathematics teacher).

Despite these variations, observations are powerful tools of research. A researcher visiting the setting to conduct interviews may unintentionally uncover much interesting data and many themes while waiting for interviewees to arrive (Hornsby-Smith 1993).

Besides participant observation and in-depth interviews, there are several other supplemental data collection techniques like questionnaire, surveys, projective techniques, psychological tests and inventories, proxemics (study of people's use of space and its relationship to culture), kinesics (study of body movements), street ethnography and so on.

All the data collection techniques have strengths and weaknesses. One way to emphasize the strengths and minimize the weaknesses is to use more than one technique in a study as while using complementary techniques, researcher can cover the weaknesses of one with the strengths of the other. Thus, good qualitative research will often include multiple techniques of data collection, known as triangulation, which permits verification and validation of qualitative data by the following:

- Reconciling qualitative and quantitative data
- Comparing multiple qualitative data sources
- Multiple perspectives from multiple observations using several interviews so as to reduce the potential bias or subjective as a result of observations by single 'observer'.

Evaluate Yourself

- (i) Which type of data collection techniques will you use to collect data and why? Justify your answer with the help of an example.
- (ii) What are the problems faced by the researchers while using participant observation as a data collection tool?

▲ Data Analysis in Qualitative Research

Organization of Data

The first step in analysing qualitative research involves organizing the data, which depends on the research strategy and data collection techniques used, for example, interview data may be organized according to individual respondents or by grouping answers together across respondents. Similarly, observations may be considered individually or by grouping similar types of occurrences together while also looking for the differences among individuals, settings or times. The selection of approach depends on the purpose of research; the number of individuals, settings and times observed or interviewed; and whether the focus is on the particular person, setting or time under study or on similarities and differences among the persons, settings or times under study.

In qualitative research, data analysis can occur before the completion of data collection process. In unstructured interviews, for instance, researchers should start analysing what is being said while talking to people, otherwise, they will not be able to decide what questions to ask next in conversation. Doing data analysis while collecting data is called the 'principle of interactions between data collection and analysis'.

Qualitative data may also involve quantitative information, which may be handled by using parametric and non-parametric techniques.

Description of Data

In this stage, researcher describes the various pertinent aspects of the study including the setting (both temporal and physical), the individuals being studied, the purpose of any activities examined; the view points of participants and the effects of any activities on the participants.

Interpretation of Data

Interpretation involves explaining the findings, answering 'why' questions, attaching significance to particular results and putting patterns into an analytic framework. The discipline and rigor of qualitative analysis depend on presenting solid descriptive data in such a way that others reading the result can understand and draw their own interpretations.

The interpretation of qualitative research data is more dependent on the researcher's background, skills, biases and knowledge.

While analysing qualitative data, the following points must be kept in mind:

- Be aware of the context in which the data are obtained
- Be reflexive
- Be flexible and use as many strategies as they like

- Show the quotes supporting researcher's ideas, e.g., use quotes of the interview transcripts to support

Forms of Results

Successful qualitative research reports often include new concepts, new typology or new causal networks.

The initial task in analysing qualitative data is to find some concepts that help us to make sense of what is going on in the scene documents by the data. This process is called conceptualization. By listing concepts and relating them we can produce typologies.

Evaluate Yourself

- (i) Name and describe two data analysis techniques, which can be used in the analysis of qualitative data.
- (ii) Define triangulation.

Summary

- Qualitative research methodology has gained momentum in the recent years in the area of social sciences as it involves an interpretive, naturalistic approach to its subject matter. It attempts to obtain an in-depth understanding of phenomenon through direct contacts with the subjects and using analytic induction. It tries to see people from inside by attempting to understand meaning that people give to their deeds or to social phenomena instead of producing quantitative measurement of the characteristics or behaviour.
- Qualitative research has 10 main themes: naturalistic inquiry, inductive analysis, holistic perspective, qualitative data, personal contact and insight, dynamic system, unique ease orientation context sensitivity, emphatic neutrality and design flexibility.
- Qualitative research uses three main strategies: document/content analysis, case study and ethnography.
- In document analysis, data is collected through records, reports, printed forms, letters, autobiographies, books, and periodicals, while using documentary sources, reliability and validity must be verified.
- In case study, we select a typical person from a group for the study rather than studying the total group. Thus, a case is not only about a person, but also about the kind of person.
- Ethnographic study is a method of field study observations, used for the study of behaviour through participant observation and conversation.
- The main data collection techniques used in qualitative research are interview, participatory observation and document analysis.
- Interview may be structured, unstructured or semi-structured or even the combination of all three.

Key Words

- *Quantitative Research*: It is based on the logical-positive paradigm, which utilizes experimental research methodologies.
- *Qualitative Research*: It is based on phenomenological paradigm, which uses a variety of interpretive research methodologies.

- *Case Study*: It is a way of organizing social data for the purpose of viewing social reality.
- *Ethnographic Studies*: It is known as cultural anthropology. It is being used for the study of behaviour in an educational situation.

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Tools and Techniques of Research

9

Educational research is conducted with the help of suitable tools, which help in collecting data. A variety of tools are available for this purpose. For each and every type of research, certain tools are essential to gather new facts or to explore new field. The important tools are questionnaire, observation, interviews (both structured and non-structured), attitude scale, rating scale and psychological tests.

A great variety of methods and procedures have been developed to aid in the acquisition of data. These tools are of many kinds and employ distinctive ways of describing and quantifying the data. Each is particularly appropriate for certain sources of data, yielding information of the kind and in the form that would be most effectively used.

The discussion in Chapter 8 might have been helpful in learning the basic principles, nature, scope and processes of research, which is carried out in educational areas as an aid to effective decision-making. In the process of decision making, data play a vital role. The researchers require various data-gathering tools, which facilitate original research investigations and observations leading to useful and valuable results.

▲ Data Collection and Tools

Data collection is essentially an important part of research process. Researchers generally attempt to gather evidences either for verifying new hypothesis or for checking current conclusions. To accomplish their objectives, researchers obtain data from documentary or field sources.

In educational research, obviously, there are different methods of inquiry, ranking from controlled laboratory experiments through participant observation to action research, from historical studies to logical analysis. These have been organized in different research traditions, such as 'quantitative' and 'qualitative', or associated with different theoretical positions, such as behaviourism and critical theory. In practice, the categories of method, tradition, and theoretical position cut across each other to some extent.

—Torsten Heusen and T.N. Postethwaite, 1994, Vol. 9, p. 5021

For any research study, the research workers have to collect data and on the basis of that data they draw conclusions and arrive at generalizations. These conclusions and generalizations will be correct and valid if the data are methodically collected. For collecting reliable and valid data, appropriate tools and techniques are essential. The researchers have to select the tools and techniques of data collection carefully and judiciously. They might make use of standardized ready-made tools or may develop their own tools ensuring that the tools developed are reliable and valid so that the data obtained through these tools are also reliable and valid.

The tools of data collection are questionnaire, checklist, rating scale, attitude scale, psychological tests and so on. Whereas, the techniques of data collection are the processes through which data are obtained, like interviews, observations, documentary analysis, administration of psychological tests and so on.

The tools and techniques to be used in a study will depend upon the objectives of the study, the nature of respondents and also the persons responsible for data collection.

The tools and techniques of research have been classified into two categories: those used in qualitative research and those in quantitative research. This, however, does not mean that these are two watertight compartments. Some of the tools mentioned under one type of research can also be used in another type of research.

Educational research requires some instruments for data collection. These are called tools. The success of a research study depends on the selection of suitable tools. The researchers have to learn about various data-gathering tools or techniques, which may vary in their complexity, design, administration and interpretation. Each tool is appropriate for the collection of a certain type of evidence of information. The researchers have to select appropriate tools from the available tools, which will provide them the required data for testing hypotheses. In some situations, they may find that the existing research tools do not suit their purpose and so they may modify them or construct their own. For this the researchers should familiarize themselves with the nature, merits and limitations of the existing research tools, and should also develop skill in the construction and use of each of these research tools.

▲ Types of Research Tools

The major data-gathering tools of educational research may be classified broadly into the following categories:

- Psychological tests
- Questionnaire
- Interview
- Observation
- Rating scale
- Attitude scale

Psychological Tests

Psychological tests are among the most frequently used tools of educational research. They have been designed to describe and measure a sample of certain aspects of human behaviour, purpose of selection, classification, prediction and guidance, as well as for the evaluation of education programmes. Tests consist of a series of tasks, which the subject is required to perform. Psychological tests are of various kinds depending on the different traits they are devised to measure. They are designed to measure general mental ability or intelligence, special abilities or aptitudes, creativity, achievement, personality traits and adjustment, interests and values.

Psychological tests provide data for most experimental and descriptive studies in education. Tests may be used to compare the behaviour of two or more persons at a particular time, or one or more persons at different times. Psychological tests yield objective and standardized descriptions of behaviour, quantified by numerical scores. Under ideal conditions, achievement or aptitude tests measure the best performance of which individuals are capable. Under ideal conditions, inventories attempt to measure typical behaviour. Tests and inventories are used to describe status (or a prevailing

condition at a particular time), to measure changes in status produced by modifying factors, or to predict future behaviour on the basis of present performance. The following three parameters are very important to understand psychological tests: (i) classification of test, (ii) quality of a good test, and (iii) test development.

Classification of Psychological Tests

- There are many ways of classifying psychological tests. One distinction is made between *performance tests* and *paper-and-pencil tests*. Performance tests, usually administered individually, require that the subjects manipulate objects or mechanical apparatus while their actions are observed and recorded by the examiner. Paper-and-pencil tests, usually administered in groups, require the subjects to mark or write their response on a prepared sheet.
- Two other classes of tests are *power* versus *times or speed tests*. Power tests have no time limit, and the subjects attempt progressively more difficult tasks until they are unable to continue successfully. Timed or speed tests usually involve the element of power, but in addition, limit the time that the subjects have in which to complete certain tasks.
- Another distinction is that made between *non-standardized, teacher-made tests* and *standardized tests*. The test that the classroom teacher constructs is likely to be less expertly designed than that of a professional, although it is based on the best logic and skill that the teacher can command, and is usually 'tailor-made' for a particular group of pupils. By contrast, the standardized test is designed for more general use. Each item and the total scores have been carefully analysed and validity and reliability established by careful statistical controls. Norms have been established based upon the performance of many subjects of various ages living in many different types of communities and geographic areas. Not only has the content of the test been standardized, but the administration and scoring procedures have also been set in a pattern that those subsequently taking the tests will take them under like conditions. As far as possible, the interpretation has also been standardized.

Although it would be inaccurate to claim that all standardized tests meet the optimum standards of excellence, these instruments have been made as sound as possible in the light of the best that is known by experts in test construction, administration and interpretation.

Psychological tests may also be classified in terms of their purposes, i.e., the types of psychological traits that they describe and measure. By this standard, we may distinguish five major classes of tests, each with many sub-classes such as follows:

Intelligence Test. The tests of general mental ability or intelligence measure general ability, enters into performance of all activities and differs in magnitude from individual to individual. The items in such tests assess the subject's ability to perceive relationships, solve problems and apply knowledge in a variety of ways. Tests of intelligence should not be considered as measure of pure intelligence because the performance on such tests is partly determined by one's background and schooling. The items in an intelligence test are numerous and varied. They test different abilities, which are supposed to constitute general intelligence.

With all their limitations, intelligence tests are indispensable tools in educational research. They are used for classifying and categorizing subjects into various groups. They help the researchers to make decision about the placement of individuals for school and work, and, therefore, help them in making certain predictions. The researchers should be familiar with different intelligence tests. They may come across some standardized tests of intelligence, which may serve the purpose of this study. In case no test is available for use with a specific group, the researchers should develop a new test.

Aptitude Tests. Aptitude tests attempt to predict the degree of achievement that may be expected from individuals in a particular activity. To the extent that they measure no deliberate or unplanned learning, they are different. These tests attempt to predict an individual's capacity to acquire improved performance with additional training. Actually, capacity cannot be measured directly. Aptitude can only be inferred on the basis of present performance; particularly in areas where there has been no deliberate attempt to teach the behaviours to be predicted.

Aptitude tests have been similarly designed to predict improved performance with further training in many areas. These inferred measurements have been applied to mechanical and manipulative skills, musical and artistic pursuits, and many professional areas involving many types of predicted ability. Aptitude tests may be used to divide students into relatively homogeneous groups for instructional purposes, to identify students for scholarship grants, to screen individuals for particular educational programs or help guide individuals into areas where they are most likely to succeed.

Aptitude tests, particularly those that deal with academic aptitude, used for purposes of placement and classification have become highly controversial, and their use prohibited in many communities. The fact that some individuals with culturally different backgrounds do not score well on these tests has led to charges of discrimination against members of minority groups. The case has been made that most of these tests do not accurately predict academic achievement since their contents are culturally biased. Efforts have been, and are being, made to develop culture-free tests that eliminate this undesirable quality.

Creative Tests. Guilford (1967) has brought into force the existence of two distinct types of thinking abilities: convergent thinking and divergent thinking. Convergent thinking involves the generation of ideas and facts from the known information and in tests of thinking (tests of general intelligence and aptitudes) the subject is asked to define and solve an arithmetical problem, find the next number to continue a series and so on. Divergent thinking involves generating novel responses to situations; responses that are original, unusual and varied. This thinking generally goes by the name of creativity.

Achievement Tests. Among the various types of tests, achievement tests attempt to measure what an individual has learned, i.e., an individual's present level of performance. Most tests used in schools are achievement tests. They are particularly helpful in determining how much an individual or a group of individuals have learnt as a result of teaching—learning process. Achievement test scores are used in placing, advancing or retaining students at particular grade levels. They are used in diagnosing strengths and weaknesses, and as a basis for awarding prizes, scholarships or degrees.

Frequently, achievement test scores are used in evaluating the influences of courses of study, teachers, teaching methods and other factors considered to be significant in educational practice. In using tests for evaluation purposes it is important not to generalize beyond the specific elements measured. Achievement tests may be classified as traditional or essay-type and now-type or objective tests. New type or objective tests include multiple-choice, true-false, completion, matching and short answer items.

Achievement tests require only content validity. The reliability of such tests may be found out either by using test-retest method or split-half method. Equivalent forms reliability seems to be of little value with respect to achievement tests because it is concerned with two different forms of a test giving consistent results.

Personality Measures. Personality tools are usually self-reporting instruments. The individual checks responses to certain questions or statements and yield scores, which are assumed or have been shown to measure certain personality traits or tendencies.

Because of the difficulty, inability or unwillingness of individuals to report their own reactions accurately or objectively, these instruments may be of limited value. Part of this limitation may be due to

the inadequate theories of personality upon which some of these inventories have been based. At best, they provide useful data in suggesting the need for further analysis. Some have reasonable empirical validity with particular groups of individuals, but prove to be invalid when applied to others. For example, one personality inventory has proven valuable in yielding scores that correlate highly with the diagnoses of psychiatrists in clinical situations. But when applied to college students, its diagnostic value has proved disappointing.

The development of instruments of personality description and measurement is relatively recent, and it is likely that continued research in this important area will yield better theories of personality and better instruments for describing and measuring its various aspects. Personality measures are mainly classified into projective and non-projective techniques. Projective techniques are used to assess areas of personality that cannot be measured easily by other means, or areas in which direct questions are not likely to be answered truthfully. These techniques disguise their purpose in such a way that the individuals unconsciously project their personality through their responses to a series of fluid and weakly structured stimuli. The subjects are presented with ambiguous stimuli such as pictures, ink blots, words and unfinished sentences, and are asked to describe or interpret what they see or to complete sentences. There are few projective media, materials and procedures, which have been standardized and are widely used. A scoring procedure has also been devised for these techniques. However, the interpretation of the responses often demands a high degree of skill and a prolonged period of training on the part of the person using them. The Rorschach Inkblot Test, the Thematic Apperception Test (TAT), Children Apperception Test (CAT) and Rosenzweig's Picture Frustration Test are some projective techniques, which are extensively used in personality assessment.

The *non-projective techniques* of personality measurement include personality inventories. An inventory is constructed in the form of a questionnaire. It consists of a series of questions or statements to which the subjects respond by answering 'yes' or 'no', 'agree' or 'disagree', or in some similar way to indicate their opinions or feelings. The subjects are required to indicate preferences or mark those items that describe their typical behaviour. Valid results cannot be obtained with the help of inventories if the subjects do not provide truthful frank replies.

The inventories have been mostly used for the investigation of interests and values, but increasingly their use is being made in the assessment of personality traits and adjustment. The predictive validity of their results will be low if the subjects tested are below 17 years of age, since studies by Strong (1943) suggest that interests are unstable until this age is attained.

Qualities of a Good Test

While selecting test for collecting data in research situations the researchers must evaluate their validity, reliability and usability. These evaluative criteria are considered desirable for a good test.

- (i) **Validity:** The test, as a data collection tool for research, must produce information that is not only relevant, but also free from systematic errors, i.e., it must produce valid information. In general, a test is valid if it measures what it claims to measure. A test, however, does not possess universal and eternal validity. It may be valid for use in one situation, but invalid if used in another.
 - (a) **Content validity:** This refers to the degree to which the test actually measures, or it is specifically related to, the traits for which it was designed. It shows how adequately the test samples the universe of knowledge, attitudes and skills that a student is expected to master. Content validity is based upon careful examination of course textbooks, syllabi, objectives and the judgements of subject matter specialists. The criterion of content validity is often assessed by a panel of experts in the field who judge its adequacy, but there is no numerical way to express it.

- (b) *Criterion-related validity*: This is a broad term that refers to two different criteria of timeframe in judging the usefulness of a test. Predictive validity refers to the usefulness of a test in predicting some future performance such as the degree of usefulness of the Scholastic Aptitude Test taken in high school in predicting college grade point averages. Concurrent validity refers to the usefulness of a test in closely relating to such other measures as present academic grades, teacher ratings or scores on another test of known validity. If a test is designed to pick out good candidates for appointment as shop foremen and the test scores show a high positive correlation with actual success on the job, the test has a high degree of predictive validity whatever factors it actually measures. It predicts well and serves a useful purpose.
 - (c) *Construct validity*: This is the degree to which scores on a test can be accounted for by the explanatory constructs of a sound theory. If one was to study such a construct as dominance, one would hypothesize that people who have this characteristic will perform differently from those who do not. Theories can be built describing how dominant people behave in a distinctive way. If this is done, dominant people can be identified by the observation of their behaviour, rating or classifying them in terms of the theory. A test could then be designed to have construct validity to the degree that the test scores are systematically related to the judgements made by observation of behaviour identified by the theory as dominant.
- (ii) *Reliability*: A test is reliable to the extent that it measures consistently, from one time to another. In tests that have a high coefficient of reliability, errors of measurement have been reduced to a minimum. Reliable tests, whatever they measure, yield comparable scores upon repeated administration. An unreliable test would be comparable to a stretchable rubber yardstick that yielded different measurements each time it was applied.

A test may be reliable, even though it is not valid. A valid test is always reliable. There are four procedures in common use for assessing the reliability of a test. They include: (1) the test–retest method, (2) the parallel forms method, (3) the split-half method and (4) the rational equivalence method.

- (a) *The test–retest method*: In this method the same test is re-administered shortly after the first administration, and the two sets of scores are correlated to obtain the reliability of the test. The main disadvantage of this method is that if the time interval between the two administrations of the test is short, the immediate memory effects, practice and the confidence induced by familiarity with the test material may over-estimate the reliability of test. On the other hand, if the time interval is long, the real changes in behaviour is long; the real changes in behaviour in terms of growth may under-estimate the reliability of the test. Owing to the difficulties in controlling conditions, which influence test scores on second administration of the test, the test–retest method is generally less useful than the other methods.
- (b) *The parallel forms method*: This method requires that two equivalent or parallel forms of a test are prepared, administered to the same group of subjects and the results in terms of two sets of test scores are correlated to obtain the reliability of the test.

In drawing up parallel forms, care should be taken to match test materials for content, difficulty and form, and precautions must be taken not to have the two items in similar form. When the parallel forms are virtually identical, reliability is too high. On the other hand, when parallel forms are not sufficiently alike, reliability will be too low. It is also worth mentioning that practice effects are not eliminated by this method. In spite of all these limitations, the parallel forms method of determining reliability is widely used.

- (c) *The split-half method*: In this method, the test is first divided into two equivalent 'halves' and the scores on the half of the items are the half-test; the self-correlation of the whole test is then estimated by Spearman–Brown Prophecy formula. The items of the test can be divided into two sets in a variety of ways. This method of reliability measures the internal reliability of the test and if the two halves do not correlate highly it suggests that they are not measuring the same thing. Moreover, the method has the advantage of controlling the fatigue and practice effects. The main criticism of the method is that a test can be divided into two halves in a number of ways and, therefore, the correlation between the scores on the two halves may not have a unique value.
 - (d) *The rational equivalence method*: This method of reliability is evolved to get an estimate of the reliability of a test, free from the objection raised against the methods discussed. Two forms of a test are defined as equivalent when corresponding items are interchangeable; and when the inter-item correlations are the same for both the forms. Two internal consistency formulae developed by Kuder–Richardson are often used to obtain coefficients of equivalence for tests where one point is given for every correct answer and zero for a wrong answer.
 - (e) *The reliability coefficient*: The reliability of a test is usually reported in terms of reliability coefficient; it is the coefficient of correlation between the test and retest scores of the same subjects on the same form or a parallel form of the test, or between the scores on the two halves of the test. The test and retest coefficient becomes a close estimate of the stability of the test scores and, therefore, Cronback (1964: 139–41) has called it coefficient of stability. He has called other coefficients as the coefficients of equivalence.
- (iii) *Usability*: The usability of a test includes objectivity, economy of time and cost, simplicity and ease of administration, scoring and interpretation in using test for collecting data in a research study. A test should yield objective results, i.e., the results should be independent of personal judgement of the researcher using the test. The tests that can be administered in a short period of time are likely to gain cooperation of the subjects and save the time of all those involved in the test administration. The cost involved in the construction or administration of a test should be limited. The simplicity and ease of administration, scoring and interpretation is an important factor in selecting a test, particularly when the expert advice is not easily available. The test should be interesting and fascinating to the subjects so as to gain their cooperation.
- (iv) *Test development*: The development is an independent, extremely advanced and technical area of research, and is based on well-developed theory of psychometrics. The theory and procedures are being continuously subjected to research, criticism and improvement. Development of a theory or test is one form of research. Adaptation and improvement of the existing tests and construction of new ones also amount to research activity.
- (a) *General procedure of test construction*: When the researchers set out to construct a test, there are several factors, which may determine their operations and line of action. The factors include the area, the age group and the grade for which the test is to be developed. The approach of the researchers will depend on whether the test is designed for general purposes or for some specific purpose. But in spite of all such factors, there are some general principles and procedures which one has to follow while constructing a test.
 - (b) *Planning*: The construction of a test must start by consideration of the limitations under which the test has to be developed. It includes a detailed set of specifications as to the purpose of the test and the time, cost and sources at the disposal of the researcher or test maker. The nature of the population for which the test is constructed has to be defined.

The length of the test, type and nature of the test items, and the method of scoring the test are also some basic considerations that have to be planned in advance.

- (c) *Preliminary draft* While making the preliminary draft of the test, the researchers or test makers must consult the existing tests in the area. The test makers may also create some original items of their own to cover the attribute or trait adequately. The preliminary draft must have more than double the items required for the test. For ability and attainment tests it is necessary to compile a large number of items of suitable difficulty. A rough idea of the difficulty of the items can be obtained by trying out a few items on a small group of subjects from the population. The items are then edited, and carefully worded instruction which briefly indicate the nature and purpose of the test and the nature of the task with a few examples must be supplied with the test. The final manuscript of the preliminary draft is then submitted to experts for their opinion and criticism. It is also worthwhile to administer the final manuscript of the preliminary draft to a small group of subjects from the population and check the answers. It is called 'small-group try out' of the test. This procedure may suggest further modification. After the necessary modifications in the light of experts' suggestions and small-group try out, the preliminary draft is printed or photocopied. For recording the responses of the subjects a separate answer sheet must also be printed or photocopied, which may be enclosed with the booklet of the preliminary draft.
- (d) *The try out:* At this stage the preliminary draft is administered to a large random sample of the population for which the test is constructed. The size of the sample for try out is usually taken as 370 because it helps the test maker to get the indices of difficulty and discrimination quickly for selecting good items for the final test with the help of the table developed by J.C. Flanagan. At the try-out stage the time limit should be generous. The test may be so timed that nearly 90 per cent of the individuals in the sample complete the last item. In case of speeded test, the time limit that produces a good scatter of scores without fatigue should be fixed. The test booklets along with their answer sheets are collected and scored with the help of a scoring key.
- (e) *Item analysis:* A major objective of item analysis is the improvement of total score reliability, total score validity or both, and the achievement of better item sequences and types of score distributions. Item analysis procedures provide two indices for each item of the test of ability, i.e., its difficulty and power, to discriminate between the good and the bad performers on the test. Many kinds of such indices have been proposed. One begins by arranging the answer sheets from the highest to the lowest obtained score. From the arranged answer sheets, the top 27 per cent and the bottom 27 per cent of the answer sheets are taken separately. Next the proportions of the two groups passing a given item are found. Entering Flanagan's Table with the proportion of the two groups, read the biserial r from the intersecting column and row in the body of the table. The biserial r will be the discriminative power or the validity index of an item. The mean of the two proportions is the difficulty index of the item. Garrett (1962: 368) suggests that items with validity indices of 0.20 or more and difficulty indices of 0.40–0.60 are regarded as satisfactory. Items having zero or negative validity are useless and must be discarded or they must be carefully examined for ambiguities, inaccuracies and other errors. It is worth noting that the items for non-cognitive tests are selected only on the basis of validity index. In such type of tests there is no question of the difficulty value of an item as the subjects are required to respond to a series of statements or questions in 'yes' or 'no', 'agree' or 'disagree' or in a similar way to indicate their feelings or opinions.

- (f) *Final draft* The selected items are put in the final draft of the test, which is administered to as large a sample as is practicable for estimating the parameters of validity, reliability and norms. Different types of validity and reliability and the methods of their estimation are already discussed earlier. Norms represent a descriptive framework for interpreting the test score of an individual or a group. A raw score, taken by itself, has no meaning. It gets meaning only when compared with some reference group or groups. Different types of norms are commonly derived from these comparisons. When the population is heterogeneous and covers a wide range of academic attainment or age, norms related to those ranges are developed and are denoted as 'grade norms' and 'age norms'. In these types of norms, we give meaning to an individual's test score by determining the age or grade group in which it would be just average. In 'percentile norms' each individual's score is transformed into an equivalent percentile rank. This comparison is based on a single group and indicates what per cent of the group the test score surpassed. Four types of norms are called as 'standard scores' in which comparison is again based on a single group and makes use of the mean and standard deviation as a basis for comparison.

Evaluate Yourself

- (i) What is psychological test?
- (ii) Describe the various types of validity and reliability tests.

In this chapter, some of the most commonly used tools or techniques for data collection are explained, e.g., questionnaire, observation, interview, psychological tests and inventories. Each of these tools differs in their nature and scope. The researchers have to bear in mind the suitability of these tools, i.e., their relevance and effectiveness depending upon the type of problem under consideration. Let us now understand each of them in detail.

Tools Used in Quantitative Research

A questionnaire is one of the most commonly used data-gathering devices. As the name implies, it includes a set of questions. The respondent is asked to supply answers to these questions in the space meant for this purpose in the questionnaire itself. The questionnaire is generally mailed to the respondents, although it can also be administered personally. It is used both in quantitative and qualitative research. The answers the respondents give on a questionnaire are determined by the nature of questions and their reactions to these questions, i.e., in case of obtaining merely factual information like physical or demographic details, it is only a matter of using language clearly and concisely. However, if the purpose is to find out internalized characteristics about emotions and personality traits, the job of the researchers become difficult and requires a great deal of skill, because the items need to be written in such a way that the respondents are able to reveal what the researchers really want them to reveal.

This is a popular device often used in behavioural researches including education, where it usually takes the form of surveys. It has several advantages as follows:

- Planning the use of the questionnaire is easier than any other tool.
- These are economical and time saving and can easily be administered on a large sample.
- Both qualitative and quantitative information can be obtained.

Questionnaire

One of the most widely used tools for collecting information from a vast or inaccessible area is questionnaire. It is treated as a reliable tool in compiling data both quantitatively and qualitatively. By using questionnaire, one can collect data from large, varied and dispersed social groups. Let us now have an insight into the nature of questionnaire.

A questionnaire is a schedule consisting of a number of coherent questions related to various aspects of the problem to be investigated.

Definitions of Questionnaire

Various researchers have defined questionnaire in their own ways, as

Bogardus treated, 'questionnaire as a list of questions sent to a number of persons for their answers and which helps in obtaining standardized results that can be tabulated and treated statistically'.

According to Goode and Hatt, 'in general, the word questionnaire refers to a device for securing answers to questions by using a form which respondent fills in himself'.

G. Lundburg defined: 'Questionnaire is a set of stimuli to which illiterate people are exposed in order to observe their verbal behaviour under social stimuli'.

The *Dictionary of Statistical Terms* puts questionnaire as a 'group of or sequence of questions designed to elicit information upon a subject or sequence of subjects from an information'.

Now we might have understood the nature of questionnaire from the above definitions. It can be concluded that a questionnaire is a tool in which there is a set of questions, to which the respondents are expected to provide relevant and specific information. The investigators do not go to respondents. Usually, the questionnaire is mailed to them and the informant replies to the researchers by sending back the filled-in questionnaire. The researchers collect necessary information and put it to suitable analysis techniques for drawing a conclusion.

Types of Questionnaire

Depending upon the nature of problem, the questionnaire can be classified into the following:

- Structured or closed-form questionnaire
- Non-structured or open form questionnaire
- Codified questionnaire
- Uncodified questionnaire
- Pictorial questionnaire

Structured or Closed Form Questionnaire. In closed-form questionnaires, the respondent merely selects a suitable answer from multiple answers supplied with the questions. It requires all the respondents to answer within the same framework, i.e., such questions have a restricted set of possible responses. According to P.V. Young, 'a structured questionnaire is one which contains definite, concrete and pre-coordinate questions, with additional questions limited to those necessary to classify inadequate answers to elicit a more detailed response'.

Some examples of closed-structured forms are as follows:

- (i) The teachers come well prepared for classes. Yes/No/Undecided
- (ii) What should be the duration of orientation course?

One week	()
Two weeks	()

Three weeks	()
One month	()

The questions in the open or unstructured questionnaire are framed in such a way that the respondents themselves have to take initiative in deciding upon the answer. Clues are not provided. Examples of unstructured open questions are as follows:

- (i) What are the reasons for choosing teaching as a career?
- (ii) How far has the use of computers proved useful to you in your teaching?

Sometimes, a questionnaire may include both types of questions. While making questionnaire, the following guidelines should be kept in mind:

- Be as simple and clear as possible
- Frame short and logical questions
- Be explicit in your questions
- Avoid questions with two parts
- Avoid double negatives in the question
- Avoid vague questions and try to be specific
- Include brief directions with regard to filling up the questions
- Ensure that physical get up is appealing
- Ask only those questions, which are very essential

Here the questions are prepared in advance and are not constructed on the spot during the questioning period.

Types of structured questionnaire: The structured questionnaire may be further classified into closed-form and open-form questionnaires.

- (i) *Closed-form questionnaire:* When we frame questions with very few alternatives for the respondents to answer, it is called as closed-end questionnaire. It could be either of 'Yes/No' type or the one where the respondents are required to select one answer from a limited number of answers. A few examples are as follows:

Do you daily observe News on TV? Yes/No

Which source of News do you like the most?

- (a) TV
- (b) Radio
- (c) Newspaper
- (d) Magazines

One advantage of these close-end questionnaires is simplicity in administration and inexpensive analysis. In few cases, when the question is vague, the given alternatives help the respondents to understand the question.

But there is also a disadvantage in the sense that by providing fixed alternatives the respondents are restricted from giving their own response irrespective of their own opinion.

- (ii) *Open-end questionnaire:* Here the respondents have full liberty to express their opinion in whatever style, language and length they find suitable. Such questionnaire is mainly adopted for intensive studies.

1. Why do like TV as a source of news?
2. How in your opinion the defects of present system of examination can be removed?

These open-ended questionnaires are useful as they allow the respondents to give primary information. But there is a difficulty in these questionnaires too.

Non-structured questionnaire: This includes questions, which are not determined and structured beforehand. Here, the questions can be framed and adjusted keeping in view the need of question hour, e.g., during interviews. We can collect information for definite subject matter areas as there is greater flexibility.

Codified questionnaire: These are the questionnaires in which the expected answers are given in code numbers. Every question contains alternatives represented by codes like 1, 2, 3. The respondents are required to write the code in the box provided or to encircle or tick the code only. Such types of questionnaires are nowadays very popular and used when calculations are to be done through computer, for example:

What is your educational background?

- (i) Below matriculation
- (ii) Matriculation
- (iii) Graduate
- (iv) Postgraduate

Uncodified questionnaire: These are simple forms of questions without any codification. Codification may be done at the time of analysing the data, if necessity is felt.

Pictorial questionnaire: Another type of questionnaire, which is also used for collecting information from children or illiterate persons is known as pictorial questionnaire. Here, the selective alternatives are given in the form of pictures and the respondent is required to select the best, according to him, out of these. In this type the interest of respondent is aroused and the concept is more clarified. But there is a disadvantage of it in being highly expensive and lengthy too.

Designing a Questionnaire

Designing of a questionnaire is an art, the success of which depends mainly on the imaginative and skilful presentation of questions. An imperfect questionnaire may fail to gather the relevant data. The following steps may help to understand the process of designing a questionnaire, which should be kept in mind.

Covering Letter. Every questionnaire must be accompanied with a brief covering letter. Covering letter includes the following information:

- Name, status and address of the data collector
- Main objectives of the study
- Assurance to the respondents that whatever information they provide is important and will be used for research purpose only

Physical Appearance. The first step in the designing of a questionnaire is to decide about its physical format. An elegant and a good-looking questionnaire with good printing on white paper certainly attracts the attention of the respondents.

Nature of Questions. As discussed earlier, in the qualities of a good questionnaire, the questions should not be lengthy, vague or ambiguous; it should be specific. Proper care should be taken so that the questions should be understandable and in accordance with the educational and professional background of the respondents. There should be logical arrangement so as to ensure the continuity of the responses. Some questions, which cross-check the reliability of the information should be added.

Pre-testing the Questionnaire. Now it is possible to prepare a questionnaire according to the specific problem keeping in view the above-mentioned characteristics. After designing the questionnaire, it can be administered. At this stage, pre-testing is very important before it is presented to the informants. This process is also known as pilot survey, which helps in removing any inconsistencies, repetitions, unclear, irrelevant phraseology, controversial issues and leading questions.

Pre-testing helps in locating the irrelevant questions and other mistakes. These can be removed and improved. This process also helps in designing a better and effective questionnaire. According to R.F. Sletto, 'pre-testing is especially a trial and error procedure wherein the successful trials are repeated and errors are avoided when the final questionnaire is sent to the final group'.

After pre-testing, a questionnaire is ready for administration to collect the information about, for example, educational background of respondents, their socio-economic status, their adjustment to various aspects of environment, their attitudes and interests.

Merits of Questionnaire Method

- *Large coverage:* This method is quite useful when the sample for the research problem is spread over a large area like over whole of the state, country or worldwide, or even when the informants live at a place where travelling cost is high.
- *Low cost:* This method is more economical than others like interview. As stated earlier, mailed questionnaire is most useful and feasible when the population is thinly and largely distributed. Here, the total investment per head is low. The investigators have to bear the cost of only printing, postage and follow-up.
- *Rapidity in obtaining information:* Questionnaires help in quick conduct of surveys. Mailing the questionnaire and getting sincere response from the respondent takes very short time.
- *Ensuring anonymity:* A good questionnaire aims at obtaining information only, and not in revealing the identity of the respondent. In a good questionnaire, the respondents are not required to give their identification like name or address. They are free to express their opinion.
- *Uniformity of responses:* This is ensured by adopting standardized vocabulary and syntax of questions and standardized sequence of questions. This controls the individual interpretation of sentences and words by the respondents.
- *No personal influence:* As there is no physical interaction between the researcher and the respondent, the influence of any kind is prohibited during the collection of information.

Demerits of a Questionnaire

- (i) *Unreliability:* The questionnaires have been criticised for lack of reliability and validity as the opinions or views of people change with the changing times. The reliability of the data collected is tested by two ways:
 - Mailing the same questionnaire to the same respondent after some lapse of time. Collection of same information data through this process indicates the reliability of questionnaire.
 - Administering the same questionnaire on two different samples. A similar percentage and nature of responses also indicates reliability, but the human behaviour is greatly influenced by the environment, either social or biological. This influence can lead to changes in the responses.
- (ii) *Limited scope:* The questionnaire can only be successfully applied to the educated and research conscious people who could respond sincerely.

- (iii) *Poor response*: In actual practice, it is observed that the respondents do not reply promptly. People delay the reply because of no direct connection or use of such questionnaire with them. Sometimes the return of questionnaire may be less than 50 per cent. In few cases, this poor response may be due to bad designing of the questionnaire too.
- (iv) *Incomplete entries*: Sometimes people do not answer all the questions and thus these incomplete entries make the analysis meaningless.
- (v) *Illegible entries*: Bad handwriting, use of pencil, over-writing or over-erasing makes it sometimes difficult to understand what is answered.

Construction of a Questionnaire

- Study other questionnaire and keep in mind the characteristics of a good questionnaire.
- Get all the helps you can and make all preparations for planning and constructing your questionnaire.
- Submit your questionnaire items for criticism to your friends and colleagues.
- Try your questionnaire on a few representatives of the population to be studied. Items that seem perfectly clear to you may turn out to be ambiguous. Improve them so that the questions are clear and unambiguous and fit to draw the desired information from the respondents.
- Methods of determining the reliability and validity of a questionnaire are often unwieldy and unsatisfactory. More dependable results are ensured by: (i) Minimizing the effect of certain conditions, which impair reliability or validity (refer to the above principles). (ii) Designing the items with a view to quantification of results. It should be possible to translate replies into quantitative expression of absolute or relative values, which may be described by statistical techniques. The plan for quantitative treatment should be sufficiently adequate to permit question-to-question comparison as well as the comparison of the findings of the inquiry with those of other investigations.
- On the whole, the questionnaire as a research tool should be brief, sharply focused on its specific purpose, and explanatory of what, why, who for whom and how. It must reveal the following facts:
 - (i) The auspices—Who is sanctioning the study?
 - (ii) The purpose—Why is the study initiated?
 - (iii) The incentive—Why should the respondent bother to answer?
 - (iv) The direction—How to fill it out?
 - (v) The guarantee—of anonymity and secrecy.
- While preparing directions for answering questions, one should observe the golden mean between extreme completeness and detail on the one hand and extreme incompleteness and vagueness on the other hand. One must work back and forth, shuttle-like, between the questions and directions as one constructs a questionnaire. The respondents' psychology of motivation is getting attention, interest, sympathy, co-operation and honesty in answering questions, which should be kept constantly in mind.

Use of Questionnaire

Some of the questions the investigator should ask concerning the use of the questionnaire are as follows:

- Is the questionnaire a more appropriate tool than, or as appropriate a tool as, some other data-gathering instruments for the specific problem in hand?
- Does the information one require are available through documentary sources or related literature?
- Do the recipients of the questionnaire have the required information and are they free and willing to respond?

Administration of Questionnaire

Choose respondents carefully—those who possess the required information and are sufficiently interested to respond conscientiously and objectively. It seeks information, which are not obtainable from other sources (like school reports or census data). It is as short as possible, through comprehensive and clear enough for securing all the essential information. It is attractive in appearance, neatly arranged and clearly duplicated or printed.

It contains directions, which are clear and complete. Important items are defined and each question deals with a single idea in unambiguous terms, so that it is valid and reliable. Items are arranged in categories to ensure easy and accurate responses. It contains questions of an objective nature without any leading suggestions as to the responses, from simple to complex, from those that will create a favourable attitude to those that may be somewhat delicate on intimate. It avoids annoying or embarrassing questions. It is easy to tabulate and interpret, based on a pre-constructed tabulation sheet and a visualized final analysis of data.

Evaluate Yourself

- (i) What are the characteristics of a good questionnaire?
- (ii) Describe the construction of a questionnaire as a research tool.

Tools Used in Qualitative Research

Interview

Interview is probably the most adaptable and useful informal evaluative device, which a researcher uses to study human behaviour. There are many types of interviews, each has its own peculiarities and purposes, but basically all types have certain common characteristics.

Interview is one of the most important techniques used in behavioural and social researches. There are certain types of inquiries, which do not give satisfactory results through devices like questionnaire and checklist due to several limitations. In such cases, interview is found useful. It is possible to probe deeper and seek clarification regarding the issue to be studied. Thus, interviews can be regarded as oral questionnaires where one can ask probing questions on the basis of the replies received from the respondents. Interviews are designed to obtain certain information from the respondents. The respondents personally give their answers to the interviewer. There is one-to-one approach between interviewer and interviewee during the process of gathering information. Although this takes much longer time in comparison to an ordinary questionnaire, it provides authentic and valuable information, some of which a questionnaire may fail to elicit. In an interview, it is possible to combine both open-ended and structured questions. In addition, there is enough scope both for the interviewer and the respondent to seek clarification, which is not possible in the case of a questionnaire.

Interview as a research tool is, in a sense, an oral type of questionnaire or schedule whereby the subject supplies needed information in a face-to-face relationship. The dynamics of interviewing, however, involves much more than an oral questionnaire. It is based on a process of communication or interaction between the interviewer and the interviewee or respondent. A good interview is, based on proper motivation provided by the interviewer to the respondent in the form of achieving some practical ends or some satisfaction in the psychological climate of the interview itself. Interview is relatively more flexible a tool than any written enquiry form and permits explanation, adjustment and variation according to the situation.

Normally, interview is an exchange of ideas between two persons in a face-to-face relationship carried on for a purpose and constructed or guided, in some degree, by one of the parties involved. The difference between various types mainly lies in the methodology adopted by the interviewer for achieving this purpose.

As a teacher we usually have interviews with students, parents, faculty members or administrators. We collect information regarding their attitudes, interests, ambitions, hopes, feelings, and problems. The nature of interview depends upon our purpose. We conduct interview as a doctor, lawyer, journalist, social worker, administrator, employer, and so on. As an employment interviewer, we ask such question through which we can compare and evaluate the qualifications, and academic and professional skills of the candidate.

Psychiatrists conduct interview to look into the behaviour pattern of their client. Our government conducts, for example, fact-finding interviews, census survey, information service interview (employment services), and therapeutic interviews.

Directly or indirectly all of us are involved in the process of interview at one or another stage of our life. In our society all persons are interrelated and interdependent—this makes the process of interview continuous. With the increasing utility of interview in the fields of selection, placement, educational administration, evaluation, clinical and industrial the process of conducting interviews has become scientific to collect useful and relevant data.

Definitions of Interview

Various authors have defined interview in their own ways:

P.V. Young defined that ‘interviewing is not a simple way of conversation between an interrogator and informant. Gestures, glances, facial expressions and pauses often reveal subtle feelings’.

According to Denzin (1970), ‘an interview is any face-to-face conversational exchange where one person elicits information from another’.

Goode and Hatt (1962) treated, ‘interview as a fundamental process of social interaction’.

Fred N. Kerlinger defined it as the, ‘face-to-face interpersonal situation in which one person, the interviewer asks a person being interviewed, the respondent, questions designed to obtain answer pertinent to research problems’.

Eckhardt and Brmann pointed out that ‘interview is a data collection procedure involving verbal communication between the researcher and respondent either by telephone or in a face-to-face situation’.

According to *Oxford English Dictionary*, the term ‘interview’ has the meaning as ‘a meeting of persons face-to-face, especially for the purpose of formal conference on some point’.

The above definitions give us an idea about the nature of interview. These definitions reveal that normally in interview there is face-to-face meeting and social interaction. The investigator collects information by adding questions and the responses are given by the informants verbally.

Types of Interviews

The interviews can be classified as follows (Figure 9.1):

- On the basis of approach adopted (structured and unstructured)
- On the basis of number of persons participating (group or individual interview)
- On the basis of functions (diagnostic, therapeutic or research interview)
- On the basis of period of contact (short or long interview)

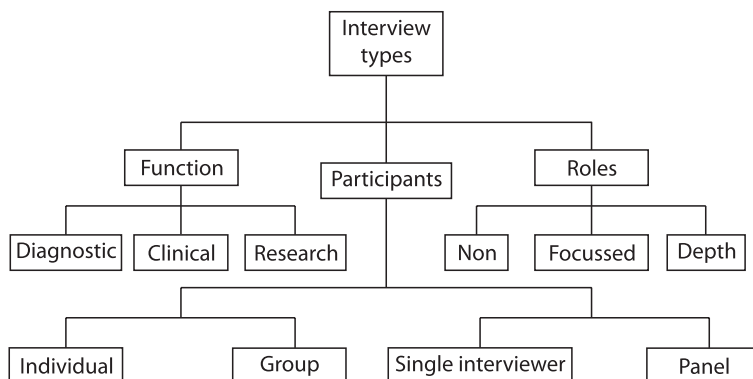


Figure 9.1 Classification and types of interview

A few of them are described below:

Structured Interview. Structured interview is one which is conducted on the basis of pre-determined questions. In this, all the components are standardized, e.g., the number and nature of questions, wording of questions, way and order of asking them and recording of the information by investigators. Normally, the questions are close-ended type.

In structured interviews, the questions, their sequence and wordings are specified in advance and there is little liberty in asking questions. Structured interviews use interview schedules, which are carefully prepared to obtain information pertaining to the problem under investigation. On the other hand, un-structured interviews are more flexible and open, and schedule ordinarily is not used. But it should not be confused with casual chit-chat as unstructured interview also requires a broad plan on the part of interviewer. Sometimes, semi-structured interviews are also planned.

In educational researches, interviews are used to gather information from busy educational administrators and planners, politicians, typical psychological cases, young children, parents and so on.

There are certain specific advantages of this data-gathering device due to which it is preferred to other devices.

- (i) Generally, people are more willing to talk than to write.
- (ii) Due to close rapport and friendly environment, certain types of information may be obtained, which the individual may be reluctant to commit in writing, e.g., information related to personal life and family affairs.
- (iii) In case the respondent misinterprets a question it can immediately be clarified.
- (iv) Up to a certain extent it is possible to check the truthfulness and sincerity of the responses.

The relationship between interviewer and respondent plays a very important role in its success. The initial task of securing the confidence and cooperation of the subject is crucial. Privacy should be maintained while conducting an interview. Unnecessary presence of persons not connected with the interview might hamper the process of interview.

- *Merits of structured interview:* As we adopt standardized procedures, the structured type of interview is considered to be more methodological and easy to administer. Here, the uniformity and accuracy of information can be maintained.

- *Demerits of structured interview:* Sometimes the set procedure of asking questions and receiving informations makes the process more rigid. This affects the social and personal interaction of the investigator and the interviewee.

Unstructured Interview. This type is somewhat more liberal about time limits, wording of questions, order of questioning and so on. Here, the emphasis is on purpose rather than form and there is much greater opportunity to explore various issues related to the problem in an unrestricted or flexible manner. Due to these characteristics, the unstructured interview is also known as informal type of interview.

In the process of unstructured interview, much flexibility is observed in the regulations and constraints. The interviewer has greater freedom to change the actions depending upon the context.

- *Merits of unstructured interview:* This method permits a natural conversation between the interviewer and interviewee, therefore a congenial atmosphere is created which helps in collecting maximum information. All the problems are tackled in an unrestricted manner, allowing full freedom to the respondents to express their views in their own style and way.
- *Demerits of unstructured interview:* From the above discussion it is clear that there is flexibility in the manner of asking questions and their wordings. As there is no systematic control over these procedures, a lot of time is wasted in conducting interview as the investigator and informer may engage themselves in unproductive, unnecessary and repetition conversations.

Research Interview. In research interview, we try to locate the possibilities and potentialities while working on a problem. Let us understand this with the help of an example.

Example: If we want to explore the effectiveness of space communication in the field of education, we conduct research interview. While conducting this interview with scientists, technologists, media persons and educationists, we will collect relevant data regarding the utility and potentialities of space satellites in beaming down information to the school children simultaneously all over the globe, e.g., in the form of satellite-conference or computer-conference, local area network (LAN) or video-conferencing.

The main disadvantage of this research is that it involves much manual power and other administrative constraints.

Group Interview. This can be conducted in two ways. Either a single person collects information from a group of informants simultaneously or a group of interviewers collect information from the respondent. When there is a group of respondents, the idea may be to save time. But one of the disadvantages in this case may be that the respondents can influence each other through their gestures, manners, speeches and ideas while answering to the interviewer.

Individual Interview. This is the most commonly adopted method where single interviewer meets one interviewee and conducts interview. Here the group influence is avoided and the respondents can express themselves in natural way. But if there are a large number of respondents, this method may take very long time to get completed.

Process of Interview

The interview is conducted in three stages:

- Establishment of harmonious relationship
- Getting information through inquiring
- Recording the responses

Establishment of a Harmonious Relationship. The first condition for a successful interview is to establish harmony or rapport with the informant. It can be done by creating a permissive situation where the respondents feel free to voice their frank opinion. The respondents should be put at their ease. Much will depend now on the nature of the interviewer. If the interviewer is courteous, friendly, conversational and unbiased, the respondents will reveal the actual information.

The interviewers should start interview with a brief, casual and informative introduction of themselves, they should ask simple and friendly questions about the respondents' education, family and achievements in the beginning. However, this should not be too long because the respondents are actually interested in the real purpose of interview and too long introduction may lack their interest. Here are some probable suggestions which, we will find, may create enough confidence in the respondent to speak freely during the interview:

- The respondent should be greeted cordially and warmly, offered a comfortable seat in a pleasant room.
- Be a good listener. Do not show surprise or any value of judgement, which may affect the respondent's behaviour.
- Never ask leading operations, which may suggest the possible answer. Also try to avoid putting words into the mouth of respondent by suggesting answers.
- Do not believe the respondents blindfoldedly of what they say unless their honesty and integrity are ascertained.
- Finally, do assure the respondents that it was a nice meeting and they will be welcomed in future also. But this should not be a direct invitation.

Getting Information Through Inquiry. After establishing a rapport, the interviewers start collecting information by asking questions. The questions are asked in the same order as they appear on the questionnaire. In structured interviews, asking questions exactly as they have worded have great importance.

Recording the Responses. The recording of responses must be done at the same time during the interview, because after a lapse of time chance error of forgetting the information may occur. Hence, electronic gadgets like video camera or a tape recorder can be used for this purpose. However, the main disadvantage of using them is that respondents may hesitate to express themselves in their presence.

Another way of recording the opinions is to write them down either in the form of sentences or codes. If the questions are pre-coded, the interviewers need only to tick the code or write down the particular code corresponding to that question and its answer.

Advantages of an Interview

The main advantages of an interview are the following:

- *Easy to conduct:* Interview is relatively easy to employ in its simple form.
- *Natural conversation:* It closely resembles the natural conversation, thereby helps in revealing the desired information.
- *Study of behaviour:* Neurotic disorders or bodily movements related with nervousness and the actual causes for any behaviour situation can be effectively investigated.
- *Effective assessment of personality:* Through structured, unstructured or diagnostic interviews we can understand the personality of human beings in an holistic perspective regarding their emotions, attitudes, aptitudes, feelings, aspirations, ideas, beliefs, health, education and status.
- *Dual nature:* It could be diagnostic, research and therapeutic in nature and conducted at one and the same time.

Disadvantages of an Interview

Major disadvantages of an interview are as follows:

- *Difficult for speech deficient persons:* Interview may not be a proper tool for collecting information from the persons with verbal disability or very young children who find themselves unable to express their opinion.
- *Reliability and validity:* Reliability and validity of the data is not definite as the facts may be difficult or even impossible to verify, e.g., it becomes difficult to verify whether persons actually behave the way they say they behave.
- *Subjectivity:* It is subjective in nature as the data obtained may be based upon misconceptions or certain biases.
- *Emotions:* Sentiments and emotions may affect the process of interviewing.

Overall, it can be explained that interview is highly subjective in nature. To a greater extent, it depends upon the philosophy and skill of the interviewer, who must be an expert of human psychology and behaviour. The technique of interview requires objective process, effective training, sufficient practice and professional skills to search for actual causes and real, valid and reliable informations.

Values and Uses of Interviews. The following are the values and uses of interviews:

- (i) The interview, with skilful interviewers, is much superior to other data-gathering devices because:
 - (a) People are usually more willing to talk than to write, especially on intimate, confidential topics.
 - (b) The purposes and meaning of questions can be better explained to get valued responses.
 - (c) The sincerity and insight of the interviewer can be judged through cross-questioning.
 - (d) A depth and penetration of responses can be achieved in areas where human motivation is revealed in the reasons for actions, feelings and attitudes concerned.
- (ii) It is especially appropriate when dealing with young children, illiterate and those with limited intelligence or in an abnormal state of mind.
- (iii) Often the interview is used for practical purposes rather than gathering that for research. It is used for, e.g., student counselling, occupational adjustment, selection of candidates for education or employment, psychiatric work for commercial or social surveys, and legal proceedings. It is now frequently used as a research tool in historical, experimental case-clinical and normative studies.

Evaluate Yourself

- (i) Enlist different types of interviews as a research tool.
- (ii) How will you prepare 'interview', execute it and interpret the interview notes?

Some Tips for Holding Successful Interviews (Practical Guidelines)

The following are some of the tips for conducting a successful interview:

- Plan the interview well in advance, fix up suitable time and place.
- Select those participants who possess adequate knowledge of the subject/issue.
- The two parties must establish good rapport.
- Ask short and clear questions.
- Give adequate time to the subject to think and reflect on the questions posed.
- Provide clues and emotional support as and where needed by the respondent.

- Be attentive and responsive to the verbal and non-verbal communication of the respondent. Be a good listener.
- Ensure systematic recording of the information. Tape recorder can also be used.
- The purpose of interview should always remain clear.
- Remember that the interview is an art of hearing.
- Do not close the interview abruptly. Express thanks for co-operation.

Observation

From the early days of development up till now, human beings have been constantly observing physical or social changes occurring around them. We learn as we observe something happening—either to us or around us. This observation is the basis of all learning and understanding. It is the unique characteristic of human beings to observe the change and adapt themselves according to that change. Due to this very characteristic we have survived successfully irrespective of all environmental or social changes, whereas those who did not or could not adapt themselves, perished.

In educational fields, observation is probably the oldest method used and it continues to be one of the most used methods for studying social problems. We can hardly find any person who does not observe the events to a certain extent. Some observe keenly while some just observe superficially, but do not probe into it. It was this process of observation which made greatest scientists of our times.

Einstein propounded the theory of relativity by observing the clocks of a church and sitting in tram where he used to go to his working place. Also, it was observation which made James Watt to realize the strength of steam—encouraging him to invent steam engine. Let us try to understand the meaning of observation.

Observation has been regarded as a classical method of scientific inquiry. It has been used from the earliest history of scientific activity. Great scientists and philosophers like Plato, Aristotle, Gandhi, Newton, C.V. Raman and others have given many scientific and universal principles on the basis of observation of natural phenomena.

Observation as a tool of research deals with the overt behaviour of persons in appropriate situations controlled or uncontrolled. As a rule, it is not concerned with what the respondents place on paper, or what they say in an interview. It is not haphazard or unplanned. As a research technique, it must always be expert, purposive, systematic, carefully focused and thoroughly recorded. It should be accurate, valid and reliable. For accuracy in measuring and recording, tools such as checklist and score-card or some other inquiry form are utilized along with camera and tape recorder and measuring instruments like thermometer, audiometer, stop-watch and binoculars. Reliability of observation increases if observation is repeated by the same individual or by simultaneous observation done by many individuals. Validity increases by keeping the setting as natural as possible and not letting the subjects be unduly influenced by the presence of the observer or by the measuring or recording devices. Direct observations, as a research tool, have developed during the present century due to the development of research in child growth and due to the limitations of interview, paper and pencil tests or laboratory techniques.

Observation can be used in many kinds of researches: philosophical, historical, as well as experimental and descriptive researches. This method has been widely used in ethnological studies mainly by anthropologists. Observation is considered quite useful when the purpose of research is to study the overt behaviour of persons or groups. Through this technique, the researchers obtain information by way of direct observation without having to ask the respondents. For example, in a study related to the classroom behaviour of teachers or students, the researcher observes the behaviour and activities in the classroom and records relevant information. Similarly, the behaviour of nursery school children can also be studied effectively by observing them.

The main advantages of observation technique are as follows:

- It provides first-hand information of the current happenings.
- It is independent of respondents' willingness and less dependent on their co-operation.
- If carried out accurately, the subjective bias can be more or less eliminated.
- It is possible to collect information in greater detail.

Observation is particularly suitable for the studies dealing with subjects who, due to various reasons, are not capable of giving verbal reports/responses, particularly in studies where the actual phenomena cannot be described by the respondents.

Observation can be participant or non-participant. If the observers observe the phenomena by making themselves a member of the group, it is called participant observation. This technique is used mostly in anthropological and sociological studies. For example, researchers in such types of studies live in tribal communities as members and observe their life, customs and traditions, which enable them to obtain striking information that may be highly revealing. When the researcher remains detached from the group and observes as an outsider, it is called non-participant observation. For example, observation of school activities, classroom behaviour and meetings fall under this category.

Meaning and Definition of Observation

C.A. Moser (1958) expressed that, 'observation can fairly be called the classic method of scientific study.' In the strict sense, observation implies the use of eyes rather than of the ear and voice.

Goode and Hatt (1964) revealed that science begins with observation and must ultimately return to observation for its final validation.

According to P.V. Young (1977), 'observation may be defined as systematic viewing, coupled with consideration of the seen phenomenon, in which main consideration must be given to the larger unit of activity by which the specific observed phenomena occurred.'

In the words of Koul (1988), 'Observation is the process in which one or more persons observe what is occurring in some real life situation, and they classify and record pertinent happenings according to some planned scheme.'

In *Concise Oxford Dictionary*, observation has been described as 'accurate watching and noting of phenomena as they occur in nature with regard to cause and effect and mutual relationship'.

After going through the above-mentioned definitions, it is now understood that observation is nothing but seeing and understanding the things either from a distance or from the vicinity to the object of study. This method is quite useful for collecting primary data in the fields relating to learning, attitudes, perception, emotions, personality, leadership group behaviour and social development of a child.

Process of Observation Method

We now explain the steps followed during observation.

Planning: Adequate and proper planning about the objectives of the study, tools and apparatus to be used, duration of the study, place of observation and participants should be made.

Observation of behaviour: The next step is to observe the behaviour of the subjects under study according to the plans decided. Necessary tools and apparatus are to be used, e.g., we can take the help of a tape recorder or video camera for our purpose.

Recording of facts: We also note down the facts and events as they happen and are being observed simultaneously.

Interpretation of results: After the necessary and adequate data have been computed, suitable techniques are applied, e.g., statistical or quantitative and qualitative methods for the analysis of data. We try to get results from our observations.

Generalization: Finally, we come to a conclusion and generalization, which is done by taking help of established laws and principles.

Types of Observations

After explaining the process of observation, let us now understand the types of observations? Observations are classified into various types according to the method used and type of control exercised (Figure 9.2).

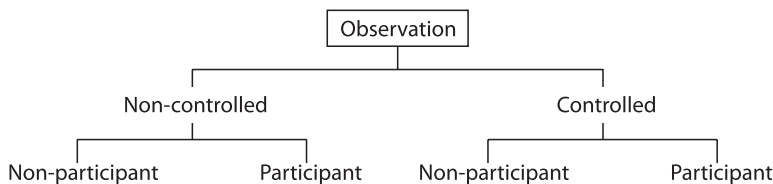


Figure 9.2 Classification into various types of observation

Non-controlled Observation. In this method, we observe the events in their natural setting, which are free from any extra influence, control or guidance. The subject under the study is let free to act and behave, under no interference.

According to Young, in non-controlled observation we resort to careful scrutinizing of real-life situations, making no attempt to use instruments of precision or to check the accuracy of the phenomenon observed.

Advantages of observation: This type is very useful for studying behaviour in social science because it becomes difficult to create artificial, controlled or laboratory conditions. Also it may be the need of our study to be conducted in its natural way, without any control. The observer visits the place of occurrence of events for observation (e.g., to study home conditions of delinquents or to study the behaviour pattern of tribals).

Disadvantages of observation: This type of observation may get affected by personal biases as there is no check over observer. Also the results or observations may differ because different observers may observe differently thereby questioning the objectivity and reliability of data. But overall, this type is preferred to study real-life-like situations. This is further classified into two groups: uncontrolled non-participants and uncontrolled participant observation.

- *Uncontrolled non-participant observation:* Here we observe not only the physical aspects of the community, but also the social atmosphere, the symbiosis (living together) and the effects of such living in such a social world. The observers watch the subjects from a distance. They are not a part of the group and even does not try to influence the activities of their subjects. This method has the merits of keeping the observer unattached and impartial, collecting information objectively.

But one of the main problems associated with this type is the fact that how and for how long can a person remain non-participant? It becomes difficult to feel and understand the real issue until

they become a part. Also, it is very difficult to leave apart one's ideas or personal beliefs, which may have their influence on the observation.

When the observer is not becoming attached, there may be a problem of co-operation from the subject. Also, when the observers are present on the actual site, the group tends to be conscious of their presence and may behave in unnatural way or may conceal certain facts or behaviour pattern. Thus, a purely uncontrolled non-participant observation is extremely difficult. A suitable measure to this problem can be to participate in some very ordinary functions and avoid others. Such a process is called as quasi-participant observation.

- *Uncontrolled participant observation:* In this type, the researchers take part in the activities of the group under investigation. But it is not necessary to give their identification to the group. Goode and Hatt suggested that this procedure may be used when the investigators can disguise themselves as to be accepted as a member of the group. Here, the observers get mixed up as a member of the society, take part in their normal workings, functions and festivals.

The main advantage of this method is that it produces a natural, spontaneous and unposed picture of the subjects under investigation as they are not conscious of the presence of the observer.

This method has some disadvantage also like the familiarity of observer with the activities of the social group. These activities become routine and may be overlooked, which otherwise may be important to be noted down. Sometimes it is not possible to take active participation, e.g., to study criminal gangs; and behaviour pattern of terrorists of Jammu and Kashmir, Punjab and Assam.

Controlled Observation. The above-mentioned demerits of non-controlled observation have been rectified and improved in the form of controlled observation. It is also known as systematic observation. In controlled observation, there are definite pre-arranged plans, which might include considerable experimental procedure. The most common field of study in this type is related to child behaviour.

This method gives us precise, accurate and objective data, having the characteristics of verifiability and validity. The main purpose of a controlled observation is, thus, to check any bias due to faulty perception, inaccurate data and influence of outside factors on the particular incident.

We take the help of various kinds of devices of collecting data through controlled observation like one-way screens, mirrors, movement recorders and sound recorders.

In a nutshell, we can say that controlled observation is the process of collecting data for the research problem by exercising control over the phenomena and on observer.

Advantages of controlled observation: The advantages of controlled observation are as follows:

- *Simple method:* This method is very simple and easy as the investigator is required to go to the field and observe the phenomena. An insight, understanding of human behaviour and proper training are the sufficient requirements of any observer.
- *Greater accuracy:* As the data are collected by the researchers themselves, they may be treated as more accurate.
- *Helpful in framing hypotheses:* Hypothesis framing is an essential step in research. Observation helps the researchers in its formulation to proceed further in their problem area. We try to understand the cause and effect of certain sequences and their mutual relationship. These form the basis for new hypotheses.
- *Validity of information:* The validity of the data can be proved by making the people observe the same thing the observer has observed. Also, for establishing the accuracy of generalizations, the observation must be done from time to time for that problem.

Evaluate Yourself

- (i) In an educational research situation, what do you mean by observation as a research tool?
- (ii) Enlist the advantages of using observation as a research tool.
- (iii) How will you construct 'observation' as a research tool.

Shortcomings of Observation

Shortcomings of observation are following:

- *Attraction by appealing features:* When we visit the field to study the behaviour or any phenomena, we may be attracted by some striking features of the same. This can result in observing those features keenly and ignoring some, which do not appear so attractive, but otherwise equally important.
- *Culture bias:* A major weakness of this method is that often the observers view the phenomena in light of their cultural background affecting the reliability of information.
- *Slow process:* As the phenomenon is to occur at its own speed, it may take long time to get completed or even it may take long time to occur. So we have to wait for that long.
- *Erratic behaviour of our sense organs:* It is understood from the above discussions that observation is done through our sense organs, which we take as reliable. However, in fact, our sense organs like eyes or ears operate in a highly variable, erratic and selective manner. Psychological investigations have proved that our state of body and mind is the control factor of our perception of a phenomenon at that particular instance.

Opinionnaire

An opinionnaire is another important device, which is used to study the opinion or belief of an individual on certain important issues. Human behaviour is quite complex. It is quite difficult to measure how people feel or what they believe. For this, researchers have to depend upon what people say about their beliefs and feelings. This, in fact, falls in the area of opinion. Thus, with the help of questions or by getting people's expressed reactions to some statements, a sample of their opinion can be obtained. This can help the researchers to estimate or infer what they really believe. For example, in educational studies, opinionnaire can be framed for eliciting the responses about the issues such as nationalization of education, making higher education economically self-sufficient, language policy, delinking of degrees with jobs and so on. Questions related to different areas of such problems can be framed for seeking opinion of the respondents. In spite of many similarities with questionnaire, the emphasis on opinionnaire is not on seeking facts but on seeking opinion. In other ways, opinionnaire is similar to questionnaire, hence while constructing an opinionnaire, the guidelines given for questionnaire should be followed.

Attitude Scale

An attitude scale consists of a number of items (statements) that have been just as carefully selected and edited in accordance with certain criteria as the items contained in any standardized psychological test. The statements are prepared about a given psychological object, which is often called a 'universe of content'. In the scaling method, the individual is required to react with expressions of approval or disapproval. For each subject, a total score is obtained by summing scores on all the items.

There are four types of attitude scales. They are: (i) Thurstone's method of equal appearing intervals, (ii) Likert's method of summated ratings, (iii) Guttman's cumulative scale and (iv) Bogardus' social distance scale. Besides these, 'free response method' and sentence completion tests are also used. They are scorable from negative through neutral to positive attitudes towards various objects and hence are called scales. The first two of the above methods are generally used in educational researches.

Likert Scale

In the Likert scale, a statement is followed by a five-response continuum, such as strongly agree, agree, undecided, disagree and strongly disagree. The subjects select the category that best describes their reaction to that statement. The statements prepared for Likert types of scales are definitely favourable or definitely unfavourable towards the object. An almost equal number of favourable and unfavourable items are selected. For scoring, five marks are given to 'strongly agree' response in a favourable item. Similarly for agree, undecided, disagree and strongly disagree four, three, two and one marks are given, respectively. For the unfavourable items in the scoring procedure, weight of 1 is given to 'strongly agree' response, and the weight of 2 to 'agree' response and so on.

Steps for construction of Likert-type scale are the following:

- Decide and define the universe of content. Various dimensions or components of a psychological object (attitude to be measured) should be first defined
- Construct items/statements, as many as possible, on various dimensions

The following points may be kept in mind while constructing items for the attitude scale:

- Items should be written in simple, clear and direct language
- An equal number of positive (favourable) and negative (unfavourable) items should be prepared
- Double negative items should be avoided
- Items that were likely to be endorsed by almost everyone or by almost none should be avoided
- Items that may be interpreted in more than one way should be avoided
- Items containing universals, such as all, always, none and never should be avoided
- Items that refer to the past rather than to the present should be avoided
- Items that are factual or capable of being interpreted as factual should be avoided
- Preparation of first draft and tryout
- Preparation of second draft and item analysis
- Selection of valid items and preparation of final attitude scale. Delete items, which have poor discriminative value
- Construction of scoring key

Thurstone-type Attitude Scales

These are developed by giving a large number of statements to several judges. Each judge sorts each statement into one of the several categories (usually 11) ranging from extremely favourable through 'neutral' to 'extremely unfavourable'. Each statement is written on a separate slip. The judges are asked to rate the intensity of each statement. Those statements on which the judges agree reasonably well are selected for the final scale. Usually 20–45 statements that spread evenly over intensity scale are selected for the final scale. The intensity scale value is determined by the median category to which the judges assigned a given statement. The selected statements are randomly distributed in the final print form of the scale. Since considerable time and effort are required in construction of the Thurstone-type attitude scale, educational researchers generally use the Likert type of scale.

Making attitude items: Study the lists of statements prepared and used for measuring attitude by investigations in related area of research. Survey widely available literature on the subject. Meet and talk to various individuals on the subject. Make them express their ideas on the subject orally or in writing. Collect statements, both favourable and unfavourable, from the above three sources rather than inventing them yourself.

Collect a larger number of statements than you need for your scale. Select the statements as: (i) which present as wide a variety of situations as possible; (ii) which prevent the individual from detecting the nature of the attitude that is being evaluated; (iii) which do not mention the attitude object of even any stereotype association with it, as antagonism or prejudices are aroused by mention of such terms as Socialism, Reds, and Prohibitionists; and (iv) which have proved to be unambiguous in their meaning through a pilot study. Arrange the statements in a random order irrespective of their favourable or unfavourable indications. Keep the number of favourable and unfavourable statements approximately equal.

Limitations of Attitude Scales

Attitude scales are not exact in so much as it cannot be believed that the five positions indicated in the Likert scale, e.g., are equally spaced. It is unlikely that the statements are of equal value in positive or negative form. It is doubtful whether equal scores obtained by several individuals would indicate favourableness towards a given position. Different combinations of positions can yield equal score values without necessarily indicating equivalent positions of attitude or opinion. It is unlikely that a respondent can validly react to a short statement on a printed form in the absence of real-life qualifying situations. In spite of the anonymity of response, individuals tend to respond according to what they should feel rather than what they really feel.

However, until more precise measures are developed, the attitude scales or opinions remain the best devices for the purposes of measuring attitudes and beliefs in social research. They determine the direction and intensify a person's feelings for or against some belief or practice. They are used to measure any changes in attitude, which may result from factors introduced purposely or occurring independently.

Evaluate Yourself

- (i) What are the differences between Thurston and Likert scales?
- (ii) What are attitude scales? Clarify.

Checklist

This is a simple tool in which a list of statements or of items is given. The respondents tick-marks the things or statements which concern them, e.g., in a problem checklist, a list of problems is given related to different areas such as health, economy, educational and interpersonal. The respondents check the problems which concern them.

Another example of a checklist is a list of items in a physics laboratory for higher secondary classes. One can visit any laboratory and check the items, which are available in that laboratory. A very common example of checklist from day-to-day life is a grocer's list of items purchased from that shop. When one brings the items home, one checks the items from the list supplied by the grocer to ensure that all the items have been received. Checklist is a simple tool that helps in getting a preliminary idea of the personality problems or any other situation, which can form the basis for further deep probing.

Rating Scale

The rating scale is a tool in which the respondents rate the individual on a five-point or seven-point scale ranging from very high to average to very low. More than one quality or trait is listed and an individual is rated on each of these traits on a five-point or seven-point scale, for example.

Rating is a term applied to expression of opinion or judgement regarding some situation, object or character. Opinions are usually expressed on a scale of values. Rating techniques are devices by which such judgements may be quantified. The rating scale is a very useful device in assessing quality—specially when quality is difficult to measure objectively. For example, ‘How good was the performance? Whether a question can hardly be answered objectively?

Rating scales record judgements or opinions and indicate the degree or amount. Descriptions of different degrees or quality are arranged along a line from high to low or otherwise, and this line is the scale, e.g. How good was the performance?

<i>Very High</i>	<i>High</i>	<i>Average</i>	<i>Low</i>	<i>Very Low</i>
Punctuality				
Initiative				
Honesty				
Orderliness				

The person using a rating scale must be closely associated with the person to be rated. In order to make a rating scale reliable each point on the scale must be defined in behavioural terms, e.g., for initiative, points can be defined as follows:

‘*Very high*’ means persons who go out of the way to take responsibility. They tend to search out such opportunities themselves.

‘*High*’ means persons who immediately come forward to take up a responsibility.

‘*Average*’ means persons who fulfil the assigned responsibility well but does not come forward on their own to take up the responsibility.

Low finds excuses to avoid responsibility.

Very low does not accept any responsibility at all.

Construction and Use of Rating Scales

- (i) *Rating scales include three factors:* (a) the subjects or the phenomena to be rated, (b) The continuum along which they will be related, and (c) The judges who will do the rating. All these three factors must be very carefully selected.
- (ii) The subjects or phenomena to be rated are usually a limited number of aspects of a thing, or of traits of a person. Only the most significant aspects for the purpose of the study should be chosen as:

- (a) The usual way to get qualitative-cum-quantitative judgements on the selected aspects of a thing or person is to set up five to seven categories in such term as follows:

Superior	Above average	Average	Fair	Inferior
Excellent	Good	Average	Below average	Poor
Always	Frequently	Occasionally	Rarely	Never

- (b) Another procedure, however, establishes position in term of specific behavioural or situational description; e.g., instead of deciding whether the individual’s leadership qualities are superior or above average, it may be easier to decide between ‘always exerts

strong influence on his associates’, and ‘sometimes is able to move others to action’. One may with advantage consider the use of the latter form too.

- (iii) The different degrees of quality are usually adjectives or descriptions. Their meaning should be clearly different from each other, and in going ‘up’ the scale one should feel that the next description represents better quality than the last. In writing and arranging these descriptions it is good to have the judgement and agreement of several people.
- (iv) Items may be arranged in ascending or descending order from left to right. Ordinarily, an odd number of steps should be used and the average or usual quality should be kept in the middle.
- (v) At least three divisions of quality must be kept. A two division rating scale—‘Yes/No’. ‘Bad/Good’—forms a checklist. A rating scale may have as many divisions as can be readily distinguished by the raters. Practically, most scales have not more than seven divisions. Usually, they contain five divisions. By numbering each division in sequence, the descriptions can be converted into arithmetic value for averaging.
- (vi) The rating scale is always composed of two parts:
 - (a) An instruction, which names the subject and defines the continuum.
 - (b) A scale, which defines the points to be used in rating.

Arranging the Rating Scale

According to Homer Kempfer, One can arrange the rating scales in four ways:

- (i) On a straight line, e.g., the raters record their judgement along the top of the line by marking a ‘x’ symbol at the appropriate place.
- (ii) Ratings may be arranged one after the other on a line so that all are visible at a glance, e.g., how valuable were the ideas contributed by:

	Very good	Good	Average	Poor	Very poor
No. value					
Some value					
Average value					
Superior values					
Highest values					
A					
B					
C					
D					

Or, ratings may be marked in a column at the right. e.g. Express your opinion by encircling the proper letter—VC (very clean), C (clean), D, (dirty), VD (very dirty)

The school compound	VC	C	D	VD
The class rooms were	VC	C	D	VD
The children were	VC	C	D	VD

- (iii) The scale can run down the page and look much like a checklist, e.g., for me the idea of the lecture
 - Was entirely over my head
 - Was difficult to understand
 - Was clearly understandable
 - Was clearly understandable
 - Contained nothing new
- (iv) The scale may call for ranking, e.g.,: (a) Which instructors helped you most? Rank them by number from most (1), next most (2)... onto least (5).

Kishan	5
Mukerji	2

Ram Lal 1

Singh 3

- (b) Rank these solutions (W, X, Y, Z) of the problem in order of merit starting with 1 for the best.

3	W	2	X	4	Y	1	Z

This type of ranking is a higher form of rating whereby individuals or phenomena are arranged in order of merit, i.e. they are given positions determined by their relation to the other in the group, not by certain predetermined standards. It is a superior device because the comparisons are very close. But it cannot be used well when large numbers are concerned. The investigators must arrange their items in any or all of the above forms according to the nature of the item and its purpose.

- (v) Any one can serve as a rater where non-technical opinions, likes and dislikes and matters of easy observation are to be rated. But only well-informed and experienced persons should be selected for rating where technical competence is required. So an educational investigator should employ only those persons as raters who are either experts in the field or who form a sample of the population in which the scale will subsequently be applied.
- (vi) Pooled judgements increase the reliability of any rating scale. Employ several judges, depending on the rating situation, to obtain desirable reliability. Individual ratings when combined into a final rating give a safer assessment. For this, supply a separate copy of the scale to each rater to mark the judgement on, independently, to avoid the possibility of contamination of judgement otherwise. Tally the marks on a single copy. (If eight raters were employed, their ratings could be tabulated and quantified.) Mark the quantification of ratings by transmuting letter designations, or verbal characterizations, into numbers and by computing total score.
- | | | | | |
|---|---|----|-----|---|
| X | X | XX | XXX | X |
| 1 | 2 | 3 | 4 | 5 |
- (vii) A single rating index can be calculated by adding the numbers in the above example (1, 2, 3, 3, 4, 4, 4, 5) and dividing the total by the number of ratings (8). The average rating index thus is 3.25.
- (viii) One rating index can be compared with the result of other ratings using the same scale if it serves some logical purposes.

Difficulties in Constructing and Using Rating Scales

- It is difficult to convey to the raters just what quality one wishes them to evaluate. An adjective or adverb may have no universal meaning. Brief behavioural statements or situational descriptions, which have clear objective connotations should be used in place of vague terms.
- It is difficult for raters to get rid of the halo effect, which causes a rater to carry qualitative judgement from one aspect to another. For example, one tends to rate a person with a pleasing personality high on traits like intelligence or professional interest too. Halo effect appears frequently when the raters have to rate a number of factors on some of which they have no evidence for judgement. It is advisable to keep the number of essential characteristics to be rated at a minimum. Otherwise, it should be provided to the raters to omit rating characteristics that they have no opportunity to observe.
- Generally, the raters tend to be generous. It has been verified that 60–80 per cent of an unselected group tend to receive above-average ratings in all traits. The raters are inclined to be unduly generous in rating aspects, which they have had no opportunity to observe.

- Although pooled judgements of many refer reduce subjectivity of individual judgements, yet the average of scores thus arrived at are by no means either totally objective or highly valid. In interpreting the rating indices due allowance has to be made of this factor.

Evaluate Yourself

- (i) How will you construct a rating scale?
- (ii) Describe four different ways of arranging a rating scale.

It is not sufficient to rate a person only once. The rating should be done two or three times so that a reliable picture of the person being rated is formed. Thus, there is less possibility of a chance factor influencing the rating. A rating scale can also be developed for rating an institution or a programme. Different aspects of the institution or programme can be listed and each aspect can be rated on a five- or seven-point scale.

Data Schedule/Information Bank

In many research studies, the research worker has to collect some factual information about institutions or individuals. In collecting such data, a data schedule information bank is used. The data to be filled in does not need any personal judgement and anyone from the office can fill in the data, for example, the items in a data schedule related to an institution could be as follows:

- Number of classrooms in the college
- Number of chairs
- Number of tables
- Number of professors
- Number of readers
- Number of lecturers
- Year of establishment
- List of members of the managing committee
- Name of the principal
- Qualification of the principal and so on

While preparing a data schedule only those items should be included, which are essential in the light of objectives. Unnecessary factual information if collected results not only in wastage of time of the respondent, but also lead to difficulties for the research worker in handling the data.

Psychological tests are among the most crucial, significant and useful tools of research, which have been devised in order to test the human behaviour in standardized manner for the purpose of selection, classification, prediction and guidance.

Psychological tests are the standardized measuring instruments, which give the quantitative assessment of various personality traits. These tests are very useful in studies, which include psychological variables like intelligence, personality traits, interests, aptitudes, attitudes, level of aspiration and creativity. Now standardized tests developed in India are available for measuring most of the psychological variables.

Meaning and Definitions of Psychological Test

A dictionary definition of the verb 'to test' means the subjection to conditions that reveal the real character of a person or thing in a particular condition. A test is a series of questions or exercises or other means of measuring the skill, knowledge, personality, intelligence or aptitude of an individual or a group.

English and English (1958) defined a psychological test as, 'a set of standardized or controlled occasions for response presented to an individual with design to elicit a representative sample of his behaviour when meeting a given kind of environmental demand ... it is now common usage to include as a test any set of situations or occasions that elicit a characteristic way of acting, whether or not a task, and whether or not characteristic of the individuals best performance. Thus even a self-inventory or an attitude survey is called a test'.

According to Freeman (1962), 'a psychological test is a standardized instrument designed to measure objectively one or more aspects of a total personality by means of samples of verbal or non-verbal responses or by means of other behaviour'.

Anastasi (1961) says, 'a psychological test is essentially an objective and standardized measure of a sample of behaviour'.

While selecting a psychological test for use, the following points should be kept in mind:

- Check whether the test is meant for the age group to which it will be administered.
- The language of the test should be suited to the population under study.
- Check whether the population on which the test has been standardized is similar to the population under study.
- The test should have high validity and reliability.
- While selecting a test, the cost of the test should also be taken into account.
- The procedure of administration should not be too complicated.
- The scoring procedure should be objective and simple, preferably scoring keys in the form of stencils.
- Norms of the tests should be available.

While using a psychological test, the following points should be kept in mind:

- Get yourself familiar with the test before administering it to the subjects.
- Follow the directions given in the test strictly. Do not add or delete anything from your side.
- Strictly adhere to the time limit prescribed for the test.
- Seating arrangements should be such that one subject is not able to see the responses of any other subject.
- It is always better to use a pencil for answering a test.
- Use the scoring key or scoring stencil for scoring the test responses.
- After obtaining the raw score, convert it into standard score using appropriate norms given in the test manual.
- Wrong use or interpretation of a psychological test may have harmful consequences.

Characteristics of a Good Psychological Test

A good psychological test should have following characteristics.

Reliability: There should be consistency in measurement if a trait is measured at different times with the same instrument. If two or more persons score the responses, the results should be the same. This is called inter-scorer reliability. Also, there should be internal consistency in the test.

Validity: The test should be valid, that is, it should measure accurately what it purports to measure.

Objectivity: The scorers should not be required to use their judgement while scoring.

Practicability: The test should be easy to administer and score.

Being culture-free: As far as possible the test should be free from cultural influences.

Uses of Psychological Tests

Psychological tests have been devised and are used primarily for the determination and analysis of individual differences in general intelligence, specific aptitudes, educational achievement, vocational, fitness and non-intellectual personality traits. Tests also have been used for a variety of psychological, educational, cultural, sociological and employment studies of groups rather than for the study of a particular individual.

Among these studies of groups, the following have been most common and include most important fields of investigation: the nature and course of mental development; intellectual and non-intellectual personality differences associated with age, sex and racial membership, differences that might be attributed to hereditary or to environmental factors, differences among persons at different occupational levels and among their children; intellectual and other personality traits of typical groups such as the mentally gifted, the mentally retarded and the psychotic.

Purposes of Psychological Tests

What are the various purposes achieved by psychological tests? Here are given some important purposes of psychological tests:

- *Classification, selection and prediction:* On the basis of these tests, persons are put in different categories and are selected for different posts or occupations. With the help of tests, normal, neurotics and psychotics are classified; persons can be classified as brilliant, normal and idiot and on other IQ levels, they can be selected according to their level of IQ for different occupations and jobs. Who can be a suitable person for a specific task, may be predicted by psychological test.
- *Guidance:* Another goal of psychological tests is to guide a person in personal, occupational and educational fields. After passing matriculation or graduation many students face the problem of choosing the right carrier and the subjects according to their calibre and interests. Through these tests we can assess the mental and physical abilities so that they can be guided in right direction for a bright future.
- *Research:* Tests play a crucial role in research. It acts as a medium or instrument with the help of which one achieves the purpose. In other words, there is a great need of different instruments. As in physical sciences, in behavioural and social sciences, psychological tests have a significant role to play in data collection.
In other words, it is suffice to say that tests have a significant importance almost in all fields of life since they try to study almost every phenomena of life.

Classification of Psychological Tests

It is surprisingly difficult to classify tests. There is no one single and complete system of test classification. Actually, there are a variety of ways in which they can be classified.

Classification on the Basis of Behaviours Sampled. One common way of classifying the test is to divide them on the basis on which they sample various types of human behaviours. There are a lot of advantages in classifying the tests in this manner, e.g., the test users can very easily locate tests, if they know what sort of behaviour they are interested in measuring. The classifications are as follows:

- Intelligence tests
- Aptitudes tests
- Creativity tests
- Personality tests

- Achievement tests
- General intelligence tests

The purpose of these tests is to measure the general intelligence, which is reflected in performance of all activities. These tests assess the subject's ability to perceive relationships, solve problems and apply knowledge in a variety of ways. These are used for the classification of subjects into different groups.

Given below is the list of some of the intelligence tests, which are widely used for research purposes:

- (i) Group intelligence test by Prayag Mehta
 - (ii) Battery of performance tests of intelligence
 - (iii) Sadharan Manasika Yogyata Pariksha
 - (iv) Adaptation of Raven's progressive matrices test
 - (v) Hindi adaptation of Stanford Binet test of intelligence.
- *Special aptitude tests:* Earlier intelligence tests paid a lot of attention on general intelligence. Then no attempts were made to cover such psychological functions as musical, mechanical, artistic and other such special aptitudes or abilities. The needs of vocational selection guided the interest of psychologists in this field. According to Freeman (1965) an aptitude test is designed to measure one's potential ability in an activity of specialized kind and within a restricted range.

Nowadays, special tests are available for a wide variety of aptitudes. Some of them measure simply sensory activity, speed and dexterity in motor movements of various types. Aptitude tests for medicine, law, music, painting and clerical and a number of other tests are also available today.

- *Clerical aptitude test battery:* It has been constructed by the Bureau of Education and Vocational Guidance, Patna (Bihar). It can be applicable to persons of 14 years of age and above.

A battery of mechanical aptitude tests: This battery includes the three following tests:

- (i) Tweezer dexterity test
- (ii) Detroit's manual ability test
- (iii) The steadiness tester

There is no time limit. This test is meant for children of age 11 plus to 16 plus.

- *Aptitude tests for secondary school teachers:* This test has been constituted by M.M. Shah. It is a verbal group test and measures the aptitude of prospective secondary school teachers. The time limit of this test is about 100 min. The split-half reliability of the test is 0.88.

A battery of mechanical aptitude tests: This battery was constructed by A. Sharma and is meant for grades VIII–XII. It includes tests of the following:

- (i) Knowledge of tools
- (ii) Form relations
- (iii) Mechanical comprehension
- (iv) Mechanical adaptability

The split-half reliability coefficients for the tests included in this battery range between 0.90 and 0.98.

- *Creativity tests:* In order to measure creativity, many tests have been developed in recent years. Guilford and his associates developed many tests, which require from subjects to produce multiple

responses to a problem. The responses are scored in terms of fluency (number of responses), flexibility (number of different categories of responses) and originality (number of rare responses given by few other respondents).

Few important tests of creativity are as follows:

- (i) *Rachna shakti parikshan*: It was developed by N.S. Chauhan and Govind Tiwari. This test measures following five factors: creative production, flexibility, fluency, original power and ingenious solution of problems.
 - (ii) *Verbal test of creative thinking*: This test was developed by Baqer Mehdi. It can be applied on all grades of students except primary. It measures three factors: fluency, flexibility and originality. The time limit for the test is 48 min.
- *Personality tests*: There are a wide variety of personality tests, which broadly fall in following four categories:
- (i) Rating scales
 - (ii) Personality questionnaires or inventories
 - (iii) Situational tests
 - (iv) Projective tests
- These tests usually measure behavioural characteristics like emotional adjustment, neuroticism, emotional instability or various other traits of human personality such as aggressiveness, co-operativeness, honesty and perseverance. Similarly, these tests also measure motivation, attitudes and interests.
- *Achievement tests*: These tests measure the performance in relation to a skill, knowledge or understanding. They measure quality and quantity of learning. These are employed in education, business and industry, civil services and the armed forces.

Sociometry

Sociometry is a broad term indicating a number of methods of gathering and analyzing data on the choice, communication and interaction patterns of individuals in groups.

—Kerlinger (1964: 556)

Sociometry is a technique by which attractions and repulsions of members of groups can be measured. Choices from the individuals are gathered on questions like: 'With whom would you like to play/work?'; 'Who are the three best/worst students in your class?'; 'Whom would you choose to represent you?'; 'Name in order of preference three students of your class whom you would like to keep as your room partners?' and so on. These choices are then drawn in the form of sociograms. In sociograms one-sided choices are drawn by single-head arrows and mutual by double-head arrows. Through a sociogram one can see at a glance that an individual X is the centre of choice. That person can be called a 'star', a 'leader' or a 'popular'.

We can also see various 'cliques' in the sociograms. Cliques are obtained when three or more individuals mutually choose each other having no relationship with other members of the group. Those who are not chosen by anybody are called 'isolates'.

Thus sociometric techniques are highly useful in identifying leadership, prejudices and attitudes. A number of sociograms over a period of time for the same group can help in seeing the changing relationships of individuals in the group.

▲ Computer as a Tool of Research

Recently, the computer has become one of the most useful tools for the educational researchers as it calculates very rapidly. Researchers are essentially concerned with storage of data, their fast retrieval when required, their processing and tabulation in various ways and their analysis and drawing inferences. In all these operations, computers are of great help. The use of computers, apart from expediting the research work, has reduced human drudgery and added to the quality of research activity.

Researchers in education and other social sciences have found computer as an indispensable equipment. This is because they can perform various statistical calculations easily and quickly on huge data. Software packages are readily available for various simple and complicated analytical and qualitative techniques. Moreover, once the data are fed into the computer, pictorial graphics and reports can also be developed easily. Thus, the knowledge of computer helps the educational researchers in many ways. When the researchers decide to make use of the computer for data analysis they should be clearly aware of the requirement.

Data Organization and Coding

If the data are not properly organized, the researchers may face difficulty while analysing their meaning later on. For this, the data may be coded. A code book is generally prepared in which various categories of a given variable are allotted some numbers. For instance, regarding sex, we may give number one for male and two for female, regarding socio-economic status, number one, two and three may represent high, average and low socio-economic data. The IQ range may be classified into five categories and they can be numbered from one to five, respectively. Once the researchers know how many spaces each variable will occupy, the variables can be assigned to their column numbers. The first few columns are generally devoted to subject identification number.

Storing the Data in the Computer

Once the data are coded, they are ready to be stored in the computer. Input devices may be used for this purpose.

Selection of Appropriate Statistical Techniques and Package

After feeding the data, appropriate statistical techniques are selected. Ready-made statistical packages, e.g., statistical package for social sciences, can be used for analysing the data. Some researchers can develop their own set of programmes for specialized need of their data analysis.

Exception of Programmes

Finally, by executing the selected programmes, the researchers can obtain results of various statistical techniques and analyse data using specific tabular and graphic forms.

Sometimes being the only source, for example, study of the educational policies during the British period in India can be done by analysing government circulars, notifications and acts, and such other documentary evidences related to that period. Records of parliamentary debates of that time can also be of great value.

In surveys, documents like Acts of Parliament, University Acts and Statutes, minutes of the meetings of different committees and decision-making bodies, handbooks, manuals and such other official records can be sources of great value for providing authentic information. Similarly, advertisements, official

letters, newspapers, important press releases, and bank statements are also used as important sources for collecting necessary information.

Personal documents like biographies and autobiographies, letters, diaries and wills of individuals are also important documents, study of which can reveal tremendous information.

Documents are usually in written forms, for example, relevant letters written by Mahatma Gandhi to the British government can provide important information to a researcher on the history of education.

▲ Audio Tapes

Audio tapes can be of great help to a researcher. Recording interviews or discussions and talks on tape is preferred these days. These are convenient and inexpensive, and obviate the necessity of writing during the event. Some-times writing notes during interviews may be disturbing to both the interviewer and the subject. Such recorded portions can be replayed at a later time conveniently. In addition to the recording of words, the tone of the voice and emotional impact of the responses. can also be preserved by the tapes.

▲ Video Tapes

Video tapes can be used for recording important events. They have the advantage of preserving both audio-visual details for more intensive study at a later time. Considerable use of these aids is being made these days to study the athletic events and physical activities and games. Their main advantage is that they permit slow-motion analysis of actions and processes that could not be studied at the normal speed of the same. They can help the researchers in improving the reliability and validity of observations. For example, gestures and movements of teachers in the classroom can be recorded and replayed later for analysis. Video records enable the researchers to travel to inaccessible places and events and help them to study these in greater details.

▲ Photographs

Photographs are quite familiar and highly valuable tools for collecting important information. They can reproduce the reality, and make it to look as much like the original as possible. They can provide rare and rich information even about those persons who are no longer with us. They can help us to bridge both space and time. The additional advantage of photographs is that it is possible to arrest any event or action for studying specific elements and their contexts.

▲ Artefacts

Artefacts are known as simple man-made objects and materials such as print and art-work that provide evidence of ancient culture and practices. Anthropologists have often been using artefacts such as art pieces, household appliances and other materials.

The artefacts that can help an educational researcher may include old textbooks and other instructional materials such as memos, letters, records as well as logs of meetings and activities; demographic information like enrolment, attendance and relevant information about students.

The important activities involved in using artefacts include:

- Locating artefacts
- Identifying the material

- Analysing and classifying material
- Evaluating the information derived from the material

▲ Diagrams

Diagrams include those visuals drawn to represent and identify parts of a whole, a process, a general scheme and/or the flow of results of an action or process. Diagrams have proved particularly effective when used to show processes.

Such graphic representations carry visual messages and communicate visually. Diagrams showing relationship between educational system and sub-systems, organizational structures, administrative set-ups and the processes of communication can provide valuable data/information to a researcher.

▲ Drawings and Paintings

Drawings and paintings represent the life and culture of a particular period. As a source of data, they can provide valuable information to a researcher.

Variety of educational information, i.e., architectural features of institutions, buildings, life styles and costumes can be studied with the help of such sources.

▲ Cognitive Maps

These are the maps or simple line diagrams showing details of the location of the system and their spatial relationship. Such maps are the mental images and include details related to spatial environment. Cognitive maps are not drawn to the scale. Still they provide valuable information about the system, broad locations, inter-relationships, interactions and such other aspects, which can be studied with the help of these maps. Some examples would clarify the concept of cognitive mapping. Arrangement of the armies on the battlefield can be best understood by drawing a cognitive map depicting the position of infantry, tanks and cavalry.

If we undertake a study of interaction within a class, the cognitive map would indicate the position of teacher and students in the class. The interaction between the teacher and the students and between students and students in the class would be shown by arrows.

Activities

- (i) Suggest any four research problems in which techniques of observation can be used.
- (ii) Write four advantages of using interview as a technique of data collection in educational research.

This chapter presents some of the most commonly used tools for data collection, i.e., questionnaire, interview, observation and psychological tests and inventories.

Questionnaire is a fairly reliable tool, widely used for data collection in social sciences research. It is a list of questions sent to a number of persons for their answers and which helps us in getting information. The questionnaires are broadly of two types: structured and unstructured. In structured questionnaire, the questions are prepared in advance, whereas in unstructured questionnaire, the questions are adjusted according to the need of question hour.

Observation may be taken as an accurate watching and recording of the phenomena, which occur in nature with regard to the cause and effect of mutual relations. All of us observe the things, events or happenings around us daily. Curiosity is the root cause of observation. These observations can be controlled or uncontrolled.

In controlled type, the situation is observed under some control measures for accomplishment of our objectives, whereas in uncontrolled observation, the study is made under natural conditions. These can further be classified into participant or non-participant types where either the researcher participates or is actively involved in the phenomenon; or does not take any part, respectively.

The interview may be treated as face-to-face interaction between the investigator and the information. We conduct interview to select the students for a particular course, do classification according to their intelligence and to solve their academic, professional and personal problems.

The interview can be conducted in two ways: structured and unstructured. In structured interview, the number, nature, order of asking, wording of questions and recording of responses are standardized. In unstructured interview, there is greater flexibility in number of questions, method of asking and sequences. The interviewers should be an expert of their subjects and in studying human behaviour. The success of interview heavily depends upon the skills and capability of the interviewers.

Psychological tests have been proved to be of utmost importance in education and psychology. These are being extensively used for guidance, appointments, selection for training, classification, prediction diagnosis and research.

Summary

- In this chapter, we have studied about different tools and techniques, which are used as data-collection devices in qualitative and quantitative researches. A researcher has to select appropriate tools and techniques keeping in mind the nature of the research.
- Use of some modern devices like computers and other audio-visual equipments has also been discussed.
- The researchers may use one or more of these tools in combination for their purpose. As research student they should be familiar with the nature, merits and limitations of these tools and should also attempt to learn how to construct and use them effectively.
- From the instruments and procedures that provide for the collection and analysis of data upon which hypothesis may be tested, the researchers choose the most appropriate.
- The data-gathering devices that have proven useful in educational research include questionnaire, observation, rating scales, interviews, psychological test and inventories scales. Since research investigations use one of these devices, others employ a number of them in combination.
- Students of educational research should make an effort to familiarize themselves with the strengths and limitations of these tools, and should attempt to develop skill in constructing and using them effectively.

Key Words

- *Questionnaire*: A list of questions sent to a group of persons for obtaining informations about the problem under investigation.
- *Interview*: Face-to-face conversational exchange between interviewer and interviewee to gather required information.

- **Observation:** Systematic and scientific viewing of the phenomenon, events or behaviour of the subjects under investigation.
- **Psychological Tests:** Standardized tools to assess various aspects of one's personality and other dimensions.

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Construction and Procedure of Research Tools

10

In a research process the researchers choose the most appropriate instrument and procedures of research tools that provide for the collection and analysis of data upon which hypotheses may be tested. The data-gathering devices that have proved useful in educational research include psychological tests and inventories, questionnaires, opinionnaires, Q methodology, observation, checklists, rating scales, content analysis, interviews, and sociograms. Some research investigations use one of these devices. Others may employ many of them in combination.

In general, construction of all kinds, of evaluation tools with slight differences here and there involves the following activities:

- Planning
- Preparation
- Try-out
- Standardization

▲ Planning the Construction of Tools

At this stage, various decisions are taken and certain activities are completed. But before doing all these it is suggested by Stanley and Hopkins (p. 172) that certain principles should be taken into consideration. These principles of planning are as follows:

- Principle of adequate provision—outcomes of instruction
- Principle of emphasis of the course (approximately)
- Principle of purpose
- Principle of conditions under which the test is administered

The first principle is quite clear. It simply says that the test should be so designed that it measures the most important outcome of instruction or objectives. The second principle says that if the test has to cover a large amount of materials, it would be necessary to determine which part or aspect should receive that weightage in terms of number of items. Proper sampling has to be done. This should reflect relative importance of various components of the course. The third principle explains that the purpose of the test should be made clear and kept in mind. It means clarifying whether test will employ relative, absolute or criterion-related standards of achievement. The validity and reliability of the tests are linked with these purposes. Different methods of providing reliability and validity are used depending upon these purposes. The fourth principle requires that decisions should be taken regarding the number of items to be finally kept in the test, time to be allowed for completing the test, how frequently test will be

administered, what will be the format of the test, what kinds of items will be included in the test, how the responses of the examinees will be recorded, and so on.

Steps of Planning

Planning of a performance test involves the following steps:

- Identifying the learning outcomes
- Defining the outcomes in terms of specific observable behaviours
- Outlining the subject matter content
- Preparing a table of specifications
- Using the table of specifications

Identifying Learning Outcomes

In constructing an objective-type performance test the first order of business is to identify the instructional objectives, which are intended to be measured. This is a difficult job. However, one useful guide is the taxonomy of educational objectives. Learning objectives in other areas such as skills, attitudes and interests are measured by rating scales, checklists, anecdotal records, inventories and similar non-testing procedures. It is only cognitive domain objectives, i.e., knowledge, and intellectual abilities and skills, which can be measured through paper and pencil test. These cognitive objectives of the Bloom's taxonomy are divided into two major areas: (1) knowledge and (2) intellectual abilities and skills. These are further divided into five areas which are as follows:

- Knowledge
 - (i) Knowledge of specifics
 - (ii) knowledge of terms
 - (iii) knowledge of specific facts
 - (iv) knowledge of ways and means of dealing with specifics
 - (v) knowledge of conventions
 - (vi) knowledge of trends and sequences
 - (vii) knowledge of classifications and categories
 - (viii) knowledge of criteria
 - (ix) knowledge of methodology
 - (x) knowledge of the universal and abstractions in a field
 - (xi) knowledge of principles and generalizations
 - (xii) knowledge of theories and structures
- Intellectual abilities and skills
 - (i) Comprehension (understanding the meaning)
 - (a) Translation
 - (b) Interpretation
 - (c) Extrapolation
 - (ii) Application
 - (iii) Analysis
 - (a) Analysis of elements
 - (b) Analysis of relationships
 - (c) Analysis of organizational principles

- (iv) Synthesis
 - (a) Production of a unique communication
 - (b) Production of a plan or proposed set of operations
 - (c) Deviation of a set of abstract relations
- (v) Evaluation
 - (a) Judgments in terms of internal evidence
 - (b) Judgments in terms of external criteria

All these objectives are arranged in order of increasing complexity. Subdivisions within each area are also in order of increasing complexity. The whole structure of objectives is hierarchical in nature. This taxonomy is useful in planning the performance test.

▲ Defining Objectives in Specific Terms

Identifying the learning objectives, defining them in specific behavioural terms which provide evidence that the outcomes have been achieved. For this purpose the objectives are written in sentences, which use action verbs such as 'recognizes' and 'identifies'.

▲ Outlining Subject Matter Content

Taxonomical learning objectives are general and may apply to any topic or area of the subject matter. A performance test is designed to measure these objectives, which cover students' abilities and skills, their mental development, their reactions as well as the knowledge of the subject matter being taught. Therefore, it is essential to identify how much and which aspects of the subject matter will be covered by the test. Only major elements need to be listed.

▲ Preparing a Table of Specifications

Having identified the learning outcomes and outlined the course content a table of specifications is prepared, which relates outcomes and indicates the relative weight to be assigned to each of the areas of the subject matter. The table ensures that the test will measure a representative sample of the learning outcomes and the subject matter content. Table 10.1 roughly illustrates how it is done.

Table 10.1 Specification of course content of learning outcomes

Content	Area-1	Area-2	Area-3	Total No.
Outcomes of items				
Knows terms	2	3	5	10
Knows procedures	4	—	2	6
Understands principles	3	2	2	7
Can apply principles	—	3	2	5
Can analyse facts	2	2	4	8
Total number of items	11	10	15	36

The figures in the cells indicate the number of items (weightage) to be given to each area and the outcome.

▲ Using Table of Specifications

While preparing the performance test, items have to be constructed according to the table of specification. Thus, the table serves as a guide, a blue-print for constructing the test.

▲ Preparing the Test

Some of the most important points to be kept in mind while preparing the test as mentioned by Stanley (1964) are as follows:

- Have more items in the first draft of the test than decided to be kept in the final form
- Most of the items should have 50 per cent difficulty levels
- After a gap of some time make a critical revision of the test
- The items should be arranged in ascending order of difficulty
- A regular sequence in the pattern of correct responses should be avoided
- The direction to the examiners should be as clear, complete and concise as possible

There are a variety of item types, which can be chosen for constructing a performance test, such as completion type, true–false, matching and multiple-choice type. Of all these, multiple-choice type tends to provide the highest quality items. They provide a more adequate measure of learning outcomes than the other items. In addition, they can measure a variety of outcomes ranging from simple to complex. Hence, the following section is devoted to listing a few rules of constructing multiple-choice items.

Rules of Constructing Multiple-choice Items

Following are the important rules:

- Present a single, clearly formulated problem in the stem of the item
- State the stem in simple, clear language
- Avoid repeating the same material over again alternatives
- State the stem in positive form, unless not possible
- If using negative form of stem, underline the negative wording
- Make certain that the intended answer is correct or clearly the best
- Make all alternatives grammatically consistent with the stem and parallel in form
- Avoid verbal clues, which might enable students to select the correct answer or to eliminate an incorrect alternative

Similar to wording in both the stem and the correct answer, stating the correct answer in textbook language or stereotyped phraseology, stating the correct answer in greater detail, including absolute terms (e.g., all, any, never, only) in the distracters, including two responses that are all inclusive and including two responses that have the same meaning should be avoided.

- Avoid use of the alternatives ‘all of the above’, and ‘none of the above’.
- Vary the position of the correct answer in a random manner.
- Control the difficulty of the item by varying the problem either in the stem or by changing the alternative.

(For explanation and examples of these rules consult N. E. Gronlund, *Constructing Achievement Tests*, Prentice-Hall, inc. Englewood Cliffs, NJ, 1968).

Having written out the items, they are arranged and assembled in the form of a complete test. Then, the thus-completed test is reviewed and shortcomings are removed. After this the directions for the examinees are prepared.

The directions should contain information about: (i) the purpose of the test, (ii) time for completing the test, (iii) ways of recording the answers (separate answer sheet or in the text booklet), (iv) instruction for not to guess, and so on.

Thus, the test and instruction prepared, is then reproduced either in the form of photocopy, cyclostyled material or printed material.

Item Analysis

For the purpose of item analysis the preliminary form of the test is administered to a representative sample to the population for which it is meant. Then, it is scored and all the test booklets are arranged in a pile according to the size of the scores serially, the topmost score being at the top.

Purpose of item-analysis: The purpose is to find out how the items and the distractors of the items in the test are working. In other words, to find out which item is good and which is bad so that bad items, which are ineffective may be eliminated and, finally, a test of good items may be constructed.

Bases of item-analysis: The item-analysis is done based on the following:

- Item-difficulty index
- Item validity index
- Effectiveness of the distractors index

These three statistical indices constitute the criteria on the basis of which an item is selected or rejected.

Procedure of item-analysis: There are a number of item-analysis procedures that might be applied. Dowine (1967) presents a detailed discussion of these. But, the most simple, popular and effective procedure is described here and is illustrated by taking an example of 47 test papers arranged serially from top to bottom according to the magnitude of the total scores. Following steps are involved:

By taking approximately one-third of the total from top and one-third from bottom two top and bottom groups are formed and the middle group is set aside. Out of a group of 47, a group of top 15 and another group of bottom 15 are formed. The 17 papers in the middle are set aside.

For each item, number of students in top and bottom groups selecting each alternative is counted and recorded. The results for each item are presented item wise on a sheet of paper as follows:

Item No. I	Alternatives	A	B	C*	D	E	
	Top 15	1	1	6	4	3	
	Bottom	15	2	2	4	3	4
	* = Correct answer						

Such kinds of tables are prepared for all the items. After this item-statistics (difficulty index and validity index) for all the items are calculated as follows:

Item difficulty: This is calculated by applying the formula:

$$\text{Difficulty index} = \frac{\text{Number answering correctly}}{\text{Total number in both groups}} \times 100$$

In the previous example 10 students (6 + 4) from both the groups answered the item correctly out of the total of 30 (total in both groups).

$$\text{So, } Dt = \frac{10}{30} \times \frac{100}{1} = 33.3 \text{ or } 33\%$$

This is the simplest procedure based on the top-bottom groups. This provides a close approximation to the estimate that would be obtained with the total group. The foregoing item has a difficulty level of 33 per cent, which means that out of 100 only 33 students answer the item correctly. The difficulty index is interpreted in such a way that higher the index, easier is the item and lower the index, difficult is the item.

Some people call this as facility index instead of difficulty index. But the meaning is the same.

Validity index: Validity of an item means the extent to which the item measures the same thing, which is measured by the whole test. In a way it is an index of homogeneity of items. This is also known as discrimination index because it is calculated on the basis of discrimination an item makes between the top and the bottom groups. The two groups are formed in such a way that the top group is of high-ability students and the bottom group consists of low-ability students on the trait being measured by the whole test. So, if an item also measures the same trait it must also function in the way the whole test is functioning, i.e., larger number of students in the top group and lesser number in the bottom group must answer it correctly. If so, the item is said to be significantly correlated with the whole test. In other words, if the item significantly discriminates between the two groups, it is said to be valid, and that is its validity index. It is a kind of biserial correlation between the item and the test. It is calculated as follows:

Validity index $= \frac{T - B}{N}$ in which T = total number of students. Reliability coefficient for the whole test is estimated by applying the following formula known as the Spearman-Brown prophesy formula:

$$R = \frac{\frac{1}{2} \cdot \frac{1}{2}}{1 + r_{\frac{1}{2}, \frac{1}{2}}}$$

If the obtained reliability coefficient of the half test is 60, then by the Spearman-Brown formula the reliability (R) of the whole test will be as follows:

$$\frac{2 \times 60}{1 + 60} = \frac{1 \cdot 20}{1 \cdot 60} = .75$$

It may be seen that the increase in the length of the test increases the reliability coefficient of the test.

One great advantage of split-half method of reliability is that the test is administered only once which saves a lot of time and provides greater convenience. But, probably administration is by using Kuder-Richardson formula-21 which runs as

$$R(KR-21) = 1 - \frac{M(K^2M)}{KS^2} \text{ in which}$$

k = Number of items in the test

M = Mean of the test scores

S = Standard deviation of the test scores.

Kuder-Richardson formula provides a conservative estimate of reliability. In other words, it provides a smaller correlation coefficient than other methods. It is also indicative of internal consistency of test scores. It is not appropriate with speeded test like split-half method.

In case of parallel form method of reliability, forms of the test are prepared. These forms are made similar as far as possible with regard to the item statistics, estimated by means and variability of scores judged by observation or computed experimentally. The scores obtained on these two forms administered to the same group simultaneously are correlated, which yields a coefficient known as coefficient of equivalence. In a way, split-half method also yields a coefficient of equivalence between two halves of the test. An extension of this method is coefficient to equivalence and stability. This is calculated by finding out a correlation between the two forms of the same test given at two different points of time with a gap of few days in-between.

Factors affecting reliability: There are several factors, which adversely affect the reliability of a test. Some of them are as follows:

- *Poorly constructed items:* If the items of the test have very low or very high difficulty levels, i.e., if most of the items cluster at the extremes the reliability of the test is decreased. Similarly, if the items have low discrimination indices, the reliability will be adversely affected.
- *Length of the test:* The length of the test also affects its reliability. A short test of very few items cannot be very reliable. Increasing the length of the test increase its reliability also. The application of Spearman–Brown formula has clearly demonstrated this fact. But, a very lengthy test may also affect reliability adversely by way of causing fatigue, monotony and disinterest in the students.
- *Inadequate scoring methods:* These also lower down reliability. If the scoring is subjective as is the case with the essay-type examinations, it affects reliability adversely. Similarly, giving differential weights to some items also reduces reliability.
- *Inadequate time:* If sufficient time is not given to the students to complete the test, this also reduces reliability.

Relation with validity: It is also important to note how reliability is related to validity. A reliable test need not be essentially valid. A 100 per cent reliable test may be invalid or may suffer from poor validity. For being reliable a test need not be valid. But the contrary is not possible. A test cannot be valid unless it is reliable. For validity, reliability is an essential condition. If a test does not measure something reliably, it cannot be valid? If a test fails to measure something with consistency, it cannot purport to measure anything at all.

Thus, when a test is standardized all these facts are taken into account while establishing its reliability.

Validity

A standardized test has a proved validity. Hence, standardization of the test involves calculation of its validity also. Validity of a test means the extent to which a test measures what it purports to measure. If it is a test of performance, then its validity would mean the extent to which it measures the objectives or the outcomes of learning. Hence, validity is calculated by correlating the scores of the test with the scores on the criterion (i.e., the scores on some other measure of performance).

Types of validity: French and Michael (1966), and a committee designated by American Psychological Association, the American Educational Research Association and the National Council on Measurement in Education (1966) have described three types of validities, which is a standard and widely adopted classification system. These three types are as follows:

- Content validity
- Criterion-related validity
- Construct validity

Some writers mention concurrent validity, predictive validity and factorial validity also. But, these can be considered as sub-classifications of criterion-related validity only.

Content validity: Content validity means to what extent the test measures performance objectives identified and stated for the purpose of constructing the test. It is especially important in achievement testing or in constructing a performance test. The main purpose is to know how well the test measures the subject matter content and learning outcomes. It is concerned with the sampling of a specified universe of content. All that is taught cannot be measured in a single test; hence, the test items sample the most critical aspects. But, these should be representative of the whole that has been taught. If not so, the content validity cannot be high or even satisfactory. Thus, the content validity of a test explains whether the items of the test cover sufficiently well the appropriate content. Every subject has a definite structure of knowledge consisting of certain facts, concepts, major understandings, principles, generalizations, and so on. A high content validity test samples all of these in a very judicious manner. If any of this area is not well represented, the validity of the test cannot be considered to be high or satisfactory.

Content validity is not determined statistically. Hence, it has no statistical index. It is determined by inspection of the test items and by relating them to an outline of the subject matter, or by checking them against the table of specifications. Just by inspection the test-maker or the test-user tries to find out the extent to which the content areas of a subject and taxonomic performance behaviours are reflected in the items. If the items are found to be a good match to the content areas and performance objectives the validity of the test maybe estimated to be high.

Criterion-related validity: This kind of validity is a 'sort of relationship of the test with some external criterion.' The criterion may be a future performance or phenomenon or a current phenomenon. If the test is related to a future performance or phenomenon, it is known as *predictive validity*. This is a kind of criterion validity. But, when the test is related to the criterion currently available, it is known as *concurrent validity*.

Criterion validity becomes important when the performance of an individual or a group of individuals on some criterion is to be predicted on the basis of the test under construction. For example, if the test under construction is meant for predicting success of the students in the final examination, the test-maker should establish predictive validity of the test for examination marks or result. Similarly, a test for vocational selection must have high predictive validity for that vocation. In case of selection test predictive validity is a must. Predictive validity is established by correlating the test scores with the indices of success of performance on the criterion (examination marks or indices of vocational success), which are made available in near future.

Concurrent validity is obtained by correlating the test scores with the indices of success or performance on the criterion, which is made available currently at the same time when the test is being constructed. The purpose served by this kind of validity is to have substitute for the test under construction or just to establish that the test under construction measures the same trait, which is measured by another test already constructed and validated. For example, correlating a test of intelligence under construction with the already available test of vocabulary will yield concurrent validity of the intelligence test, which will indicate whether the intelligence test has any relationship with student's acquisition of vocabulary.

Both predictive and concurrent validities are forms of criterion validity with the difference that in case of concurrent validity the criterion is made available at the same time when the test is being constructed, while in case of predictive validity the criterion is made available at any time in future. Both of these are expressed in terms of statistical indices, which are obtained by finding out the correlation between the test scores and the scores on the criterion.

Construct validity: Sometimes, the test under construction intends to measure some trait, which is just a hypothetical entity or quality and not a concrete phenomenon, which cannot be observed directly.

For example, intelligence, aptitude, attitude, and interest are such entities. They can only be indirectly inferred from experimental data or evidence, but cannot be explicitly defined. Hence, when the test-constructors construct such a test (intelligence or attitude test), it becomes necessary for them to collect evidence to show that the test constructed by them really measures intelligence, interest, attitude and so on. This evidence must enable them to say with confidence that the test measures that trait. Establishing this fact means establishing construct validity. Thus, construct validity means the extent to which a test measures the same trait, which it was intended to measure.

It is difficult to establish construct validity of any test as valid criteria are, generally, not available. Constructs are hypothetical qualities, which can only be inferred from certain behaviours. For example, intelligence can only be inferred from student's success in the examination (school marks), teacher's ratings of students, intelligent behaviour and other tests claiming to measure intelligence. But, these criteria are not found to be sufficiently valid. Hence establishing construct validity of a test against less valid criteria creates a problem. And this is a problem *ad infinitum*.

▲ Norms

All test constructors develop norms for the tests they construct. Norms are derived or transformed scores. All, in the same way, convert the raw scores obtained by a large representative sample on the test into standard scores, which are the units of a scale, which is universally understood. Two scales are used for preparing norms: (1) percentile norms and (2) standard scores. Standard scores have a variety of transformations such as sigma (σ) scores, t-scores, T-scores and stanines. They are calculated statistically with the help of mean and standard deviation. Percentile norms are very popular. Norms help in the interpretation of scores. They render the scores obtained by any person or group of persons meaningful.

▲ Characteristics of Standardized Tests

The standardized tests have the following characteristics:

- The standardized tests follow the guidelines and technical recommendations made by American Educational Research Association and National Council on Measurements Used in Education (1955). Hence. These tests are carefully developed tools. Their items are selected after a thorough scrutiny. Experienced experts prepare the items. They are subjected to a vigorous analysis and try-out. These tests items are then analysed on a larger and more representative sample. Systematic studies are made for establishing their reliability, validity and usability. Obviously, they are of better quality and have wider applicability. They are more reliable and valid in general.
- Standardized tests have carefully prepared manual, which describes the instructions of their administration and other details. The instructions are well standardized. They give specific information to the examinees as well as to the test user with the result that the scores obtained on the test can be interpreted uniformly in the same way everywhere and by every one.
- The standardized tests have standardized procedures of recording the examinees' responses and scoring them. This minimizes the variations in the scores and errors creeping in the results.
- The standardized tests have various kinds of norms, which are generally, established, on large samples and for various groups of population. They provide valuable information and great help in interpreting the scores obtained by any single individual or any other group of individuals.
- The scope of applicability and use of standardized test is, generally very wide, both in terms of purposes and populations. They can be used for purposes of survey, selection, guidance, diagnostic

assessment in the classroom, assessment of school programs and instruction, general assessment of student abilities and achievement and for providing a criterion of standardization of other tests being newly developed. They can be used at national and, in some cases, even at international level.

Comparison with teacher-made tests: Although standardized tests are similar to teacher-made or classroom tests in several respects, there are some differences also between them. They are similar in the following respects as described by DeCecco and Crawford (p. 454).

- Both are means of performance assessment
- Both use the same types of test items
- Both require validity, reliability, objectivity and efficiency

The differences between them according to the same authors are:

- The classroom tests may have more content validity because it is constructed with special reference to classroom objectives and subject matter taught in the class. Standardized tests are constructed for common and broad objective and subject matter. They may, for that reason, miss certain immediate classroom objectives and subject matters. Hence, their content validity for classroom use may be lower than that of the teacher-made test.
- The quality of the items of standardized test is superior as compared to that of the teacher-made test. The reason is that specialists construct standardized tests.
- The standardized tests have higher degree of reliability and validity.
- The procedures of test administration and test scoring of standardized tests are carefully described and more adequately standardized as compared to the teacher-made tests.
- The standardized tests have norms, which help in interpreting obtained scores on them meaningfully. Classroom tests, generally, do not have norms.
- All standardized tests have published manual, which is not the case with teacher-made tests.

Tools of Research

After selecting a research design and deciding who will be included in the study, the next step is to identify or develop suitable tool(s) for collection of the desired information. Tools are nothing but the instruments that help the researchers to gather data. Naturally, the type of information you gather depends on the kind of tools you have used for this purpose. The selection of a tool depends upon the objectives and design of the study, and the type of respondents intended to cover. Different types of tools are required for collecting information from illiterate population and young children than from literate and adult respondents. Also, status study (concerned with question 'what') requires different types of tools than process-exploring study (concerned with 'why' and 'how'). Various kinds of tools and tests used in educational research are presented in the following pages. Mainly, the following tools are discussed and described.

- Questionnaire
- Interviews
- Schedule
- Achievement test
- Checklist
- Inventories

Questionnaire

The *Penguin Dictionary of Psychology* defines a questionnaire as a series of questions dealing with some psychological, social, educational topic or topics sent or given to a group of individuals with the objective of obtaining data with regard to some problem; sometimes employed for diagnostic purposes or for assessing personality traits. One type of questionnaire is concerned not with what the individuals can do, but with what they have done in the past or do habitually, what opinions they hold, what are their likes and dislikes, what are their fears or hopes and what kinds of persons they think they are. Another type is more objective seeking to obtain factual information about individuals, educational practices, statistics about pupils and so on. Responses to questionnaire may be verbal or numerical and they may or may not be amenable to statistical analysis.

The questionnaire as an instrument of research has been very much criticized in the past since Horace Mann first designed it in 1847. In spite of its abuses and weaknesses, the National Education Association (NEA), however, said as a result of a study in 1930 that the questionnaire as a tool of research could not be condemned outright although there is a lot of scope for drastic improvement. Today its weaknesses and limitations as well as its strengths are well recognized and a more serious attempt is made to improve its quality and to limit its use to situations where it is most appropriate. A questionnaire, undoubtedly, has certain advantages in social science research. One major advantage is that it permits wide coverage for a minimum expense of money and effort. It reaches persons who are difficult to contact otherwise. Because of its impersonality it elicits more candid and objective replies. It allows greater uniformity in the manner in which the questions are posed and thus ensures greater comparability in the answers. The advantage of the questionnaire is undoubtedly the problem of non-returns, which decreases the size of the sample. This, however, is relatively unimportant wherever the sample is large. Possibility of misinterpretation of the questions is also a great disadvantage of the questionnaire. But, constructing questions carefully and making them clear and unambiguous can minimize this. While constructing a questionnaire all these advantages and disadvantages should be kept in mind.

Construction of Questionnaire

The first step in the construction of an adequate questionnaire is to have a full and clear understanding of the objective of the study and the nature of the data needed.

The questionnaire should be neither too short nor too long. It can never be of infinite length. Stating the problem and then, objective more clearly and relating each question to the purpose may help in avoiding unnecessary and irrelevant questions. Each question must be justified on the basis of its contribution to the overall purpose of the study.

The questionnaire once prepared should be revised again and again on the basis of more discussion with experts, extensive reading, pilot study and so on.

The use of a five-point rating scale elicits more valid responses and is less frustrating to the respondent who wants to be truthful.

Questions which are emotionally toned, too broad, vague, 'difficult in vocabulary', unnecessary, out of frame of reference and having more than one idea in one should be avoided.

Leading questions—These types of questions suggest the respondents to answer in a specific manner. For example, if I ask 'Whether teacher X still abuses students in the class?', it suggests that teacher X behaves in that way with students. If you rephrase this question like 'how does teacher X behave with students in the class?', this is a neutral question and the respondents may answer this question either way.

Double-meaning questions—The questions should not be stated in a manner that they convey different meanings to different persons.

Items should not contain hidden assumptions, for example, asking someone ‘when did you stop beating children?’ may indicate that you used to beat the children earlier.

Social desirability (‘faking good’): It is said that man is a social animal. We all want to create a positive impression about ourselves in the society and make a conscious effort to conceal the negative aspects of our personality. This tendency is also reflected while answering questions in a questionnaire. Consider the following questions.

1. Don't you abuse children?	Yes/No
2. Should primary school children be subjected to corporal punishment	Yes/No
3. Do you help the needy?	Yes/No

The answers to these questions in all probability will be ‘yes’ because answering them negatively will create a poor impression of the respondent in the society. So, attempts should be made to avoid socially desirable type of questions or they should be worded carefully.

Format of Questions

Generally, two types of questions are used in a questionnaire; open ended and closed end. The type of questions the teacher sets for the annual examination such as ‘answer only five questions’ (out of 10 in 3 h time period) are known as opened-ended questions. With open-ended formats the respondents may write whatever they want, which may cover three, five, or eight pages. Their answers may or may not be related to the question; they may describe something at a superficial level or may analyse in great depth and so on. In short, the respondents are free to answer the questions the way they wish to. The coding of these types of responses is not easy and coding errors may occur in the data set. A particular response may have positive or negative effects on the researcher and the coding will be affected accordingly. However, these types of questions provide an opportunity to assess the depth of knowledge of the students on a particular topic.

The closed-end formats require the researchers to have a reasonable idea of the likely responses to the question in advance and specify those responses in the questionnaire. The common response formats in case of closed-end question are: Yes/No, True/False, multiple choice and rating scales. In case of rating scales, the respondents are asked to indicate their views on a 3 points (agree, undecided, disagree), 5 points (strongly agree, agree, undecided, disagree, strongly disagree), 7 points, 9 points or 11 points scale. In some cases, the students are asked to rank a number of items in order of priority. For example, you list 10 things (may be fruits) and the students will order them according to their liking or disliking for a particular fruit. Rank I generally indicates high liking.

Validity of Questionnaires

It is difficult to establish the validity of a questionnaire as a whole because it consists of specific and relatively independent questions, each dealing with a specific aspect of the overall situation. Mouly (1964: 252) holds a view that instead of the validity of the total instrument it is the validity of the individual items, which should be considered more important. However, this does not mean that the unity and validity of the whole questionnaire should be ignored. These should, essentially, be considered with respect to the topic under investigation, the actual validation of any other instrument of tests and measurement. In case of a questionnaire, however, face validity is considered most important. Adequate coverage of the topic, clear and unambiguous questions, checking of obtained responses against an external criterion may contribute significantly to the validity of a questionnaire. Interviews with a small sample of respondents may serve as criteria against which validity of a questionnaire may be established.

Reliability of Questionnaires

Usual procedures of calculating the reliability of questionnaire are often ignored, because it is difficult to establish and apply in this case. Split-half reliability is, of course, out of the question. According to Mouly (p. 254), the reason given is that the items of the questionnaire are relatively independent and not additive. This is true in case of a questionnaire, which elicits different kinds of information. But, in case of questionnaires such as the Job satisfaction Questionnaire and Teacher Effectiveness Questionnaire, which elicit information about a single unitary trait, split-half reliability may be calculated. However, test-retest method is considered to be the most feasible approach to the establishment of the reliability of the questionnaire.

Checklist for Evaluating Questionnaires

According to Mouly (1964: 263), the quality of a questionnaire can be improved by the following:

- It should deal with a significant topic.
 - The importance of the problem should be clearly stated in the statement of the problem and in the covering letter.
 - It should seek information not available elsewhere.
 - It should be as brief as possible.
 - The directions should be clear, complete and acceptable.
 - The questions should be objective and relatively free from ambiguity and other invalidating features.
 - Embarrassing questions should be avoided.
- Some more suggestions are given in the following sections.

Type of Information Gathered Through Questionnaires

A questionnaire can be used for collecting following types of information in research.

- *Background and demographic information:* A questionnaire may be used to collect information about the respondents' age, sex, education, SES, birth order, details of family, nationality/ethnicity, religious involvements and so on.
- *Behavioural reports:* Questionnaires are used for eliciting information about past behaviour of the respondents. In such cases it is assumed that respondents have accurate memory of past events, which may not be true. Also, many of the respondents may not be willing to report such events. Sensitive and socially desirable behaviours are often misrepresented.
- *Attitudes and opinions:* The questionnaires are most frequently used to know the attitudes and opinions of the individuals. The common procedure is to present a statement and ask people to rate on a scale (usually a 3, 5, 7, 9 or 11 point scale) that to what extent they agree or disagree with a statement. An alternative of rating scale, the forced-choice design, is also used where two opposing statements are presented and the respondents are asked to choose one out of two.
- *Knowledge:* Questionnaires are also used to test the knowledge of respondent on a particular topic.
- Questionnaires are used to gather information about the expectations and aspirations of the individuals.

Questionnaire Layout

This section is concerned with the presentation of questions in the questionnaire to gather better quality data and ensure higher response rate. It may be remembered that the questionnaire is given to the respondents to fill the necessary information. If the questions are not presented in an attractive manner in the questionnaire, there may not be enough motivation for the respondents to fill the questionnaire. There are certain guidelines of preparing the questionnaires, some of which are mentioned below.

Explanatory note: The questionnaire should be given with certain notes, which are self-explanatory in nature to foster respondents' motivation. This should include broad aim of the study and why are you asking the respondents' to fill up the questionnaire. The notes should be written in a manner such that the individuals are encouraged and feel that the researchers will value their responses and treat the responses with respect.

Length of the questionnaire: What should be the length of the questionnaire? How many questions the researchers would like to keep in their questionnaires is a difficult question to answer. There is no hard and fast rule. It depends upon the topic under investigation, age of the subjects and method of distribution (e.g., sending the questionnaire by post or delivering it personally). However, the questionnaire should not be too long that the students get tired or bored. On the other hand very short questionnaires are not taken seriously. Roughly, a questionnaire should not take more than 45 min.

Question order: What should be the order of questions in a questionnaire? Generally, the questions are arranged from easy to difficult order. The first few questions are made such that no respondent has any difficulty in answering those questions. Generally, questions related to age, sex, educational background and monthly income are kept at the beginning. This also develops confidence in the researcher to handle the questions that are placed later on in the questionnaire. It is rare to place extremely sensitive questions right at the beginning. People need time to get accustomed to the type of issues you are interested in. Slowly, the difficulty level of the questions is increased.

Question density: What should be the spread of questions on a particular page? In this computer age, by varying the size of the letters many questions can be printed on one page and thus the questionnaire may look short. It is a different issue whether the students will be able to read the questions. This exercise is undesirable and counter-productive. Clear and self-evident layout will enhance the possibility of getting valid information from the sample.

Interview Method

In general, the term 'interview' refers to an activity where an individual, who is called an interviewee, is asked a few specific questions by an individual, who is called an interviewer. What is to be highlighted in an interview situation is that an interview is a purposeful activity conducted for understanding the opinions and views of the interviewee by the interviewer for some specific purposes. This has a specific significance in educational research.

Interview as a Tool

It refers to an interview schedule, which has a series of questions/issues that serves as the focus for eliciting responses by the interviewer. These schedules are classified as follows:

- Structured
- Semi-structured
- Unstructured

A structured interview schedule is one where the items of the schedule are written in clear terms and in a particular order. The respondents are asked to answer all the items of the schedule in the same order without any change. It is a highly rigid format. These schedules can be debated for their advantages and disadvantages.

A semi-structured interview schedule is one where the items are not structured rigidly and the interviewers have the freedom of altering and adding questions or rearranging the items depending upon the nature of responses they are getting.

An unstructured interview schedule is one where a broad framework is vaguely worked out and the interviewers have all the freedom of questioning the interviewee deep as the situation demands. This is used by the specialists (particularly in qualitative research) who are willing to probe very deep into issues and opinions.

Participants in Interview Situations

The participants in different interview situations may vary. There may be the following combinations in an interview situation.

Individual to individual: This is a situation where one interviewer interviews one interviewee. It is a one-to-one situation.

Individual to group: This is a situation where one interviewer interviews a group of interviewees. For example, panel discussions even on televisions.

Group to individual: This is a situation where a group of interviewers interview an interviewee. For example, selection committee interviews.

Group to group: This is a situation where a group of interviewers interviews another group. For example, parent-teacher meeting. Such situations are also seen in certain TV interviews.

All the interview situations explained here can be used in research situations depending upon the requirement of research studies.

Functions of Interviews

Interviews serve some specific functions according to the demand of the situation. They may be broadly classified as follows:

- Social
- Diagnostic/clinical
- Research

The interview serves social purpose in the sense that it can cover various social issues, which may be found in a society. Most of the newspaper interviews belong to this category.

This interview serves diagnostic purposes when it is conducted for clinical purposes. This may be used in a hospital/clinical situation, a paramedical situation, a school situation where a counsellor is trying to understand the problems of students or any other situation where diagnostic purpose is being served with remediation in view. All the information elicited will serve the purpose of remediation.

Research purpose is also fulfilled by interviews as a lot of information is elicited as a part of the qualitative information, which is normally used in those researches where ethnographic methods are used in which participant observation is used chiefly apart from interviews.

Preparation for Interview in Research

Planning and preparation for interview in educational research assumes significance and that needs to be understood carefully. Certain steps to be followed in planning and preparation of interview schedule are as follows.

Define and profile clientele to be interviewed: It is very important to define who are the people need to be interviewed. It is also necessary to have background information about the people who are going to be interviewed.

Work out the participant composition of the interview: As discussed earlier, the participant composition may be one to one, one to group, group to one or group to group. This also needs to be planned in advance so that in different situations, different strategies may be adopted. This requires a careful planning.

List out the materials required along with the interview schedule: Depending upon the dimensions, participants and modes, certain materials that are required to be used in interview need to be listed out. This can also prompt the researchers in planning the kind of questions that are to be asked and recording the responses.

Identify different items of the interview schedule: Based on the already identified domains, various items of the interview need to be identified. For example, the length of questions, precision, language used, shifting from one set of issues to another and beginning and ending anchor items need to be carefully planned.

Further, planning items for structured, semi-structured and unstructured interviews will differ for obvious reasons. That needs to be understood.

Prepare the proposal for execution, recording and analyzing the responses: Equally important is planning for execution, recording and analysis of responses.

Once planning is over, the interview schedule is ready for use. Let us know how an interview can be successfully executed.

Execution of an Interview

The following tips will facilitate a researcher in executing the interview smoothly.

- Try to develop rapport with the respondents and put them at ease so that the respondents speak freely.
- Once you are sure that the respondents are ready for the interview, start with anchor questions smoothly in such a way that the respondents must feel that the real interview has already begun.
- Listen patiently to all their opinions and enable the respondents to be as natural as they can.
- Show keenness towards the views expressed and try to get the most out of every question.
- Keep the direction of the interview in your hand and avoid irrelevant conversation, and try to keep the respondents on track.
- Do not jump from one question to the other unless the earlier question is answered fully to the satisfaction of the respondents.
- Let our response recording mechanism not come in the way of the respondent responding the questions.
- Repeat the question slowly and clearly in case the respondents have not understood it properly.
- Keep your pace, pause and intonation at par with the respondents' abilities. If not, the whole purpose may get defeated.

Recording and Reporting of Responses

In the present-day society, use of electronic equipments has arrived as a boon. Probably, the simplest thing one can do is to record the responses using a tape recorder. If one does not have that facility, one can manually record the responses, may be with the help of another person. But it must be noted that no activity must affect the attention and tempo of the respondent.

▲ Schedule Method

There are several methods of data collection and approaching informants with a view to obtaining their viewpoint on a social problem and finding its solution. Schedule method is one of the most important methods for the study of social problems. This is close to questionnaire method in many respects, but major difference between the two is that in questionnaire method an investigator assists the respondents in filling the questionnaires, whereas in schedule method an investigator assists the informants and gives them necessary clarifications as and when required. Two methods, in many respects, are different in so far as collection of data is concerned.

What is a schedule? A schedule is like a questionnaire, which contains a set of questions. These questions are required to be replied by the respondents with the help of an investigator. According to Thomas Carson Macormic, 'the schedule is nothing, more than a list of questions which it seems necessary to test the hypothesis and hypotheses'. Goode and Hatt have said that, 'schedule is the name usually applied to a set of questions which are asked and filled in by the investigator in a face to face situation with another person'. As per G.A. Lundberg, 'the schedule is device for isolating one element at a time thus intensifying our observation'. C.A. Moser has defined questionnaire that, 'since it is handled by investigator it can be fairly formal document in which efficiency of field handling rather than attractiveness is the major operative consideration in design'. Then we come to a definition of schedule given by Bogardus who says that, 'A schedule is a form of abbreviated questions which interviewer help with himself and fills out as he proceeds with his enquiry'.

From all these definitions it becomes clear that a schedule is a list of questions formulated and presented with a specific purpose of testing an assumption of hypothesis. Since in the schedule method an interviewer is always present and can also provide stimuli, the success of schedule is linked with ability and performance of the interviewer. Similarly, since questions are asked and replies are noted, the depth to which a problem is posed depends on the interviewer who carries the schedule. A schedule is thus a formal document for maintaining uniformity in question and it is not always essential that it must be beautifully printed on an attractive paper.

Aims and purposes of schedule: Whether it is a questionnaire or schedule method, obviously the main aim is to collect data for a research project in an objective manner. Since the investigators put the questions and the informants give replies, all these cannot be memorized. A schedule helps in recording what cannot be memorized. Since all the information are available in writing, tabulation and analysis of the data collected becomes easy, because the information to be analysed is available on the schedule. Another purpose of schedule is that it delimits and specifies the object of enquiry because in this method questions are asked about a specific subject and information is collected about that alone.

Types of schedules: Although schedules are of different types, the aim is to collect data. Types of schedules are as follows:

Observation schedule: This is a type of schedule in which questions are put on a specific topic about which investigators want to collect data and information. The questions are absolutely pointed ones and the investigators collect information as well as simultaneously observe the reactions of the respondents?

On the basis of these observations, if necessary, they also put certain additional questions to clarify the position. In this case, the respondents can be individual or group of individuals and schedule is filled under certain specific conditions. Many a time, this method is adopted to verify the information already collected.

Rating schedule: In social research, rating schedules are used when information is to be collected about attitudes, opinions, preferences, inhibitions and other similar elements and their values are to be assessed and value of each is required to be measured. These prove very useful when factors that are responsible for measuring a phenomenon are to be measured. Different scales of measurement are to be constructed for evaluation.

Document schedule: In this, whole study is based on certain schedules, e.g., studies which deal with the writing of history and so on. With the help of these documents certain questions are asked about the life history of a person and on the basis of replies received efforts are made to construct life history. It is felt that more than the required material should be collected so that some materials can be kept in reserve for future use. In this quite a large number of relevant records are consulted. In this type of schedule, those terms are used, which frequently occur in the documents, otherwise some confusion may arise. The documents, which are frequently consulted include autobiographies, diaries, case histories and government records.

Institutional survey schedule: In every society there are some specialized institutions and agencies. These schedules are used for collecting information about them. The nature and complexity of the institution decides the size of the schedule. Obviously, more complex the working of the institution, more bulky will be the size of the schedule. This schedule is also helpful in studying both traditional and immediate problems of an institution.

Interview schedule: This is used for testing and collecting data and also for the collection of supplementary data. The informants take the schedule with them and interview the respondent and fill in the forms. Usually in this method certain standardized questions are asked by the interviewer.

Characteristics of good schedule: Every schedule cannot be a good one and for a good schedule it is desirable that it should possess certain qualities. These are the following.

Accurate communication: From accurate communication we mean that the questions in the schedule should be so worded that there is no gap in what is asked by the investigator and what is understood by the respondent. If the respondent understands exactly what is being asked by the investigator, then we can say that there is accurate communication. It is, therefore, most desirable that the questions being asked should be very clear and not ambiguous. These should be very short and precise so that respondents do not take a very long time in understanding them. The questions should be closely inter-linked with each other and it should appear that whole information is being sought in a rational manner and that one question is following by the other in a natural sequence. It is very desirable that all the questions should be worded and put in such a way that the respondents feel attracted to give their suggestions.

No question should be included in the schedule, which has no direct bearing with the subject matter under study. Accordingly it is essential that before pulling the questions in the schedule, whole literature dealing with the subject matter should be clearly and carefully studied. It is also desirable that those persons who are experts on the subject should be consulted and their views obtained. Before finalizing the schedule the investigators may prepare a list of primary and secondary effects and also a list of tertiary effects, and should approach the affected persons in that order.

In order to get accurate response it is better to prepare the schedule in a scientific way and also in a way that the respondents feel inspired to give correct information. The questions should not be of such a nature that while replying the respondents get bored. Similarly informants will not like to give reply to a question, which injures their feelings. In fact, after such a question has been put to them, they will

decline to cooperate with the investigators and refuse to respond to remaining part of the schedule and questions contained in that. A very conscious approach in this regard should, therefore, be adopted.

The investigators should not put such questions in which there is element of subjectivity because the people dislike both subjective questions and evaluation, more particularly when the informants are fully aware that they are under no obligation to answer the questions being put to them by the investigators.

If at all the respondents decide to respond to the questions, they will be interested in replying to such questions, which are directly connected with the study. They may resent replying to such question with which the study is not directly linked. They may even decline replying such questions and can become repulsive also. Such questions should only be put when it is seen that additional information being called for is necessary and that the informants are in a mood to cooperate and respond.

Although, all sorts of questions can be put in a schedule, select only those that are essential and proper, which can be analysed and subjected to statistical tests. In case tabulation of questions is not possible, then there is no use in collecting information on such questions.

In order to have some checks and counter-checks, as well as to have in-depth information, it is better to sub-divide each question so that the informants do not feel bore while replying and their faults and faltering can also be checked.

In a schedule, idiomatic, technical, ambiguous, indefinite-imaginative and private terms should be avoided because it is usually difficult for the investigators to clarify these and much of subjectivity gets introduced in the replies, which are recorded. When the same terms are differently understood both by the respondents as well as the investigators then the reply will become unreliable and undependable and the whole study will become a futile attempt.

No questions should be included and asked, which develops a sense of shame in the respondents, on which they are dependent for replying or on which they have no information and it is expected of them to go and collect information from others.

While collecting information investigators should always leave an impression that they are enjoying responses and being benefited by the impression being provided by them, no matter whether they are actually enjoying the responses or not.

The investigators should never try to impose themselves on the respondents and never forget that the latter is under no obligation to respond to their question. Therefore, they should never behave arrogantly and at no stage suffer from superiority complex.

The investigators should allow their respondents to respond to questions without any intervention from them. They should intervene when their help is needed or when some stimuli is needed.

Need for pre-testing: As in the case of questionnaire, it is essential that the whole schedule should be pre-tested. For this, a sample should be picked out of the universe and tested. Needless to say that this sample should be a representative. Once the defects of the questions in the schedule have come to light these should be removed and questions should be modified based on this. It should, however, not be taken for granted that modified schedule is perfect in all respects and ready for use. This should again be used on representative sample and the process should be repeated till it is clear that there is communication accuracy and the informant understands the question in the same sense in which investigator is putting that.

Of course, in a schedule method the investigators' aid is available to informant, but the latter may not need the help of the former and may like to respond to the questions without investigators' help. But all the more it is essential and also convenient that in the schedule good paper should be used. Its size should not be unwieldy. There should not be too many folds. There should be sufficient space for noting down all the information that is provided by the informant. There should also be good space for making additional notes about what the investigators observe during the course of discussions with their

respondents. As in the case of questionnaire it will always be better if the investigators do not take more than half an hour with the respondents in finishing their work. There should be sufficient marginal space. In between the two questions there should be sufficient space, so that the information supplied does not get mixed up. It is always better if the schedule is got printed instead of getting it typed or cyclostyled, because a printed schedule always attracts the respondents and also increases reliability of the study.

If the study is to be carried out in an area where the people are not highly qualified, there is no harm if pictures are also used in the schedule. In fact, in many cases use of pictures attracts people and they feel tempted to reply to the questions with eagerness. The use of pictures in some cases also helps in understanding even complex problems quickly and promptly.

Organizations of schedule: A schedule should be organized in three broad categories: (1) prefatory, (2) main schedule, and (3) direction to field workers. In so far as part I, namely prefatory, is concerned it should include the name of the survey and surveyor with their full address, name of the sponsoring agency, reference number, name of the respondents along with their age, sex, education, profession and address.

Second part should cover the title, sub-title and columns of each question.

Third part of the schedule should give clear instructions to the field workers. It should include as to what is to be covered and what is not to be covered. Similarly, it should state as to what is meant by each term included in the questions. Other relevant instructions are to be clearly given so that element of subjectivity and arbitration is removed to a considerable extent?

Difference between schedule and questionnaire: There is difference between a schedule and a questionnaire. The basic difference is that a questionnaire is mailed and there is no investigator to help the informant in filling the same, i.e., questions included in the questionnaire, whereas in the case of a schedule the investigators personally take the questionnaire with them to their respondents. They put the questions and fill the replies themselves. Wherever necessary they also helps the respondents in filling the questionnaire and provide necessary clarifications if needed. In the case of schedule the investigators also provide stimulus to the respondents which is not the case with a questionnaire. These are only a few differences. There are many other points of differences between the two. Some of these are as follows:

Direct method of collecting data: In the questionnaire, investigators do not go to the field. They mail the questionnaire and get the replies while sitting at home. Thus, they may or may not visit the field at all. In this way questionnaire is an indirect method of collecting data. On the other hand, in a schedule the investigators go to the field. They meet their informants, put questions to them and personally help them in filling up the questionnaire and so on. Thus, it is a direct method of data collection.

Difference in nature of study: In questionnaire method all such studies can be undertaken in which vast area is to be covered and the nature of information does not require going deep into the issue. It is because questionnaires are to be mailed and mailing can be done in any part of the world. On the other hand, this is not possible in the case of a schedule because the investigators are required personally to go and get the desired information collected. They can, therefore, cover a small area, but being personally present in the field can seek in-depth information from their respondents.

Importance of covering letter: As against schedule, in a questionnaire, covering letter plays an important role. Since the investigators are not present before the respondent and the former cannot seek any clarification from the latter, they have to get every information from the covering letter, i.e., why the information is being collected, who is seeking and at whose instance and so on. In fact, who, why and what are to be covered in the covering letter. Even each word in the covering letter, directly or indirectly, positively or negatively affects the attitude and behaviour of the respondents.

On the other hand, covering letter does not have that much significance in so far as schedule is concerned because the investigators are present to clarify every point that is raised by the informant. In some cases, they may not even like to spend their time in reading what is written in a covering letter.

Difference in reliability of information: Obviously, information collected through schedule method is more important than the one collected through questionnaire. It is because in the former case the investigators themselves go to the field and clarify all doubts. They know it fully well that the information which they have recorded is first hand and unbiased and as such is most reliable. On the other hand, in the case of questionnaire, the investigators have to depend on the information sent to them. They do not know whether that is right or wrong. Hence, it is less reliable. In questionnaire method, there is no method to verify whether the information supplied by the respondents are right or wrong, whereas in schedule method it is possible. Similarly, if anything is left out in the case of questionnaire, it is difficult to get that completed without loss of time. In the case of schedule, it is, however, possible to get the incomplete information completed.

Difference in format: In the case of questionnaire format counts a lot. It is well known that if the paper used is good, printing is attractive, spacing is proper, there are not many folding, handling is convenient, ink does not spread on the paper and the letter requesting for sending of information is appealing, then there is every possibility of respondents replying soon. On the other hand, in the case of schedule, although all these things count, yet not to that extent, because the respondents themselves are to use the schedule and if that is not as good as in appearance as the questionnaire, to some extent even that can be tolerated.

Gap between investigator and respondent: In the case of schedule there is no wide gap between the investigator and the respondent, because they are face to face with each other. They help each other in filling up replies to the questions and clear each other's doubts. On the other hand, in the case of questionnaire method there is a wide gap between the investigator and the respondent. It is because they have not met each other and there is every possibility that throughout the study they even may not meet at all. Of course, this helps the study as a whole.

Difference in mortality rate: Usually, mortality rate is very high in questionnaire method. The respondents, due to various reasons, do not feel tempted to return the questionnaires in spite of several reminders. Even if the replies are received, in many cases it is found that either the answers have not been given in the proper way or many questions have been left unreplied. Some times, the respondents do not reply to such questions in which they are not interested or which according to them require time or labour that are too close to their personal life. There being no method of persuasion the investigators have to satisfy themselves with the information, which they receive. In many cases mortality rate is as high 70 per cent, which practically frustrates the purpose of mailing questionnaire.

But the position is different in the case of schedule method. The investigators take the schedule themselves, collect information, persuade the informants to reply to even such questions in which they are not directly interested and carry all the information with them. Mortality rate in this case is very low and arises only when the respondents are not available, not cooperative or not inclined to give information due to various other reasons about questions put to them.

Difference in coverage: In so far as schedule method is concerned even such persons who have no high standard of education can be covered, because investigators are present to give all clarifications. Moreover, in schedule method the questions are not very complex. But in questionnaire method only such persons can be covered who have obtained a particular standard of education and can well answer the questions without the help of any investigator.

Difference in obligation: In questionnaire method, the respondents are not under any obligation to answer the questions. They may or may not return the questionnaire sent to them. Moreover, they are also free to write whatever they like and can reply even confidential questions with confidence because nobody is present right before them. On the other hand, in so far as schedule method is concerned the respondents are under obligation to reply because the investigators are right before them to fill

the schedule. In their presence the respondents may be hesitant to some extent while replying to such questions. Thus, they may not frankly come out with their views.

Difference in use in sampling method: Schedule method can easily and safely be used in sampling method of research. Whoever is covered in sample is under obligation to reply because of the presence of the investigators. Moreover, the replies received are also complete. On the other hand, sampling method may or may not be successful in questionnaire method because questionnaires mailed may not come back and even if received back the replies may be incomplete or vague.

Problem of rapport: In schedule method, there is serious problem of rapport. If somehow investigators are in a position to establish rapport with the respondents they shall not be in a position to get information from them and their project will not react to its logical conclusions. But in questionnaire method, there is no importance for rapport because the investigators and respondents are not facing each other.

Rating Scale

Rating scale refers to a scale with a set of points, which describe various dimensions of an attribute being observed. It ascertains the degree, intensity or frequency of a variable. To construct such a scale, the investigators have to identify the factors to be measured, place unit or categories on a scale to differentiate varying degree of that factor and describe these units in some manner.

No established rule governs the number of units that should be placed on a scale, but having too many categories tends to produce crude measure that have little meaning and having too many categories makes it difficult for the rater to discriminate between one step and the next on the scale.

Rating means the judgment of one person by another.

In the word of Barr, Davis and Johnson (1953), 'rating is a term applied to the expression of opinion or judgement regarding some situation, object or character (person)'. These opinions are usually expressed on a scale or by categories of values, either quantitatively or qualitatively.

The rating scale procedures are the most popular, widely used and easy to administer among all research procedures that depend upon human judgement. They are used in the evaluation of individuals, their reactions and in the psychological evaluation of stimuli. They may be used to describe the behaviour of individuals, the activities of an entire group, the changes in the situation surrounding them, or many other types of data. They are also used to record quantified observations of a social situation. A number of rating techniques have been developed, which help the observers to ascribe numerical values or ratings to their judgements of behaviour. There are seven types of rating scales:

- Descriptive rating
- Percentage of group scale
- Numerical scales
- Graphic scales
- Standard scales
- Rating by cumulative points
- Forced choice ratings

Construction of Rating Scales

Main steps for construction of rating scales are as follows:

- The knowledge of general rules.

- The judges who will do the ratings.
- The phenomenon to be rated.
- The continuum along which they will be rated, i.e., the type of rating scale.

The researcher after considering these steps will decide the type of rating scale. The scale may take any number of different forms; it may be simply a series of numbers, a graduated line, quantitative terms such as good and poor, a series of named attributes peculiar to each scale or a series of carefully worded descriptions of statements representing different degrees of each aspect to be rated.

The procedure may consist of statements which describe various forms of individual's behaviour, such as talkativeness, accurate but very deliberate, works well without supervision and so on. Sometimes, specimens of work, i.e., handwriting representing various levels of merit, for example, may be placed on a continuum according to values determined by a jury.

General Rules

There are certain main points, which an investigator or researcher should keep in view while constructing a rating scale.

A trait to be rated should be given a trait name and definition. Guilford (1954) has suggested the following rules for defining and describing the trait:

- Traits should be described univocally, objectively and specifically.
- Each trait should refer to a single type of activity.
- A trait that is to be rated should not be a composite of a number of traits that vary independently.
- Traits should be grouped according to the accuracy with which they can be rated.
- In describing traits, avoid the use of general terms such as 'very', 'extreme', 'average' or 'excellent'.
- Finally, do not use scales for traits.

A rating scale should make use of good 'cues'. Guilford (1954) on the basis of a study of cues by Chambney (1941) has listed six requirements for good cues:

- *Clarity*: Use of short statements, in simple and unambiguous terminology.
- *Relevance*: The cue should be consistent with trait name and its definition as well as with other cues.
- *Precision*: A good cue applies to a point or a very short range on the continuum. There should be no doubt about its position among other cues and if possible it should not overlap them in quantitative meaning.
- *Variety*: The use of the same terms in all or many of the cues may fail to differentiate them sufficiently. Vary the language used at different scale levels.
- *Objectivity*: Cues with implications of good or bad, worthy or unworthy, desirable or undesirable should generally be avoided.
- *Uniqueness*: The cues for each trait should be unique to that trait. Avoid using cues of a very general character such as 'excellent', 'superior', 'average', 'poor' and the like.

There are no hard and fast rules concerning the number of steps or scale divisions to be used in a rating scale. In general, five to seven point scales are seen to serve adequately. With willing, motivated, serious and cooperative raters, much finer divisions of the scales prove profitable.

Types of Rating Scales

The following are the different types of rating scales.

Descriptive Rating

In descriptive rating, the raters put a check () in the blank before the characteristic or trait is described in a phrase. In order to judge the pupil's initiative, for example, the rater may be asked to tick mark the most befitting description out of the following:

- Shows marked originality
- Willing to take initiative
- Quite inventive
- On the whole unenterprising.
- Very dependent on others.

Percentage of Group Scales

Here, the rater is asked to give the percentage of the group that possesses the trait on which the individual is rated, for example, for rating the honesty of an individual, the rater may check one of the following:

- Falls in the top 1 per cent
- Falls in the top 10 per cent but not in the top 1 per cent
- Falls in the top 25 per cent but not in the top 10 per cent
- Falls in the top 50 per cent but not in the top 25 per cent
- Falls in the lower half, but not in the bottom 25 per cent
- Falls in the bottom 25 per cent but not in the bottom 10 per cent
- Falls in the bottom 10 per cent but not in the bottom 1 per cent
- Falls in the bottom 1 per cent

Numerical Scales

In a numerical scale, numbers are assigned to each trait. Here, a sequence of defined numbers is supplied to the rater. The rater assigns to each stimulus, to be rated, an appropriate number in the line with these definitions or descriptions. One example of such a scale while rating performance of colour combinations in pictures is as follows:

- Extremely pleasant
- Moderately pleasant
- Mildly pleasant
- Indifferent
- Mildly unpleasant
- Moderately unpleasant
- Extremely unpleasant

In this type of rating it has been seen that rater usually avoids terminal categories. Here, the rater would tend to avoid categories 1 and 7, thus range of ratings gets shortened. To avoid this shortcoming it is suggested to expand the scale beyond the categories, which the researchers want to include in the scale. If the researchers want an effective scale of five points, they may make use of additional two categories so that the desired dispersions of five-point rating is achieved. Hence, they should have seven-point scale for effective five-point scale.

In some numerical scales, the raters are not provided with numbers, which they have to use in making judgements. They have to report in terms of descriptive cues and then the researchers assign numbers to them. For example, while rating performance in a drama, the cues may be the following: Extremely poor, very poor, poor, average, good, very good and extremely good. To these cues the numbers 1–7 may be assigned by the researchers.

Graphic Scales

In this scale a straight line is shown, vertically or horizontally, with various cues to help the rater. The line is either segmented in units or it is continuous. If the line is segmented, the number of parts can be varied. The examples of such a scale are shown in Figure 10.1.

How effective was the presentation of lessons in the class by the teacher?

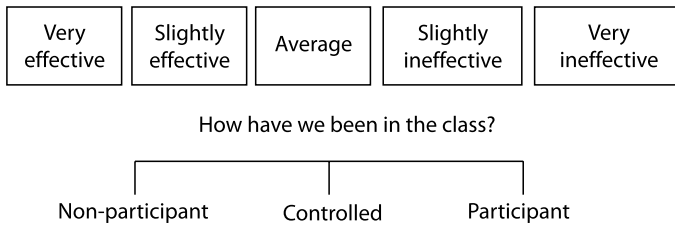


Figure 10.1 Graphic scales

The graphic scales are simple and easy to administer. They are interesting to the raters and require little added motivation. The raters can fill them quickly as such scales do not bother them with numbers. The graphic scale provides opportunity for as fine discrimination as that of which the raters are capable and the fineness of scoring can be as great as desired.

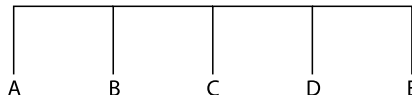
Standard Scales

In standard scales, a set of standards is presented to the rater. The standards are usually objects of same kind to be rated with pre-established scale values. In its best form, this type is like that of the scales for judging the quality of handwriting. The scales of handwriting provide several standard specimens that have been spread over a common scale by the methods of equal appearing intervals of pair comparisons. With the help of these standard specimens, a few samples of handwriting can be equated to one of the standards.

Man to man scale is another example of standard scale. In this scale, the individuals are asked to rate the raters by comparing them with the person mentioned on the scale and assuming the ratee's position. For example A, B, C, D and E are the persons who have been already rated as very persistent, everyone not easily stops, works quite steadily, somewhat changeable and gives up easily.

Example

Is he generally a persistent person?



This type of scale was originally developed for use in connection with military personnel and is of little use elsewhere. Moreover, because of subjectivity element, the use of this type of scale is very limited.

Rating by Cumulated Points

The 'Checklist method' and the 'Guess technique' belong to this category of rating. The common feature of rating by cumulated points is in the method of scoring. The rating score for an object or individual is the sum or average of the weighted or unweighted points.

'Checklist methods' are applicable in the evaluation of the performance of personnel in a job. This method was used by Hartshorne and Mary (1929) for evaluating the character of children. A list of 80 trait names describing some favourable and unfavourable qualities like cruel, co-operative, thoughtful humane and greedy was prepared. Each rater has to check every term in the list that is to be applied to a child. The weights of +1 and -1 were assigned to every favourable and unfavourable trait, respectively. The algebraic sum of the weights was the child's total score.

Guess technique was developed by Hartshorne and Mary (1929) for use particularly with child rater. In this technique, the students are asked to read each descriptive statement presented to them and then to write down the name of the student who best fits that description. The students may use more than one name for each statement, and they are also allowed to use their own name. Examples or statements used in this kind of technique are as follows:

- There is a person who is disliked by others and has lots of enemies.
- There is a person who is always doing little things to make others happy.

The score for each student is the sum of the number of times one is chosen for each descriptive statement. If the positive statements indicate socially desirable qualities and the negative statements indicate undesirable one, the total sum of the child will be the algebraic sum.

For example, if a student is mentioned positively nine times and negatively three times, the score will be $9 + (-3) = 6$. If there are several positive and negative statements for a number of behavioural attributes, it is possible to get a score for each attribute for each child of the group. These scores are useful in the study of individual roles and serve as measure of reputation.

Forced-choice Ratings

In forced-choice rating method the rater is asked, not to say whether the ratee has a certain trait or to say how much of a trait the ratee has but to say essentially whether the ratee has more of one trait than another of a pair.

In the construction of a 'Forced-choice rating' descriptions are obtained concerning persons who are recognized as being at the highest and lowest extremes of the performance continuum for the particular group to be rated. Descriptions are analysed into simple behaviour qualities, and stated in very short sentences or by trait names, which are known as elements.

These elements are used to construct items and then 'discrimination value' and 'preference-value' are determined for each element. In forming an item, elements are paired. Two terms of statements with about the same high preference values are paired, one of which is valid and the other is not.

Two terms or statements with about equally low preference values are also paired, one being valid and the other not. Two pairs of terms or statements, one pair with high preference value and the other

with low preference value, are combined in a tetrad to form an item. An example of tetrad given by Guilford (1954) is as follows:

- Careless
- Serious-minded
- Energetic
- Snobbish

The rater is asked to react to each tetrad as an item, saying which one of the four best fits the ratee and which one is least appropriate. The tool is tried out in a sample for which there is an outside criterion for the purpose of validating the responses. Then the 'discriminating responses' are determined and 'differential weights' are assigned to each item. Taylor and Wherry (1952) found that leniency error gets reduced in forced-choice rating when compared with graphic ratings.

Advantages of Rating Scales

The main advantages of rating scales are following:

- They are commonly employed in judging contests of various kinds such as speaking, declamation contests and music competitions.
- They have been put to extensive uses in the field of rating teaching and teachers.
- They are also used for testing the validity of many objective instruments like paper-pencil inventories of personality.
- They are also used for personality ratings, sociological surveys, school appraisals including appraisal of courses, practices and programmes.
- They are advantageous in several other ways, that is, they are helpful in:
 - (i) Writing reports to parents
 - (ii) Filling out admission blanks for colleges
 - (iii) Finding out student needs
 - (iv) Making recommendations to employers
 - (v) Supplementing other sources of understanding about the child
 - (vi) Their stimulating effect upon the individuals who are rated

Limitations of Rating Scales

Rating scales have several limitations, some of them are discussed as follows:

Error of Leniency

The raters would not like to run down their own people by giving them low ratings. The result is that high ratings are given in almost all cases, such raters are called 'easy raters'. Some raters become aware of the failure of easy rating and consequently rate individuals lower than they should. Such raters are called 'hard raters'.

The leniency error refers to a general and constant tendency for a rater to rate too high or too low for whatever reasons. When rating is too high, the constant error is one of positive leniency. On the other hand, the constant error is one of negative leniency when rating is too low. The positive leniency error is most common and an arrangement of 'cues' given by Guilford (1964) may prove helpful to counteract it.

In this example, only one unfavourable 'cue' is given and most of the ranges are given to degrees of favourable report. The researchers evidently anticipate a mean rating somewhere near the cue good and a distribution symmetrical about that point.

Halo Error

Halo means a tendency to rate in terms of general impressions about the rates formed on the basis of some previous performances. For example, one tends to rate a person with a pleasing personality high on traits like initiative and loyalty also. Halo effect appears frequently when the raters have to rate a number of factors on some of which they have no evidence for judgement.

Guilford (1954) suggests that the practice of rating one trait at a time on all rates, facilitated by having one trait per page rather than one rate per page, and the practice of the forced-choice technique may be used to counteract the halo effect.

Error of Central Tendency

There is a tendency in some raters to rate most of ratees near the mid point of the scale. They would like to put most of the rates as average. It is more common among the individuals who are unknown to the raters. To counteract the error, greater differences in meaning may be introduced between 'cues' near the ends of the scale than between 'cues' near the centre.

Logical Error

Such an error occurs when the characteristics or the traits to be rated is misunderstood. It is due to the fact that judges are likely to give similar rating for traits, which they feel logically related to each other. Guilford suggests that this error can be avoided by calling for rating based on judgement of objectively observable actions rather than abstract and semantically overlapping traits.

Contrast Error

This error is due to the tendency of the raters to rate others in the opposite direction from themselves in a trait. For example, in a study the raters were asked to rate individuals in the trait of 'need for orderliness'. It was seen that the raters who themselves were high in orderliness tended to see others as being less orderly than they were, and the raters low in underlines tended to see others as being more orderly than they were. This error can be avoided to some extent by making the raters feel about the existence of such a phenomenon.

Rating scale is the type of inquiry, which is devised and administered for the purpose of securing judgements of certain persons about certain limited aspects, individuals, groups or performances. They measure the degree or amount of the indicated judgements. Construction of rating scale involves knowledge of general rules, the judges who will do the ratings, the phenomena to be rated and finally the type of rating scale, i.e., the continuum along which the phenomena will be rated.

The researchers should also consider the limitations and advantages of a particular type of rating before finally deciding about the type of rating scale for their study. The main types of rating scales are descriptive rating, numerical scale, the graphic scale, the percentage of group scale, standard scale, rating by cumulated points and forced-choice ratings.

Rating scales have been put to uses in the field of rating teaching and teachers, personality ratings, school appraisals, judging contests of various kinds such as speaking, declamation contests and music competitions. The rating scales suffer from many errors and limitations, namely, leniency error, the halo error, the error of central tendency, the logical error and the contrast error.

Achievement Test

Education or teaching is an activity and its effect is learning or modification of mental or conative behaviour. This effect in education has to be evaluated or measured, i.e., it is to be discovered as what and how much the child has learnt out of one subject or one situation.

Old Concept of Evaluation

In the old system of education evaluation took the form of school examinations. They are better termed as essay-type of examinations. It was believed that intelligence and other esoteric qualities of personality were expressed through writing answers in the form of essays. How much a student had achieved in a particular subject could also be gauged from these essays in that subject. Thus, the score of these essay-type examinations were considered good enough to measure the educational effect and also to forecast how much one could achieve in future. Essay-type tests were the only instruments to know about the progress of students.

Demerits of Traditional Examinations

Soon it was discovered that these essay-types were not accurate tests of student's ability. Numerous researches were carried out as a result of which following demerits were revealed.

Unreliability

An instrument is reliable if it measures exactly the same amount of everything. In order to be reliable its results must be the same on every occasion it is used or same when used by different persons in a single case. Our essay-type examinations do not give such results. It has been found that different examiners have scored the same answer differently. The range of marks varied sometimes from 30 to 80 in the same essay. Hence, this type of assessment is unreliable.

Validity

A test or an examination is valid when it measures the same trait, quality or function for which it is made. The traditional examinations were meant for measuring education achievement in different school subjects. But, it has been found that they are not able to single out the knowledge achieved and are sometimes tests of mere rote memory which cannot be the function of school examination. Hence, they are invalid.

There are other demerits also. They have become unwieldy and are difficult to be organized. They have distorting effect on the curriculum. The questions set in the examinations are generally selective. The students prepare only important portions and leave others. Thus, the whole curriculum is distorted and its purpose is defeated. If they are reliable, their results must be the same on every occasion they are used or same when used by different persons in a single case, also highly subjective as the scores are influenced by the whims, opinions and interest of the examiners.

The New Concept

As a result of these demerits of the old examination system and emerging science of psychology, various attempts have been made to make the tests of achievements objective, reliable and valid. These attempts have resulted into construction of objective tests, which are called achievement test, or attainment tests in various subjects. In foreign countries, their use has become very popular and wide. In India, an attempt is being made to supplement the prevalent examinations with these tests.

Attainment Test

Achievement tests measure one's acquisition of knowledge in a particular subject. In a technical sense, they measure the functional effect and behavioural changes produced by a school subject within child's personality. Teaching of language has a definite function, which is to produce such mental and behavioural changes as acquisition of vocabulary and its use (verbal behaviour), fluency in speech and expression

(linguistic behaviour), improvement in writing (expressional behaviour), grasping and understanding (receptive behaviour), refinement of feeling and emotions (affective behaviour). Similarly, each subject has a functional effect, which has to be located, defined and assessed.

Construction. In the construction of a psychology test four steps are involved. This is so with the attainment test also. Following are the four steps:

- Planning the test
- Preparing the test
- Trying out the test
- Evaluating the test

Planning of Attainment Test. While planning the attainment test one has to record the functional effects and the behavioural changes desired to be produced by a particular subject. It means that they have to thrash out various aims of teaching that subject. Then, an analysis of the courses prescribed in that subject is to be made. What is expected from the child with regard to these courses and aims is very carefully determined. For each class or grade a certain level of achievement or standard of knowledge and skill is expected. This has to be kept in mind. Planning must take into consideration the class for which the test is being constructed.

Preparing Test. After above exploration, the test is prepared. In drafting the test questions one has to see that the courses of the subject for that class are well represented. For example, memory items, grasping of the subject and interpretations, all should be tested by the questions. Care should be taken while testing discrimination, judgment, intellectual and emotional attitudes, appreciations and application of knowledge. Questions should be appropriate to the material to be included. In the first draft there should be as many as double the number of questions to be retained in the final test. For example, if you want to keep 100 questions in the final test, there must be about 200 questions in the first draft. Questions should vary in difficulty from very easy to very difficult to suit all students' ability. As to difficulty, the test should be such as the average boy should be able to make about 50 of the possible scores. Easier items should be placed at the beginning and difficult ones at the end. The test is prepared in two forms: 100 items in test A and 100 items in Test B.

Try-out. This is the stage at which one tries to know how good the test is. At this stage, they have to make a selection of most suitable questions and reject others, which are unsuitable. For this purpose the test is administered to about 200 or 300 boys representative of all grades of abilities. It is felt that there may be chances for the students to guess the answers of the questions. Hence to eliminate this effect a correction formula is applied.

which is $S = R - \frac{W}{N - I}$ in which S is the score corrected for guessing,

R is the number of right responses, W is the number of wrong responses and N is the number of responses for each time.

Evaluating Test

This stage decides which question should be retained in the test and which should not. For this purpose, an item-analysis of the test is made.

Note: For detailed study of this, students are advised to study 'measurement and evaluation'.

After this, reliability and validity of the whole test are found out. For reliability purpose any of the following three methods may be adopted.

- Repetition of the same test on different occasions and finding out the correlation between two sets of scores. This is called test-retest method.
- Use of two parallel forms of the same test, i.e., two forms are prepared of the same test and correlation is found out between their scores.
- Split-half method: In this, test is split into two equal halves and correlation is found out between their scores.

Validity of the test is found by getting the correlation between the scores of the test and some outside criterion such as school marks or teachers' estimates of the students.

The time is also fixed for the test. Time taken by each test is noted and the average of all is calculated. This is the standard time for the test.

What type of questions is framed in the test? For example, simple recall type, completion type, multiple-choice type, true and false type or matching type.

Standardized Test

Tests are of two types: teacher-made and standardized tests. There is a difference between these two. A teacher-made test is one that is prepared by teachers for their pupils, but is not standardized. It goes through the steps of planning, preparing, trying out and evaluation, but stops before standardization.

Standardization of a test goes beyond the try-out process. At this stage the test is administered to a very large population of students, for example, 2000, 3000 or more. The concept of standardization has two aspects: general and statistical. The first aspect means that it is relative to some standards. The statistical aspect means that a test is said to be standardized if its standard deviation (SD) is not more than one third of the average, which means that the questions of the test are genuine and suitable for 68 per cent of the sample population.

Every test is standardized with regard to its material, method and results. To standardize its material the constructed test is administered to a large number of students and each question or item is analysed in the same way as it was done in try-out process. Standardization means that in the second try-out necessary changes are made in the instructions required for administering the test. The results of the test are standardized through the following methods.

- (i) Mean and SD method
- (ii) Percentile method
- (iii) Age-basis method

The mean score of the whole population is calculated and the position of each testee, then, can be calculated in terms of SD on the plus or minus side of the average. This is called SD method. In the percentile method, percentiles are calculated instead of mean and SD. If one student's score is 62.3 and we want to know the relative position in the population, we have to find which percentile value is 62.3 or near about this. If it is 60th percentile, it means that the student is better than 60 of the whole group.

In this way the test is standardized. Following are the chief characteristics of a standardized test.

Characteristics of Standardized Test

A standardized test is more valid. It means that it measures only the same thing for which it is meant. Unlike the traditional examinations in which speed of writing, guess, chance and linguistic ability are

many factors that influence the scores of the student, no such factors remain operative and effective in the standardized test.

They are very reliable. They give the same results on repeated application. This is due to the fact that they include a large number of questions fairly representative of the content.

They have a meaning and a value. Each testee's score can be easily compared with the average which is calculated taking about 2000 or 3000 students. If a boy's score is 65.4 and the test says that this is a score of the pupil of 13+ who has an educational age of 15+, then the boy will be considered to have had an educational quotient (EQ) of 15 at the chronological age of 13+. EQ is calculated in the same way as IQ by dividing the educational age by chronological age and multiplying by 100.

Nature of Achievement Tests

Surpassing all other types of standardized tests in sheer number, achievement tests are designed to measure the effects of a specific programme of instruction or training. They generally represent a terminal evaluation of the individual's status on the completion of training.

The emphasis in such tests is on what the individual can do at the time. They measure the effects of learning. The course-oriented achievement test covers narrowly defined technical skills or factual information. A test in English vocabulary or television maintenance is an example of this category.

The broadly oriented achievement test commonly used today is to assess the attainment of major long-term educational goals. Here we find tests focusing on the understanding and application of scientific principles, the interpretation of literature and the appreciation of art; still broader in orientation are tests of basic cognitive skills that affect the individual's performance in a wide variety of activities. They may be such as reading comprehension and arithmetic computation.

At the broadest level, we find achievement test designed to measure the effects of education on logical thinking, critical evaluation of conclusions problem-solving techniques and imagination.

Essay-type Questions Versus Objective Questions

The traditional school examination began as a set of questions to be answered either orally or in writing. In either case, the examinee composed and formulated the response. The term 'essay question' has to be used broadly to cover all free response questions, including not only those demanding a lengthy essay, but also those requiring the examinee to produce a short answer or to work out the solution for a mathematical problem. Objective questions, by contrast, call for the choice of a correct answer out of several responses provided for each question.

This feature is especially clear in multiple-choice questions, although the recognition of the correct response choice is also the major response given in true-false, matching rearrangement and other variants. As objective items came to be widely accepted, they can be written to tap complex thinking processes, reasoning, evaluation of arguments and the application of knowledge to new situation. Moreover, in objective questions, each item requires much less of the examinee's time than does a typical essay question.

In summary, objective items have largely replaced essay questions in standardized testing programs, not only because of time restriction in test scoring, but also and more importantly because they provide broader subject matter coverage, yield more reliable and valid scores and are fairer to individual. Easy writing should be encouraged and developed primarily as an instructional procedure to foster clear, correct and effective communication in all content areas.

Uses of Achievement Tests

Many roles that objective-type achievement tests can play in the educational process have long been recognized. Achievement test scores are used in deciding which grade a student is suitable for. They also constitute an important feature of remedial teaching programme. In this connection, they are useful

both in the identification of students with special educational disabilities and in the measurement of progress in the course of remedial work.

The periodic administration of achievement tests serves to facilitate learning. They reveal the weakness in part learning, give direction to subsequent learner and motivate the learner. They also provide a means for adapting instruction to individual needs. Teaching can be most fruitful when it meets the learner at whatever stage they happen to be. Ascertaining what individuals are already able to do and what they already know about a subject is thus a necessary first step for effective teaching.

The growth of all testing programmes points to the increasing use of test results as a basis for planning what is to be taught to a class as a whole and what modifications and adjustments need to be made in individual cases.

Further example of the role of achievement tests in the teaching process can be found in connection with criterion-referenced testing, individually tailored instructional systems, mastery learning and computer-aided learning procedures.

Finally, achievement test may be employed in the evaluation and improvement of teaching and in the formulation of educational goals. They can provide information on the adequacy with which essential contents and skills are actually being taught. They can likewise indicate how much of the course content is retained and for how long. Moreover, public demands for educational accountability require proper use of well-constructed achievement tests to assess the results of the educational process.

Construction of Achievement Tests

The following are the main steps in the construction of achievement tests:

- Planning test
- Administration of the test for pre-tryout
- Try-out testing for item analysis includes:
 - (i) Sample for try-out testing
 - (ii) Instruction to the testes
 - (iii) Time limit
 - (iv) Scoring
 - (v) Item analysis of data
 - (vi) Item selection for final draft
 - (vii) Reliability and validity of the test
 - (viii) The final form of the test
 - (ix) Time limit for final test

■ *Planning test:*

The test constructor who plunges directly into item writing is likely to produce a lopsided test. Without an advance plan, some areas of the syllabus will be over-represented while others may remain untouched. A test constructed without a blue-print is likely to be overloaded with relatively impertinent and less important material. Many of the criticisms of objective tests stem from the common overemphasis of rote memory and trivial details in poorly constructed tests.

To guard against imbalances and disproportions in coverage of the syllabus, test specifications should be drawn up before items are prepared. For drawing up test specifications the test constructor should study two types of literature critically:

- (i) Relating to test construction
- (ii) Syllabi and university or board examination question papers in the subject areas, which would help the test constructor to decide the weightage to be given to each independent topic in the syllabus.

Thus, the test constructor will prepare a blue-print by taking into consideration the relative importance of the content and also the amount of time spent in giving instruction in each category by the teachers. This blue-print will then be discussed with 20–25 teachers dealing with the subject in the various institutions.

■ *Administration of test for pre-try-out:*

The number of items in test draft should be nearly one and a half times or double the number required in the final test. The items with wide range of difficulty should be constructed. The instructions to be given to the testes should be framed. The typed draft on the test should be submitted to various teachers teaching the subject, the supervisor, and experts with long experiences of test construction, for frank opinion and criticism.

Many false assumptions, slips and oversights are corrected in this process. Then 50 cyclostyled or photocopies of the test are administered to 50 students of the class for which the test is to be constructed, and the answers are checked with the help of the scoring key. A few further modifications will come to light during this stage, called the pre-try-out stage. Then the modifications will be made and tests will be printed and administered to a sample selected for try-out testing.

■ *Try-out testing for item analysis:*

The next step is to select a sample for try-out testing.

(i) *Sample for try-out testing:*

A true representative sample of 400 testees will be selected by the following appropriate technique of sampling. As the test constructor needs 371 scripts for the item analysis, about 400 scripts are taken to keep enough margin for discarding the spoilt ones.

(ii) *Instructions to the testees:*

The test constructor has to write comprehensive instructions to be printed on the title page of try-out test. The instructions should be self-explanatory, yet how to answer a matching or multiple-choice items may be explained orally with the help of example taken from daily life of the testees. The oral instructions may be as follows:

- Do not discuss anything with your neighbours.
- Do not make unnecessary haste to finish the test.
- Please see that no item is left out. You have to answer all the items. At the end we shall check whether you have answered all the items.
- Please go through the written instructions carefully before you start your work.

(iii) *Time limit:*

There should be no time limit for taking the try-out tests. The test is to be administered to all the testees of the sample of 400 students selected for try-out testing. The test is to be taken back from the testees only when, except three or four testees, all had completed the test in the class or section.

(iv) *Scoring:*

The scoring is to be done with the help of scoring key prepared by the test constructors, on the basis of one mark for a correct answer and an out right zero for an incorrect one.

(v) *Item analysis of data:*

After the try-out testing and scoring, the test constructor has to take 371 answer sheets by deleting the rest at random. After that:

- All the 371 answer sheets will be arranged in a descending order from highest score paper at the top to the lowest score at the bottom.

- From the above pile upper 100 papers which form the 'upper group' and lower 100 papers which form the 'lower group' will be taken. Thus, 27 per cent of the 371 trainees, 100 scripts, making the highest scores constituted the superior group, and the 27 per cent, 100 scripts, making the lowest scores comprised the inferior group. Only these two top and bottom piles will be taken into consideration for computing the internal consistency discrimination index and the difficulty value, the middle 46 per cent of the papers will be kept aside.

After the formation of two groups, the number of correct responses to an item in each group will be found and tabulated. These numbers, naturally, show the percentage of correct response for each item for both the groups, as each group comprises of 100 testees. The percentage will be easily converted into proportions.

Difficulty Value

The average of the proportion of the correct responses on each item in the two end groups will be taken to be an estimate of the difficulty value of that particular item. The formula for calculating difficulty value dv of each item is,

$$dv = \frac{P_u + P_l}{2}$$

where dv = difficulty value of the item.

P_u = Proportion of correct responses to the item from the upper group.

P_l = Proportion of correct responses to the item from the lower group.

Internal Consistency

The relationship between the total scores derived from a test and item scores are referred to as internal consistency discrimination index of an item. The internal consistency discrimination index of each item will be found by reading the biserial coefficient of correlation between the items and the total score from the J.C. Flanagan's abac. Flanagan's abac was designed for use when the middle 46 per cent of the examinees on total score have been eliminated and each tail contains 27 per cent.

The proportion passing the item in the upper criterion group will be read from the ordinate and the proportion passing the item in the lower criterion group from the abscissa, and the value of coefficient will be read at the intersection of the perpendiculars.

After determining the difficulty values and the internal consistency discrimination indices of each item as discussed above, a list will be drawn for all items of the test showing the discrimination value and difficulty value of each item.

Item Selection for Final Draft

The item for the final test will be selected on the basis of the following criteria:

■ *Internal consistency:*

With regard to the internal consistency discrimination index or item validity Garrett (1967) says, 'as a general rule, item with validity indices of 0.20 or more are regarded as satisfactory'.

According to Thorndike (1949), 'an item with a validity coefficient as high as 0.25 usually represents and outstandingly valid item.' Keeping these in view, it may be decided to retain only items, having internal consistency of 0.25 and above. The higher the value, better it is to retain the item.

■ *Difficulty value:*

It is desirable to select most of the items of medium difficulty and a few of higher and lower difficulty values. Lindeman (1971) writes, 'some easy items should be included in a test in order to encourage the students of low ability. Some difficult items should be included to challenge the abler students. However, in the interest of constructing a measuring instrument of maximum quality and utility, most items included be in the middle range of difficulty'.

A bivariate scatter-diagram will be prepared for the test placing each item in the appropriate column and row according to its difficulty value and discrimination index, respectively. Then, items will be selected keeping the above criteria of d_v and r_b in view.

Final Form of Test

After selecting items for final test; re-arrange them in accordance with the principles laid down by experts. It is desirable that items should be re-arranged from easy to difficult in the final form, i.e., easiest item at Serial No. 1 and the most difficult item as the last item. On the cover page of the test, the standardized instructions for the testees will be printed as in the case of try-out. The scoring key for the final test will also be prepared.

The time limit for the final test will be fixed after administering the test in a section of a class for which the test is developed. The time taken by 90 per cent students to complete the test will provide time for the final draft.

Reliability and Validity of Achievement Test

The reliability coefficient of the test may be found by split-half (odd-even) method. It should be above 0.80. The higher the reliability coefficient, the better it is. The validity of achievement tests is taken for granted, because they are constructed after keeping in view the weightage of the different portions of the syllabi in view.

This point of view is supported by Guilford (1954), who says that, 'there are some measures whose validity is taken for granted for example, achievement test is formulated by analysis of curriculum and textbooks and by the pooled judgement of recognized authorities in the field. Under these circumstances a well constructed test may constitute the best available measure of criterion, in a sense the test itself defines the function it is to measure. Such tests may be described as self-defining'.

Content validation procedure is commonly used in evaluating achievement tests. This involves essentially the systematic examination of the test content to determine whether it covers a representative sample of the behaviour domain to be tested must be systematically analysed to make certain that all major aspects are covered by the test items and in the correct proportions. A well-constructed achievement test should cover the objectives of instruction, not just its subject matter. Therefore, content must be broadly defined to include major objectives.

Among the various types of tests used in school, achievement tests are the commonest. They propose to measure the present level of performance of individuals or groups in academic learning. They also propose to measure how much students have learnt as a result of instruction.

Achievement test scores are used in assigning grades to students. They are utilized for evaluating courses of study or efficiency of teachers and teaching methods. Achievement tests may be standardized or non-standardized. Objective-type achievement tests are designed to measure the effects of education on logical thinking, critical evaluation of conclusions, problem-solving techniques and imagination.

In standardized achievement tests, objective items have largely replaced easy items because they provide broader subject matter coverage, yield more reliable and more valid scores and are fairer to individual.

In the construction of achievement tests main steps are planning the test, administration of the test for pre-try-out, try-out, item analysis and item selection for the final draft. The reliability of achievement tests is found by split-half (odd-even) method.

The reliability coefficient for achievement test should be very high, i.e., above 0.80. Content validity is the main type of validity needed for achievement tests. Content validation involves the systematic coverage of large content area of the syllabi in correct proportions. Content must be broadly defined to include major objectives of instruction.

Evaluate Yourself

- (i) Enlist the tools of research in brief.
- (ii) What are characteristics of standardized test?
- (iii) Reliability and validity of test.
- (iv) Evaluate good questionnaire.

Checklist

Meaning: It is a type of questionnaire in the form of a set of items, which the respondent is asked to check.

Characteristics: This tool systematizes and facilitates the recording of observation and helps to ensure the consideration of all important aspects of the object or act observed.

It is an important tool in normative surveys, case histories, studies of behaviour and educational appraisal studies. The list of items in the checklist may be continuous or divided into groups of related items.

It may be administered by post or otherwise. It records facts, not judgments.

Construction of Checklist

The following points must be taken into consideration while constructing a checklist.

- An intensive survey of the literature should be made to determine the type of checklists to be used in an investigation.
- Terms used should be clearly defined.
- Items should be complete and relevant.
- Items should be arranged in a logical or psychological order.
- Related items should be grouped together.
- Checklists prepared and used for educational research by various investigators may be examined closely.
- Items should be arranged in such a way as they are discriminative in quality.

Four common styles of constructing checklists: Homer Kempfer suggests the following common styles of arrangement.

Bernreuter personality inventory: Consists of 125 items, measures (1) neuroticism, (2) self-sufficiency, (3) extroversion, (4) dominance, (5) sociability, (6) lack of self-confidence. Reliability is 0.80–0.95, used 9 and 16, also adults.

Items: Do people ever come to you for advice.

Minnesota Multiphasic Personality Inventory (MMPI): Consists of 550 items, used in 16 years or above. Every item or statement is printed on separate cards and the subject sorts it into three groups: true/false, cannot say, items in 26 heads, e.g., family, general health, attitude, religion phobias, delusions, delusions and items grouped in traits. Its main use is clinical and diagnostic. Administration and scoring requires training. It has high prediction validity (MMPI). There are nine clinical scales in the inventory. *Items*: 'I wish I could be as happy as others seem to be' T.F. cannot say. 'I believe I am being plotted against.'

MPI appeared in 1940 and first manual in 1943. It is available in individual (card) and group (booklet) forms.

Allport and Allport: A-S Reaction study for men and women. The study has 33 items for men and 34 items for women. Situations are presented verbally.

California test of personality: There are five scales: (1) primary, (2) elementary, (3) intermediate, (4) secondary and (5) adults reliability (0.80–0.94).

Items: 'Do you find that a good many people are mean?'

Evaluation of Personality Inventory

- High reliability, validity inadequate.
- Items are sometimes very ambiguous.
- We do not know any norm for ideal adjustment or behaviour.
- They have very low diagnostic value.
- They are useful in the study of group trends, in differentiating between group of adjusted and maladjusted rather than between individuals.

Summary

- Research tools are of many kinds and employ distinctive ways of describing and qualifying the data.
- As research scholar should be familiar with the nature, merits, limitations of these tools and should also attempt to learn how to construct and use them properly.
- There are various types of tests used in educational instructions, achievement tests are the commonest.
- Achievement tests may be standardized or non-standardized.
- In construction of achievement tests main steps are planning, administration, pre try-out, try out, item analysis and item selection for the final draft.
- The reliability of achievement test is estimated by split-half method.
- The construction and procedure of research tools depends on situation and nature of research.

Key Words

- *Achievement Test*: It is a test designed to measure a person's knowledge, skills, and so on in a given area at a particular time.
- *Discrimination Index*: It is a measure of the ability of an item in a test to discriminate between students of high and low ability.

- *Instruction*: Means of providing knowledge, skills, and so on.
- *Item*: This is a single component in a test.
- *Item Difficulty*: This is the extent to which items in a test are arranged in the order of increasing difficulty.
- *Halo*: Means a tendency to rate in terms of general impressions about the rate formed on the basis of some previous performances.
- *Criteria*: A characteristic measurement with which other characteristics or measurements are compared.
- *Grade*: A grade is a label representing an evaluation.
- *Generosity Error*: Error refers to a general and constant tendency of a rater to rate all ratees high.
- *Contrast Error*: Error due to the tendency of the raters to rate others in opposite direction from themselves in a trait.
- *Rating*: Means the judgement of one person by another.

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New Approaches to Educational Research

11

Education in modern society has become an industry. It is concerned with the production and distribution of knowledge. The development of educational research is mainly based on priority of field, because our sources and finances are limited. There are various fields for educational research, but all are not concerned with new approaches to educational research. Although there are a number of approaches in educational research, but we do not search and practice in our research work so, it is necessary to familiarize with new approaches to educational research.

A more appropriate perspective is to consider educational research as cross-disciplinary in nature, cutting across and transcending or working at the interfaces between a variety of disciplines including the social and behavioural science, and the humanity.

During twentieth century, most developments in educational research have taken place as a result of thinking about educational problems from the perspective of social science, humanities and the behavioural sciences. Each discipline in these areas can contribute to an examination of educational questions.

—T. Heusen and T. N. Postethwaite (1994: 5034)

There are many approaches to educational research. Some of these are very common such as survey, history and experiment. These are given in almost all the books on educational research. There are some approaches, which are relatively new and are not commonly found in the books on research methodology. These are being described here.

▲ Heuristic Research

The term 'heuristic' had its origin in the Greek word *heuriskien*, which means 'to discover' or 'to find'. It refers to a process of internal search through which one discovers the nature and meaning of experience and develops methods and procedures for further investigation and analysis.

The self of the researcher is present throughout the process while understanding the phenomenon with increasing depth. The researcher also experiences growing self-awareness and self-knowledge. The heuristic process incorporates creative self-process and self-discoveries.

Heuristic inquiry is a process that begins with a question or a problem, which the researchers seek to answer or illuminate. The question is one that has been a personal challenge and puzzlement in the search to understand one's self and the world in which one lives. The heuristic process is autobiographic, yet with virtually every question that matters, there is also a social and perhaps universal significance.

Six phases of heuristic research guide unfolding investigations and comprise the basic research design. They include the following:

- The initial engagement

- Immersion into the topic and question
- Incubation
- Illumination
- Explication
- Culmination of the research in a creative synthesis

Heuristic inquiry also differs from hermeneutic thinking. In heuristic approach, the focus is exclusively and continually aimed at understanding human experience. The research participants remain close to depictions of their experience, telling their individual stories with increasing understanding and insight. The depictions themselves achieve layers of depth and meaning through the integrations, explorations and elucidations that occur between the primary researcher and the other research participants.

▲ Phenomenological Research

Phenomenology is the contribution of Edmund Husserl. Martin Heidegger has also contributed in this area. It is a philosophical pursuit. Human experience is the object of research in phenomenology. In this method the investigators reflect their way of experiencing the universe in which they are living.

In this method, participants are invited to reflect on their experiences about a phenomena. Then the researchers try to analyse to what extent the perception of the participants is similar to their own and in what way it differs. A related area of phenomenology is phenomenography, which is the empirical study of different ways in which people experience, perceive, understand and conceptualize phenomena around them. For example, children experience, perceive, understand and conceptualize some mathematical concepts—say the number system in different ways. It would be interesting to make an empirical study of these variations. Even in languages, students understand some literary text in different ways. The difference in perception, understanding and conceptualization is due to the difference in relating different components of phenomena with each other and with totality. The main methods of collecting data in this type of research are interviews, participant observations, analysis of interactions and written responses of subjects, study of drawings and analysis of historical documents.

Many times a question arises about the reliability of this method, that is, whether different persons analysing the responses would come to the same conclusions. The proponents of this method have an argument about this criticism. They say that this method is not a measurement procedure but an attempt to discover a phenomena and a discovery need not have to be replicable.

▲ Differences Between Phenomenological Research and Heuristic Research

Clark Moustakas (1994) explains the difference between these two methods:

- In phenomenological research, the focus is on a situation, on which the experience under study occurs, whereas in heuristic research, there is an attempt to undertake a wider investigation, which is more open.
- In the heuristic research, the description of the phenomena is supplemented by diaries, journals, self-dialogues, stories or other personal documents, whereas in phenomenological research, the main stress is only on description of an experience.

- While phenomenological studies end with a general description, the heuristic investigations culminate in creative synthesis.
- In the phenomenological studies, the co-research workers have a negligible role in the analysis and interpretation of data, but in heuristic research, they remain actively involved even at the stage of examination and analysis of data.

▲ Interdisciplinary Research

With the fast explosion of knowledge, the boundaries of disciplines are getting thinner. Any problem in one discipline can be better understood and solved by looking at it in its entirety. In doing so, we will find that we have to transgress the boundaries of one discipline. To be specific, any educational phenomena can transgress the boundaries of one discipline. That is, any educational phenomena can be understood correctly if it is viewed comprehensively in its socio-cultural-economic-geographical-psychological context. Hence, in gaining an understating of educational phenomena or for finding out a real solution, it would be necessary to recognize that these problems are linked with other disciplines. Thus, educational research in modern times has to develop close links with other related disciplines. This realization has led to the origin of interdisciplinary research.

Interdisciplinary research is merely taking help of some disciplines in solving an educational problem. It should be a genuine multi-disciplinary approach. In interdisciplinary research, an attempt has to be made for integration at conceptual as well as methodological levels across disciplines. Ecological or management researches are good examples of interdisciplinary research. Ecological research draws heavily on disciplines such as biology, chemistry, and geography.

Yadav and Mitra (1989) have given four ways in which educational research can be made interdisciplinary:

- (i) Conceptual integration—Skinner's theory of operant conditioning led to the development of programmed instruction in different subject areas.
- (ii) Adoption of conceptual structure of other disciplines as a model for building conceptual framework of educational research, for example, the Cybernatic model, which was meant for explaining information processing in the auto-regulation system has become the basis of systems approach and systems analysis in educational research.
- (iii) Adoption of methodology originally evolved in other disciplines – Educational research has widely used the tools developed in the area of psychometric. Clinical interview, a gift of psychoanalysis, is widely used in educational research. Participant observation used in anthropology is also a popular technique in the field of educational research. Many more examples can be quoted to show that educational research has adopted the methodological contributions from other disciplines.
- (iv) Studies on pedagogical aspects of various disciplines and technology of transmission of their discipline are also an area of interdisciplinary research. In this type of research the method and content are integrated. This had given rise to new areas like science education, mathematics education, and language education.

Two ways of promoting interdisciplinary research are the following:

- (i) Experts from different disciplines can work together for solving a problem.
- (ii) Educational research workers can try to gain expertise in other disciplines and then use that knowledge for tackling a research problem in the field of educational research.

▲ Ethnographical Studies

Ethnographic research has emerged from the discipline of Anthropology. These aim at studying a social group and giving its cultural description. The researchers enter a group or a setting that already exists intact and has its own history. They establish intimate relationship with that cultural group over a long period of time and also take residence in that social setting. They try to observe various actions and events of the members of the group and to understand the meanings of such actions and events, finally resulting in defining the roles and relationships of the members of the group and understanding the meanings of such actions and events. When the researchers spend considerable time with the group they are able to observe how these relationships undergo changes over a period of time. This type of research lays many demands on the research workers. They have to first learn the language of the group, have to reside in that social setting, participate in the activities of the social group and finally locate some members of the group with whom to develop a close rapport, which, in turn, will provide them with rich information about the cultural group.

One important precaution to be taken in ethnographic studies is maintenance of objectivity. Many times, when one is associated with a group for a long duration, one's observations get coloured. But some significant features may completely escape notice.

In educational research, the ethnographic studies can help in describing the aspirations related to education and expectations from the educational set-up of a social group. These studies can also describe the physical attributes, the relationships and other features of an educational setting.

The steps in an ethnographic research are as follows:

- Initial exploration
- Study of the geographical setting
- Planning for the observations
- Getting into the social setting
- Making observation about the setting
- Finally drawing conclusions about it

▲ Policy Research

In pure research, the problems are posed from inside a discipline and the solutions lead to progress of the discipline. Its impact on educational practices may be incidental.

In policy research, the problems emerge from outside the discipline from the field of action. The research is undertaken for providing a relevant information base for policy framing. The policy research findings are not meant for enhancing the boundaries of knowledge of a discipline. They have a bearing on the way educational programmers are to be implemented.

The policy research may be further classified in two:

- (i) Research flowing out of some policy decisions such as universalization of elementary education. It is a policy decision and has given rise to a number of research studies.
- (ii) Research taken up for formulating a policy. Research which revealed that a large number of school children are malnourished, has given rise to a policy decision of providing mid-day meals to school children.

The flowchart given in Figure 11.1 clearly explains the two types of researches, which can be included under the heading policy research.

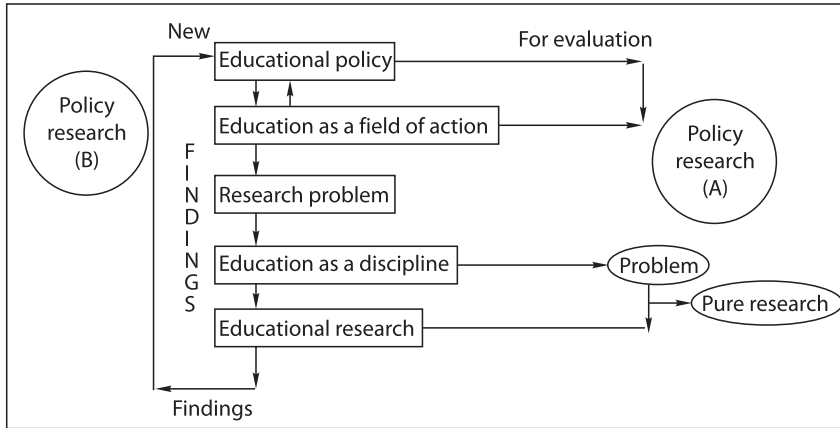


Figure 11.1 Flowchart of pure and policy research

Route A depicts the policy researches, which flow out of implementation of an educational policy or for evaluation of the impact of an educational policy. For this, one has to see the impact of the policy in the field of education and come to some conclusions, which could be useful for making necessary changes in the policy itself or the ways of its implementation.

Route B depicts the policy researches, which lead to an educational policy. Education as a field of action gives rise to many research problems, which when investigated, taking help of education as a discipline, result in crucial findings that can form the basis of formulation of an educational policy.

Intervention Studies

Generally, research studies are conducted for describing a reality, that is, what are the existing conditions. For example, studies have been conducted for knowing the problems of scheduled caste or scheduled tribe students. Studies have also been conducted for finding out dropout rates or stagnation at primary stage. These are known as status studies.

National Council for Teacher Education recently launched State Level Studies to find out the status of teacher education in each state. These studies were launched in collaboration with SCERTs/SIERTs/SIEs. These are illustrations of Status studies.

A time has come when it is not sufficient to know and describe the social, economic, political or educational realities. The more important need is to find out methods of changing or intervening with the reality. Only describing the problems would not take us any further unless intervention efforts are made to improve the existing conditions. This is the area where interpenetration studies can play an important role. An intervention study is that research work in which some methods are suggested and tried out for changing the existing condition. These studies are generally experimental in nature and on the basis of experimentation come out with some strategies or models, which are helpful in improving the existing conditions. For example, it is a general practice to enumerate the weaknesses in the existing teacher education programme, but an intervention study in this area would attempt to develop a

new model of teacher education programme, which is likely to be more effective. The model has to be tried out and, if found really more effective, would be helpful in changing existing state of teacher education programme. Such intervention studies are needed in the area of eradication of illiteracy, improving the retention of children in schools, diminishing the stagnation rate, and so on. Care should be taken while evolving models through intervention studies that the models are replicable on a wider scale.

For effective conduct of intervention studies, a research team should be formed comprising practicing teachers, leaders from the community, administrative heads or their representatives from the departments related to the area of study and research workers. The experiences of all these persons can go a long way in evolving a model which is practicable and down to earth.

Table 11.1 Differences between example of status and intervention research

Status Research	Intervention Research
• Study of dropout rate of children	• Reducing dropout rate among tribals by providing mid-day meal
• Study of the competencies of primary school teachers	• Developing training packages for competency-based in-service programme for primary school teachers
• Study of organizational climate in schools	• Improving organizational climate through special training
• Study of causes leading to drug addiction	• Rehabilitation of students falling prey to drug addiction

Baseline Studies

For taking any administrative decision or framing a policy we need some basic data. The studies, which provide such basic data are known as baseline studies. Some examples are as follows:

- Location of the school (average distance from learner's home)
- Infrastructural facilities available (e.g., building, drinking-water, toilets, furniture, black boards)
- Educational background of teachers
- Mid-day meals (quality, stability, timing, impact and general reaction)
- Enrolment (factors that promote and retard)
- Retention (factors that promote and retard)
- Wastage and stagnation studies
- A survey of literacy rate in an area
- A study of educational disparities

Evaluate Yourself

- (i) Suggest two research problems which are interdisciplinary in nature and identify the disciplines involved.
- (ii) What is the difference between intervention studies and other types of research studies?
- (iii) Suggest two research problems from the area of policy research.

Summary

- This chapter gives some recent ideas about the changing nature of educational research. Educational research nowadays is considered as cross-disciplinary in nature, cutting across the boundaries of a variety of disciplines belonging to the area of social and behavioural sciences.
- Along with some new approaches of research, the difference between pure and policy research, and status and intervention research, for example, are also studied.

Key Words

- *Heuristic Research*: The process incorporates creative self-process and self-discoveries.
- *Phenomenological Research*: In this kind of research, the investigators reflect their way of experiencing the universe in which they are living.
- *Interdisciplinary Research*: It is merely taking help of some disciplines in solving educational problems.
- *Ethnographical Studies*: It is the studying of social groups and giving their cultural descriptions.
- *Policy Research*: In this kind of research, the problems are posed from inside the discipline and the solutions lead to progress of the discipline.
- *Intervention Studies*: It is the study to find out methods of changing or intervening with reality. Efforts are made to improve the existing conditions.
- *Base Line Studies*: The studies which provide basic data are known as base line studies.

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A research report deals with results of completed research work. After completing a research work, it is generally produced in the written form, which is called research report or thesis. This provides a detailed description of research activities. It has a variety of formats and varies in its length. It is written in past tense and third person. It is the final form of the research work. A research report usually includes the following chapters: Introduction of Theoretical Background, Review of Related Literature, Methodology, Data Collection, Analysis of Data, Discussion of Results and Findings of the Study, Bibliography and Appendices. It is also submitted for evaluating its contributions. It serves the purpose of communicating the results of research work.

▲ Meaning of Research Report

After completing the research, the researchers prepare research report. There is not much difference in these with respect to writing. The only difference is that the proposal is typically written in present or future tense and the report is always written in the past tense. The researchers are obligated to give a complete detailed account of all their experiences in the thinking process involved in the method of the research so as to carry the reader with them from identification and definition of the problem, formulation of hypotheses, collection of data and evidence, analysis and interpretation of data, testing of hypotheses and drawing out of conclusions. Such a complete and detailed account of research experience is called a research report. Since research is considered to be the more formal, systematic, intensive process of carrying out the scientific method of analysis, it involves a more systematic structure of investigation, usually resulting in some sort of formal record of procedure and a report of the results or conclusions. The process of writing research report is explained in four sections. The first section outlines and describes in detail the general format of the research report under three subsections; the preliminary section, the main body of the research report and the reference section. The second section describes briefly the style and format of writing the research report logically and objectively. The third section describes the procedure, which is followed in typing different sections of the research report. The fourth section provides certain hints, which are useful in detecting and correcting the typing errors while making proofreading of the final report.

▲ Steps of Writing a Research Report

The research report is the last but not the least of the research activity, with the worth of a research assessed by reporting of it. Some universities, research organizations or journal boards have established their own format to which their thesis, dissertation or research papers must conform; but all formats are

somewhat similar to the following outline, which comprise of three main sections: (a) the preliminary section, (b) the main body of the report and (c) the reference section. Each of the three main sections consists of several subsections, which are listed as follows:

- (i) Preliminary section
 - (a) Title page
 - (b) Preface, including acknowledgement (if any)
 - (c) Table of contents
 - (d) List of tables (if any)
 - (e) List of figures, maps or illustrations (if any)
- (ii) Main body of the research report
 - (a) Introduction
 - Review of related literature of analysis of previous research
 - Relation of present problem to theoretical position of the previous research
 - Statement of the problem
 - Delimitations of the study
 - Objectives of the study.
 - Statement of hypotheses
 - Definition of important terms or terminology
 - (b) Development of the tools
 - (c) Methods of the study
 - Design of the study
 - Sample
 - Tools used
 - Procedure of data collection
 - Statistical techniques used
 - (d) Analysis and Interpretation of the Data
 - Text
 - Tables (if any usually included in the text)
 - Figures (if any, usually included in the text)
 - (e) Summary and conclusions
 - Brief, restatement of the problem and procedures
 - Principle findings and conclusions
 - Educational implications of the findings
 - Suggestions for further research
- (iii) Reference section
 - (a) Bibliography
 - (b) Appendix
 - (c) Index (if any)

Preliminary Section

The preliminary section of the research report includes the following information:

- (i) *Title page*
The first page of the research report is the title page. Although title page forms differ from one institution to another, they usually include the following:

- (a) Title of the study
- (b) Name of the researcher (if desired previous academic degrees may be listed after name)
- (c) The relationship of the report to a course or degree requirement
- (d) Name of the institution to which the report is submitted
- (e) Date of submission of the report

The title should be concise and indicate clearly the purposes of the study. One should keep in mind its possible usefulness to the reader who may scan a bibliography in which it may be listed. The title should not claim more, for the study, than it actually delivers. It should not be stated so broadly that it seems to provide an answer that cannot be generalized, either from the data gathered or from the methodology employed. Figure 12.1 demonstrates a sample of the title page.

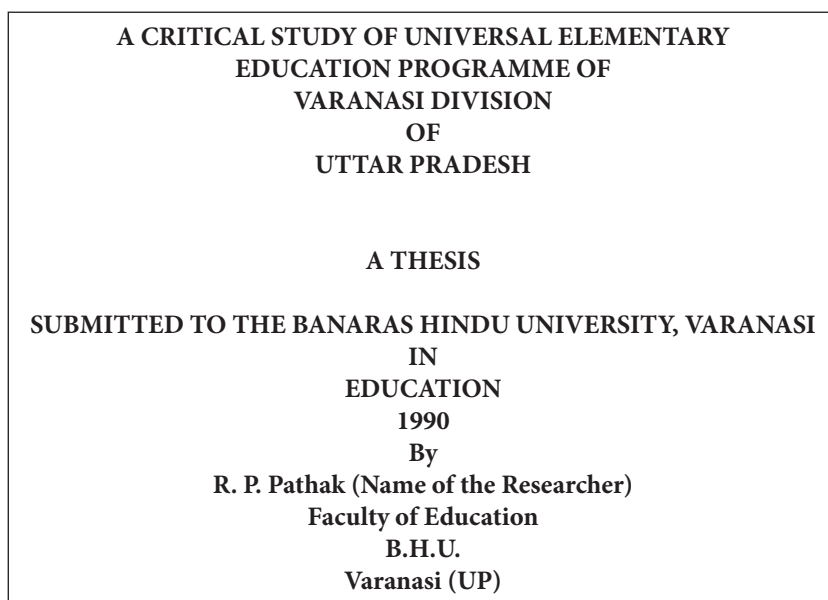


Figure 12.1 Sample of cover and title page

(ii) *Preface*

The preface usually includes a brief statement of the purpose and significance of the research problem followed by an overview of the chapters of the research report. It ends with acknowledgement of people who have given unusual assistance in the conduct of study. It is suggested that use of flattery and effusive recognition for routine participation by the members of the family, faculty advisor, librarian and clerical help are considered unnecessary. If the researchers have only little to say about the contribution of research work, a preface is omitted, instead, this section is entitled 'Acknowledgements'. Acknowledgement should be brief and simple. A brief statement of acknowledgements should sincerely recognize the persons and institutions whom the researcher is indebted for providing academic guidance, administrative facilities and financial assistance.

(iii) *List of contents*

Can you think of reading a book without list of contents, certainly not. Same is the case with research report. A good table of contents serves an important purpose in providing an outline of the contents of the report. This includes the major division of the report; the introduction, the chapter with their subsection, the bibliography and the appendix. The page number of each division and subdivisions are given. The preface or acknowledgements, list of tables and list of figures are also entered in the table of contents. The table of contents provides the reader a bird's eye view of the report and enables to quickly locate each section.

(iv) *List of tables and figures*

List of tables and figures are also included in the research report. A separate page is included for each list. Full titles of figures and tables with their corresponding number and pages are included.

Evaluate Yourself

- (i) Describe the importance of research report.
- (ii) What do you include in the preliminary section of the research report?

Main Body of Research Report

This section is divided into five subdivisions. In a thesis/dissertation these subdivisions represent the chapter. In a research paper, there may be sections with suitable headings.

Introduction

The introduction of a research report should be clear, complete and concise. It should begin with a statement of the problem. The exact statement of the problem may not be given, but a general nature of the problem to be investigated should be outlined in the first paragraph of the introduction. In the introduction, we define, analyse and state the nature of the problem. We also review the related studies so as to lay a foundation for research. The review of the results of previous researches brings out areas of agreement and disagreement. The introduction also includes the significance of the problem and the need for conducting the investigation. After reviewing the background of the problem, its scope and delimitations, the researchers present their hypotheses and the assumption on which the hypotheses are based. All important terms are carefully defined, so that the reader may understand the concept underlying the development of the investigation.

Development of Tools

Second chapter deals with the 'Development of the Tools'. This is an independent, extremely advanced and technical area of research and is based on well-developed theory of psychometrics. In this part, the researchers may give the development of a particular tool or a particular learning of teaching material. Here, they give the procedure along with assumptions underlying it. It is expected of the researchers to give sample details with the help of whom the research tool has been developed. Reliability and validity of these are given along with theoretical base. In case of teaching or learning material, process of validation is given.

However, there are some general principles and procedures, which a researcher is expected to follow while constructing a test developing material for teaching on learning. These are the following:

- Planning

- Writing of the tests items
- Tryout and item analysis
- Evaluation

Method and Procedure

Third chapter explains the 'Method and Procedure' in detail, i.e., the size of the sample, how it is selected, the design of the study used, and the variables and control employed. If the study is experimental, the researchers must clarify how the independent variables are manipulated and how the extraneous variables are controlled. The procedure of data collection, the instruction given to the subjects and safeguards are also mentioned. Third part deals with a detailed description of the data-gathering tools or tests. The psychometric properties of the test must be given clearly so that the appropriateness of tools can be judged. If the researchers develop a tool of data, chapter deals with the description of the statistical techniques employed for data analysis and interpretation and rationale for selection of a particular technique.

Analysis and Interpretation of Data

Fourth chapter deals with the 'Analysis and interpretation of the Data'. These data are presented in the forms of tables and graphs, with the text describing what is shown in table. This is the heart of the research report. The data are presented in tabulated form and figure accompanied by textual discussion. Through textual discussion and tabular and graphic devices, the data are critically analysed and reported. Tables and figures are used to clarify significant relationships. Tables and figures are well titled so that they are self-explanatory. Textual discussion may be used to point out generalization and significant interpretation. If complex tables are developed, they should be placed in the appendix. The description and inferential aspects of data should be analysed for each of the research hypotheses. If formulae or statistical producers that are not well known are used, they must be explained in detail. Statistical information may be presented in many forms. The main forms are sums, ratios, proportions or percentages, frequency distributions, means, standard deviations or variances, coefficients of correlation, and standard error of estimates. The levels of significance, the degrees of freedom available and values objectified are also reported. All the unexpected developments in the form of underparticipated results or unforeseen trends should be repeated fully. Any weakness in the research, design, tools, techniques or population that have come to light during the conduct of study should be discussed freely along with the manner in which factors may have affected the findings of the study.

Summary and Conclusion

Fifth chapter is entitled 'Summary and Conclusions'. It includes a brief restatement of the problem and a description of the procedures adopted. Impartment points in the study are highlighted but the evidence upon which they are based is not reported. The conclusions are stated precisely and related directly to hypotheses. Findings are statements of factual information based on the data analysis. The results of the study obtained after analysis of data are called conclusions. The conclusions refer to the results obtained from the observation of an example. The search does not end here. It should be possible to infer the behaviour of the population from which the sample was drawn. The description of the behaviour of the population having studied a sample of it is called generalizations. Generalizations have implications not only for target population, but also for other population. How best you can do this depends upon how carefully you have collected data and interpreted them.

The next part deals with the implications for educational practices. The chapter ends with recommendations for future researches that may be conducted in the related fields.

Reference Section

The reference section includes bibliography and appendix. Bibliography follows the main body of the research report. In a research article, the heading 'references' is used in place of bibliography. The first page of bibliography has a centre title 'Bibliography'. References are arranged in alphabetical order, i.e., the last name of the author listed first. The bibliography is a record of theses sources and materials that have been used for the study. If the number of references is large, the researchers may divide the bibliography into various sections; one for book, one for periodicals and journals, and possibly one for reports and special documents.

Appendix follows bibliography. All the relevant supporting unwieldy materials, that are important but not understanding of the report, are presented in the appendix. These materials include questionnaires, copies of covering letters used, evaluation sheets, checklists, courses of study, long quotations, tests interview forms, and raw data, which are placed in different appendices appropriately categorized and labelled.

Evaluate Yourself

- (i) List of heading under the main body of the Research Report.
- (ii) How is bibliography written?

Style and Format of Writing Research Report

An outstanding scientific investigation is of little value if its process and findings are not communicated effectively to others. Cambell (1969) and Turban have provided several style manuals. After adopting any of the style manuals, the researchers must adhere to it throughout the report. A clear statement of the hypotheses and logical objective presentation of the procedure rather than emotionalized descriptions are required in a scientific report. A research report is usually read by well-informed readers who always search for flaws in the process of reasoning. The research report should be presented in a creative, clear and concise way. The language used should be dignified and straight forward avoiding any long proverbial or discourteous phrases. Even the most profound ideas can be explained in simple language and short, coherent sentences, the personal pronouns, I, we, you, our and us are not used. Instead expression like the researcher or the investigator is used. For example, instead of saying: 'I administered achievement test in geography to both the groups of students' the preferable way would be achievement test in geography was administered to both the groups of students. The personal pronouns may be avoided by the use of such expressions as 'the researcher' or 'the investigator'.

Only the last names of cited authorities are used. Titles such as professor, Dr, Mr and Dean are omitted. The past tense should be used in describing research procedure that has been completed.

The use of abbreviations, except some universally acceptable ones such as IQ and MA should be avoided in the main text of the research report. Abbreviations may be used in footnotes, tables and figures, but they should not be used in the text of the report. A researcher should be familiar and master the following standard abbreviations:

art., arts
bk, bks
chap., chaps
col., cols

article, articles
book, books
chapter, chapters
Column, columns

div., divs	Division, divisions
e.g.	For example
et al.	and others
ed., eds	Edition, editions
ed., eds	Editor, editors
ibid.	same reference
op. cit.	previously cited
ilc. cit.	previously cited
fig., figs	figure, figures
idem	same person
illus.	illustrated
I.II	line, lines
f., ff.	and the following page (s) pp f. page and the following page pp 5 page 5 and the following pages
ms., Mss	manuscript, manuscripts
n., nn.	Note, notes
N.B.	Please note
n.d.	no date
n.n.	no name
n.p.	no place
n.s.	new series, new style
no., nos	number, numbers
pt., pts	Part, parts
sec., secs	section, sections
trans.	Translator and translated by
viz.	namely
vol., vols	Verse, verses
vv., vss	Verse, verses
rev.	revised or revision
passim	scattered
saic.	Thus
vide	see

At the beginning of a sentence, the number should be spelled out. Fractions, round numbers and numbers less than 100 should be spelled out. Figures are used for all small and large numbers, which appear in a series. In numbers with more than three digits, commas are used to point off thousands or millions, e.g., 2,503; 21,114,310. Use either letters or numbers in parentheses to enumerate items in a paragraph. Both forms of letters and numbers in parentheses are not used in the same report. All numbers at the beginning of the sentences are spelled out. Figures are used for decimals and percentage, but the word 'per cent' is spelled out, e.g., 12 per cent.

The ordinary rules of correct usage should prevail throughout the research report. A good dictionary, a spelling guide and Roger's thesaurus to what the researcher or other researchers have done should be used for linguistic correctness. The present tense should be used when the researchers are referring to the tables and charts that are presented before them and when they are presenting general truths and well-established principles. Researchers who have difficulty in written expression should have a competent

friend for proofreading their copy for correct usage before typing. Good report writing is not an easy task and can never be done in a hurry. Many revision are required in order to achieve a good report.

▲ Typing of Research Report

Although it is the responsibility of the researchers to prepare the manuscript of the research report for the typist in the proper form, it is always useful to engage a typist who is familiar with the style and form of the research report.

General Rules for Typing a Research Report

Some rules are given as follows, which should be observed while typing the report:

- A white bond paper of 8½ per cent by 11 in. size of 13–16 lb should be used for original and the finest copy of thesis. A lighter weight paper may be used for other copies. Fresh and black carbon paper and medium ink-type writer ribbon should be used.
- Material should be typed on both sides of the paper.
- The right margin should be 1 in., the left margin 1½ per cent in., the top margin 1¼ in. and the bottom margin 1½ per cent in.
- All the textual materials should be 1½ per cent spaced.
- An indentation of seven spaces is used for the beginning of a paragraph and quotations. Dividing words at the end of the line should be avoided as far as possible.
- The report looks good if typing is done on a computer. The correction of errors, additions and deletions are also easier. All the copies of the same quality can be obtained. The report can be preserved on a floppy or compact disk for future use.
- Different spacing is required for quotations, footnotes, tables and figures, appendixes and index (if any). These requirements are outlined with the discussion of each of these separately.

Rules for Typing Different Sections of a Research Report

The pattern and rules of typing preliminary section, main body, tables, footnotes, questions, bibliography, appendix and the index (if any) are different for each other. A detailed discussion of each of these will help the researcher to provide typist with the necessary diffraction for producing a satisfactory type script.

Preparing the Preliminary Section

The following are the different parts of a preliming section.

- (i) *Title page*
The title should be typed in capital letters, single spaced and centred between the right and left margins of the page. When more than one line is required, the words of the title are divided into lines so that each successive line is shorter than the one above and is centred below it since a varied pyramid style is also judged for the table tiled.
- (ii) *Preface or Acknowledgment page*
The heading 'Preface' or 'Acknowledgements' in capital should be centred. Three spaces below it should begin the first line of the contents. The researcher's initials are placed three spaces below the last line of the contents of acknowledgement and to the right of the centre of the page.

(iii) *Table of contents*

The heading ‘Table of Contents’ in capital should be centred at the top of the page. About three spaces below this heading page appears at the right margin. Preface or acknowledgements, list of tables and list of figures should be placed below this.. Then the heading ‘chapter’ appears at the left margin. The initial letters of column headings, ‘chapter’ and page are in the capital form. The ‘certificate from supervisor’, ‘preface or acknowledgement’, ‘list of tables’ and ‘lost of figures’ along with the chapter heading should be typed in capital letters and their sub-divisions in small letters, each word beginning with a capital letter. To insert page numbers for each division and sub-divisions, it is advisable to type the table of contents only after the entire final draft of the research report is typed. Table 12.1 represents a sample table of contents:

Table 12.1 Sample table of content page

	Title	Page No.
	Certificate from supervisor	(i)
	Acknowledgement	(ii)
	List of tables	(iii)
	List of figures	(iv)
Chapter I	Introduction	1–28
	Review of related literature	28–53
	Significance of problem	53–54
	Statement of problem	54
	Delimitation of study	55
	Objectives of study	56
	Statement of hypotheses	56
	Definition of important terms	57
Chapter II	Development of tools	57–84
Chapter III	Method and procedures	85–89
Chapter IV	Analysis and interpretation of data	90–138
Chapter V	Summary and conclusions	139–49
	Bibliography	150–67
	Appendices	
	Appendix A	
	Appendix B	
	Index/indices	

(iv) *List of tables and figures*

Following the table of contents are separate pages for the list of tables and figures with headings. Two spaces below these headings table and page (in case of list of tables) and figure and page (in case of list of figures) appear at the left and the right margin, respectively.

A table is a systematic method of presenting statistical data in vertical columns and horizontal rows, according to some classification of subject matter. Tables enable the reader to comprehend and interpret

masses of data rapidly. It should be organized in such a way that it facilitates the testing of a hypothesis. It should not exceed the size of the page. The title of the table should be brief, clearly indicating the nature of the data presented and understandable without the aid of textual material. Table 12.2 shows the list of tables.

A figure is a device that presents the data in a graphic form. The data are presented to a visual form, which clarifies the trend of data at a glance. Figures are of various types, e.g., graphs, charts, map sketches, diagrams and drawings. Figures should be prepared carefully and should be appropriate to the data and hypotheses, and should have all qualities of a good table. The title of the figure is placed below rather than above. If figures are numbered, follow Arabic rather than Roman numerals. Table 12.3 shows the method of presenting the figures.

Table 12.2 Sample list of tables

Table	Title	Pages
1	The scheme layout $2 \times 2 \times 3$ fractional design	86
2	Distribution of sample in different groups	87
3	School wise break up of the sample	87
4	Means of the control and treatment groups of pre and page-test Of the verbal knowledge/concept/rule learning and total test	113
5	Means and standard deviations of achievements scores for the The different sub-groups	122
6	Summary of analysis of variance of $2 \times 2 \times 3$ factorial design	123
7	t-ratios for different combinations of three learning types	124
8	t-ratios for different + combinations of treatment and cognitive styles	128
9	Summary of analysis of variance of $2 \times 2 \times 3$ factorial design of retention Scores	130
10	t-ratio for different combinations of three learning types of retention scores	132

Table 12.3 Sample list of figure pages

Figures No.	Title	Pages
1	Frequency polygon on the pre-test scores	92
2	Frequency of polygon on the post-test scores	94
3	Frequency of polygon on the retention scores	96
4	Ogive on the pre-test scores	98
5	Ogive on the post-test scores	100
6	Ogive on the retention of scores	102
7	Bar diagram of the scores of the verbal knowledge	104
8	Bar diagram for treatment and control groups	108

Typing of Main Body of the Research Report

For the purpose of clarity and ease of reading the chapters of thesis are divided into subsections. Each chapter has chapter number and heading. Chapter number is in bold roman numbers and chapter heading is capitalized and centred four spaces below the top line of the text. Textual material follows three spaces below the title. A major subdivision of a character or of a short-term paper is introduced with a centre head written in capital letters. Textual material that follows are placed three spaces below the centred head. A subdivision of a section of the part of discussion under the centred head is introduced by the free-standing side head flush with the left margin. For further subdivisions of the discussion, a paragraph side head is used with usual paragraph indentation. The divisions of the main body are the following.

Chapter Divisions and Sub-divisions. For clarity and ease of reading, the chapters of thesis and dissertations are usually divided into divisions and sub-divisions. This practice is not followed in research articles. The method of labelling chapter divisions and sub-divisions depends on the number of such divisions to be made. The type of heading used include centre headings, side headings and paragraph headings. In addition, each chapter has chapter number and chapter heading. Usually, centre headings are used for chapter divisions, and side and paragraph headings for sub-divisions. Many combinations of headings are also followed. The common types of combinations used are three, four levels of sub-divisions within a chapter. The following examples illustrate these levels of subdivisions within a chapter.

- (i) *Chapter headings:* Each chapter begins with a new page even if the last page of the preceding chapter has only two or three lines. The chapter number is typed in capitals and roman numerals with no punctuation. It is centred and placed 1½ in. lower from the top of the page. Chapter title is also centred and typed in capitals with no punctuation. It is centred horizontally one and a half space below the chapter number.
- (ii) *Centre headings:* Centre headings are used for major chapter division. It is numbered and centred horizontally on the page and typed in lower case except for the initial letter of keywords. Three single spaces usually separate the centre headings from text or from other headings above and below.
- (iii) *Side headings:* Side headings are used in major words that are capitalized. Side heading is not numbered. Three single spaces separate it from the text above and one double space below. Side headings are also typed in lower case except for the initial letter of keywords.
- (iv) *Paragraph headings:* For paragraph headings only initial letter of the first word are capitalized, which indicate divisions within sub-divisions. Each paragraph heading is underlined and typed in lower case, and separated from the text above by three single spaces.

Pagination. Every page of the research report is given a number, although it is not marked on it. The title page or the first page of the chapter, bibliography or appendix does not have a page number on it, but a number is allowed for it in the series. There are two separate series of page numbers. The preliminaries are numbered using small or lower case roman numerals (i, ii, iii and so on); the title page is assigned a number, which is not typed on it. Page numbers of the preliminaries should be placed in the centre, at the bottom of the page, and are positioned from the bottom of the page without punctuation. Roman numerals end with the last page or preliminaries preceding the main body of the report.

Arabic numerals are used to number all other pages beginning with the first page of Chapter 1. The bibliography, appendices and pages of tables and figures are numbered serially and consecutively, following the last page of the last chapter. This number appears without punctuation is the last chapter.

This number appears without punctuation in the top right-hand corner of the page. It is positioned 1 in. from the top and 1 in. from the right-hand edge of the paper. The first page of chapter I is assigned number I although this number is not typed.

Quotations. When the researchers cannot rephrase a law, mathematical formula or idea as concisely, accurately, or convincingly as the original author has phrased it, they used the exact words of the authors. Exactness means using the same words, same punctuation, same spelling and same capitalization.

Footnotes. As the name implies footnotes are found at the foot/bottom of a page. It enables the report writer authenticate a pointer argument, to explain, supplement or expand the material that is included in the main body of the report, and provide cross-references of material presented elsewhere in the report. It also enables a reader to independently consult the references and verify the materials presented. Footnotes are used sparingly these days. They are separated from the text by a line. The abbreviations already cited are used in giving reference and cross-references.

Style of Citation. Each reference beings at the left-hand margin of the page and material for each references listed is usually sing-spaced. There is double space between the references. The references are usually listed alphabetically by author's surname and the surname is typed flush with the left margin so that it stands out clearly. Second and subsequent lines of the same entry are single spaced starting three spaces from the left margin. The latest style of bibliography is as give below:

- (i) *For a single author:* Singh, Dalip (2003) 'Emotional Intelligence At Work.' London, Sage Publication, Ltd. Mehra Vandna (1995) 'Education Technology.' New Delhi, 8.8 Publisher. The name of the author (third name, first name, and second name) is followed by the year of publication. In case of book, the title of the book is underlined, while in case of journal, the name of the journal is underlined. The title of the article is typed in inverted commas. Next comes the type of publication followed by the name of the publisher.
- (ii) *For joint authors:* In case of two authors, the name of one author is written in the format: first name, second name, third name, e.g., Bhushan, Anand and Malvinder Ahuja (2002) 'Educational Technology (Theory and Practice in Teaching Learning Process).' 2nd edn. Patiala: Bawa Publication.
- (iii) *Three authors:* Carter V. Good, A.S. Barr and Douglas E. Scates (1971) 'Methodology of Education Research' (New York: Appleton Century Crofts, Inc.), p. 17.
- (iv) *More than three authors:* In case of more than three authors the abbreviation et al. is used after the first name. Other entries remain the same. Such as:
Abelson, R. P. et al. (Eds) (1968) 'Theories of Cognitive Consistency.' A Sourcebook (Chicago: Rand McNally).
- (v) *Editor is a collection readings:* Leon Festinger and Daniel Katz (eds) 1950, Research Methods in the Behavioural Sciences (New York: Holt, Rinha, Holt, Rinha, rt, and Winston, Inc., pp. 35–39).
- (vi) *For an article:* In case of journal article, the title of the article is enclosed in quotation marks. It is followed by comma and the name of journal is underlined. The volume number in roman numerals should follow it. The place of publication and publisher are not included. The date of publication enclosed in parentheses follows the volume number and a comma and page number follows it. No author is listed in the journal as the compiler in the following reference. 'Role of advance organizer in learning with respect cognitive style and learning types in High School Geography.' Journal of Recent Researches in Education and psychology, vol. 4, no. III–IV, 1999, pp. 108–117.

- (vii) *Pattern for report of commissions*: Government of India, Ministry of Human Resource Development, National Policy of Education (1986), New Delhi.
- (viii) *Pattern for unpublished material*: Mehar, Ram (1997), 'Role of Advance Organizer Is Learning and Retention with Respect to Cognitive Style and Learning Types in Geography,' Unpublished Ph.D. thesis in Education, Department of Education, Punjab University, Chandigarh.
- (ix) *Pattern for Newspaper Articles*: Pangotra, N. N., 'Audit Education – Some Issues.' The Sunday Tribune, March 10, 1991, P. 56.

Bibliography. Bibliography is typed at the end of the main body of the report and at the beginning of reference section. It is preceded by a page bearing the work BIBLIOGRAPHY, capitalized and centred on the page, the first page of the bibliography has the work 'BIBLIOGRAPHY' as center heading. It is a list of references (i.e., books, journals, reports of commission) in alphabetical order. Bibliography is different from a footnote. Bibliography is in alphabetical order. Bibliography is an alphabetical list of all the works that have been consulted for preparing the report, while footnote gives the exact references of book on the page where the references are referred.

Appendix. Different items to be included in the appendices are grouped and labelled as Appendix A, Appendix B, and so on. The headings are typed on capital letters and centred on the first page of each group of items. If there are no different groups of items, the first page of appendix should bear the capitalized general heading 'APPENDIX'.

Index. The index is preceded by a page containing the word 'Index', capitalized and centred on the page. The first page of the index has also the centred heading 'Index'. The index items are arranged by their key words. The index is set up in two columns. It is single space, with principal items beginning flush with the left-hand margin, the carry-overs indented three spaces, and sub-items indented two spaces. The items are followed by a comma and the page number (s) where the items in the text can be found.

▲ Proofreading of Final Draft of Research Report

When the final type copy of the report is completed, it is necessary to proofread each page carefully. The typing errors are best detected by proofreading line by line. A few erasures may be made to correct a copy, but crossing out or inserting words or sentences and typing over letter are not permissible. The corrections should always be made by typewriter and not in ink. It is advisable to retype the page if there are more than one or two corrections. While retyping care should be taken to accommodate the material in such a way that the last line on the page comes even. Otherwise, the researchers may have to retype the rest of the chapter and renumber the remaining pages of the research report. Before stitching the pages together or binding the research report, a final check should be made that the pages are arranged in the correct sequences.

▲ Binding and Submission of Research Report

It is the last activity of preparing a research report. Before binding it should be arranged properly and systematically and the serial number of pages should be checked carefully. It should be given to an expert binder who has the experiences of binding research thesis. Some universities require four copies of the thesis, five copies of abstract or summary and four copies of synopsis. These should also be prepared. A great precaution must be taken while imprinting the topic or title of the thesis that it must be the

Photostat form of the topic, which was approved by research degree committee. The covering page must be the same as inner cover given in preliminary section.

After binding the thesis it should be submitted to the university for evaluation. Researchers should ascertain the date of submission, evaluation, tuition fees and so on. For a post-graduate dissertation, student should plan that they should be able to submit it in time. They must also obtain the receipt of submission.

▲ Evaluation of Research Report

The evaluation of research report is a valuable exercise for the student of educational research. The critical analysis of many aspects of another researcher's report helps the evaluators in developing competency in their own research and reporting skills. The evaluation aspect is much more useful even to a guide or supervisor for instructing the research scholars in preparing a research report. Apart from these aspects of research report, its literary presentation should be worth for publications. There should be minimum or no typing errors. The researchers should have the confidence and competency to defend their work clearly and should be aware of the limitations of their study.

Evaluate Yourself

- (i) What are the main considerations in typing the research report?
- (ii) What is the place of appendices in the research report?

▲ Brief Summary of Research Report

Educational research in being concerned with the conduct of educational inquiry and the development and evaluation of its methods and findings, embodies a commitments to epistemological assumptions—at least if its findings are expected to command attention, serve as a sound basis for action, or constitute legitimate knowledge claims.

—Torsten Heusen and T. N. Postethwaite, 1994, Vol. 9, p. 5021

After completing the research, the researchers present the outcome of the study in a systematic way in the form of a research report. In case of the research being conducted as requirement of some examination, the report is submitted in the form of a thesis, otherwise it is prepared in the form of a project report.

The way the research report is presented will, to a great extent, enhance or diminish the value of the research work. Hence every care should be taken to prepare the research report in a systematic and scientific manner. These points should be kept in mind for preparing an effective report. Prospective researchers should know that writing research reports is a time-consuming and difficult task. Although research reports vary in scope and treatment, they often follow a conventional pattern and style.

▲ Format

Every research report should follow a format, which at times is prescribed by the agency or institution to which the report has to be submitted. But after going through various formats prescribed by different agencies, we can say that generally the format should include the following sections:

- *Preliminaries:* This includes the title page, preface, acknowledgement, table of contents, list of tables, list of figures and so on.

- *Main body:* This includes the following components: An introductory part giving the origin and context of the problem, its need and importance, justification of taking up the problem, delimitations and assumptions, definition of key terms, objectives, the sample and so on. The main body of the report should also include a section describing the related studies in the area of the present research.

A section of the main body should be devoted to description of the design of the study. This should include the main research methodology followed and the tools and techniques used for data collection. The most crucial part of the main body of research report consists of the presentation of data, its analysis and interpretation, which should lead to arrive at main findings and conclusions. The reporter also suggests some recommendations and lines for further research. A Ph. D. and M. Ed. dissertation often follows the following chapter scheme:

- Problem Justification/Rationale
- Review of Related Literature
- Methodology
- Tools and Techniques
- Field Work
- Data Collection and Analysis
- Interpretation and Conclusions
- Suggestions and Pointers for Future
- References
- Appendix
- References section: This section includes bibliography and appendices. The bibliography should include not the works, which have been quoted or referred to in the text, but the literature, which has been used directly or indirectly in the research work. The appendices may include a list of institutions included in the sample, list of experts consulted, addresses of places visited, specimen copies of tools used, photographs and additional graphical or statistical data.

▲ Executive Summary

A four-or five-page executive summary of the research work is prepared along with the research report. Sometimes it is presented separately or at the beginning of the research report. The old convention is to present a summary at the end of research report.

▲ Style and Language

The style of research reporting is very important. Many research reporters do not pay enough attention to the style of reporting thereby bringing down the quality of the research. It must be noted that research reporting is both a technique and an art. It is a technique as it follows a format, a pattern and a system, and it is an art because it involves a lucid, yet scientific presentation of the conclusions.

To seek international acceptance the research report has to remain within the confines of a given format or a pattern, but reporting is an art too. If the vocabulary of the researcher is not understandable by the reader, reporting makes little sense.

The language of the report need not be dull, drab and monotonous. It should be a creative work, which should give a pleasure to the person who reads it. The languages should be clear and concise, and

all efforts should be made to maintain objectivity. The language should be simple so that the reader has no difficulty in comprehending the report. This can be achieved by using simple and short sentences, which are coherent: 'Uncommon and inappropriate lexicon should be avoided', O. S. Dewal (ed.) (1997: 430).

It is always desirable to write short sentences. Complex structures and long sentences should be avoided. The author of the research report should ensure that there is a connection between sentences and paragraphs. Gaps and discontinuities should be avoided. It is always good to be brief, short, crisp and to the point. Unnecessary jargon of words is not recommended because good language should not be diffused, vague and casual. Abstract ideas should be illustrated with concrete examples. First person reporting should be avoided as far as possible. An overall structure and a detailed outline should be developed first and then it should be worked on elaborating each point.

A scientific report includes only those conclusions that emerge out of the data. There is very little place for vague and general remarks, which are not founded on empirical evidence.

'Objectivity does not mean that one should not put in sharp and biting things, at places some measure of an aggressive and assertive tone would be desirable. It would not demean the tentativeness of research findings. At times modesty and humility may be virtues but at other times they may not be so. A researcher's honesty of purpose. And courage of conviction should help him to coin richer idioms so as to express pithily and with force. Committed expression has a purpose. It crushes the intellectual inertia that pervades in our educational institution. It is achieved if the researchers put teeth into their reporting. As out self-complacency and weakness in reporting is so prevalent, that it would need Himalayan efforts to shake us out of our maintenance slumber. Many researcher who have come up with unpalatable findings have reported them in subdued tones so as to escape being called too radical in their view/or to escape from the controversy that it may stir up', (O. S. Dewal, 1997: 430).

In order to make the report brief, concise and easy to comprehend it is always desirable to present the data in tabular and pictorial form rather than giving a long description of the data. As far as possible avoid use of abbreviations. If at all used, the standard form of the abbreviation should be followed.

While reporting numbers it is advisable to write numbers less than ten in words, whereas large numbers should be written in figures. Care should be taken that a sentence should not commence with a number.

Mechanics

In preparing a good research report a research scholar should meticulously pay attention to some mechanics of reporting. Some suggestions in this area are as follows:

- Acknowledge the ideas taken from any work. If the language is reproduced verbatim it should be put within quote and unquote and the reference of the work should be given in the bibliography. When a very long quotation, five lines or more, has to be given, it should be separated from the main text and be given in single spacing with an extra margin than the original text. As far as possible very long quotations should be avoided and in place of such quotations the authors should summarize the idea in their own words. A simple rule of thumb may be useful and it is that the length of quotations should not exceed the length of the original text.
- Each chapter should not exceed the thoughtful heading. A chapter should be divided in subsections with suitable headings. In subsections coherent and related ideas should be presented.
- Graphs, figures and tables should have proper heading and should be numbered. The heading should be short. The table number and heading are given at the top of the table, whereas the figure numbers are given at the bottom of the figures and headings at the top. Generally, a figure or table

should come in between a text, and should not be given at the beginning of a paragraph. It is always advisable to give an introduction of a table first, which should be followed by the table and after that its interpretation should be given.

- References and footnotes should be provided using a well-known research format.
- Bibliography can be given at the end of each chapter and also at the end of the total report. It should be presented in alphabetic order of the last names of authors. The standard format of bibliography appearing in latest prominent research journals should be followed.

Evaluate Yourself

- (i) What should be the main constituents of the main body of a research report?
- (ii) Write down any four references to be included in the bibliography of a research report. (Use the correct format.)
- (iii) Go through a dissertation or any research report and comment upon its style, language and mechanics.

Summary

- We have learnt that writing a good research report requires skill and it is based on certain principles of clear organization and presentation. Knowledge of these principles is essential for effective communication and systematic presentation of the work done.
- Some tips regarding mechanics, presentation style, and language to be used have also been discussed.
- The research report is expected to follow the conventional pattern of style and form used in academic circles. Although style manuals may differ in some of the smaller details, students are expected to be consistent in following the pattern of style contained in the manual required by their institution. However, the style of writing should be clear, concise and completely objective. Of course, the highest standards of correct usage are expected and careful proofreading is necessary before the final report is submitted.
- Table and figures may help to make the meaning of the data clear. They should be presented in proper mechanical form and should be carefully designed to present an accurate and undistorted picture.
- The evaluation of a research project is a valuable exercise for students of educational research. Using analytical questions such as those suggested, the critique of another researcher's report helps the students develop competency in their own research and reporting skills.

Key Words

- *Research Report*: When research work, on completion, is produced in written form, it is called research report.
- *Glossary*: A glossary is a mini dictionary giving definitions or meanings of some words and terms used in the research report.
- *Footnotes*: Footnotes are those which are found generally at the foot of a page.
- *Ibid*: This Latin word is used in case of consecutive reference to the same work.

- *Op. Cit.*: It is used when a reference to same work is not used in consecutive but after some other reference.
- *Loc. Cit.*: It is used when a second but non-consecutive reference follows, referring to the same work and same page.

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Part II

Data Analysis

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Research consists of systematic observation and description of the characteristics or properties of objects or events for the purpose of discovering relationship between variables. The ultimate purpose is to develop generalization that may be used to explain phenomena and to predict future occurrences. To conduct research, certain principles must be established so that the observation and description have a commonly understood meaning. Measurement is the most precise and universally accepted process of description, that is, assigning quantitative values to the properties of objects and events. Descriptive statistical data analysis limits generalization to a particular group of individuals observed. No conclusions are extended beyond this group, and any similarity to those outside the group cannot be assumed. The data describe only one group. Much simple action research involves descriptive analysis and provides valuable information about the nature of a particular group of individuals.

In the application of statistical treatments, two types of data are recognized.

- (i) *Parametric data*: These types of data are measured data, and parametric tests assume that the data are normally or nearly normally distributed. Parametric tests are applied to both interval and ratio-scaled data.
- (ii) *Non-parametric data*: These types of data are either counted or ranked. These are sometimes known as distribution-free tests, and do not rest upon the more stringent assumption of normally distributed population.

Levels of quantitative description of parametric and nonparametric data are shown in Table 13.1.

Table 13.1 Levels of quantitative description

Level	Scale	Process	Data Treatment	Appropriate Tests
(iv) Ratio	Measured equal intervals true zero ratio relationship			t-test analysis of variance analysis of covariance factor analysis Pearson's r
		Parametric		
(iii) Interval	Measured equal intervals no true zero			
(ii) Ordinal	Ranked in order	Non-parametric		Spearman's rho (r) Mann-Whitney Wilcoxon
(i) Nominal	Classified and counted			Chi square median sign

Statistical Analysis

Statistical analysis is a mathematical process of gathering organizing, analysing and interpreting numerical data and is one of the basic phases of research process. Descriptive statistical analysis involves the description of a particular group. Inferential analysis leads to judgment about the whole population to which the sample at hand is to be related. Data are organized in arrays in ascending or descending numerical order. Data are often grouped into class-interval so that analysis is simplified and characteristics are more readily noted.

Measures of Central Tendency

Measures of central tendency (mean, median and mode) describe data in terms of some sort of average. Measures of position, spread or dispersion describe data in terms of relationship to a point of central tendency. The range, deviation, variance, standard deviation, percentile, quartile deviation and standard scores are useful measures of position, spread or dispersion.

One of the important objectives of statistical analysis is to get one single value that describes the characteristic of the entire mass of unwieldy data. Such a value is called the central tendency or an average or the expected value of the variable. The average gives a bird's eye view of the huge mass of statistical data, which ordinarily are not easily intelligible. The average gives a single measure representing all the scores. It enables us to compare two or more groups in terms of performance.

Characteristics of Average

The characteristics of an average are as follows:

- (i) *Rigidly defined*: An average is properly defined so that it has one and only one interpretation.
- (ii) *Based on all the observations*: All the items of the data are taken into consideration in its calculation.
- (iii) *Simple to compute*: An average is easy to compute so that it can be used widely.
- (iv) *Easy to understand*: Statistical methods are designed to simplify complexity, so it is desirable that an average is easily understandable.
- (v) *Sampling stability*: The average is not affected by sampling fluctuation. This means that if we pick 10 different groups of college students, and compute the average of each group, we get approximately the same value.
- (vi) *Capable of further algebraic treatment*: An average can be used for further statistical computations. We can combine average of two or more series.

Arithmetic Mean

- *Mean of ungrouped data*: The arithmetic mean or simply mean is the sum of separate scores or measures divided by number of scores. The formula for mean (M) of an ungrouped data is

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

$\sum X$ = Sum of the total scores

N = Total number of cases

Example 1: The following list gives the marks of 10 students in a class: 80, 65, 70, 68, 72, 58, 67, 56, 64, 60. Calculate the arithmetic mean of scores.

Solution:

S. No.	Marks
1	80
2	65
3	70
4	68
5	72
6	58
7	67
8	56
9	64
10	60
$N = 10$	$\Sigma X = 660$

$$M = \Sigma X / N = 660 / 10 = 66$$

Thus means of marks is 66.

Arithmetic mean of grouped data: The formula for computing mean of data grouped into frequencies is

$$M = \Sigma fX / N$$

N = Total number of observations, i.e., Σf

f = Frequency

Steps:

- Write scores (X) in first column and frequencies (f) in second column.
- Multiply the frequency (f) of each row with the scores (X) to get fX . Add the column ΣfX to get.
- Divide the total ΣfX obtained in step (ii) by number of scores i.e., N of Σf

Example 2: The marks obtained in an examination for 60 students of a class are given. Calculate the arithmetic mean.

Marks	20	30	40	50	60	70
No. of Students	8	12	20	10	6	4

Solution:

Marks		No. of Students
X	f	fX
20	8	160
30	12	360
40	20	800
50	10	500
60	6	360
70	4	280
	$N = 60$	$\Sigma fX = 2460$

$$\begin{aligned}
 M &= \Sigma fX / N \\
 &= 2460 / 60 = 41
 \end{aligned}$$

Calculation of Mean by Short Method

The method used in Example 3 is known as long method. This method often requires the handling of large numbers and involves tedious calculations. To simplify calculations the alternate method known as short method has been devised. In this method, we guess or assume a mean at the outset, and later apply a correction to this assumed mean (AM) in order to obtain the actual mean. Let us learn about this method through the following Example 3.

Example 3: Calculation of mean by short method

	Class Interval	Midpoint	Frequency	fx'	
	X	X'			
50–60	55	55	2	20	
40–50	45	45	1	20	-----+ 40
30–40	35	35	0	0	
20–30	25	25	–1	–25	
10–20	15	15	–2	–20	
0–10	5	5	–3	–15	----- – 60
			$N = 100$	$\Sigma fx' = -20$	-----

$M = [\Sigma fx'/N]i$

where M = mean

AM = assumed mean

F = Frequency

X' = deviations of midpoints (x) from assumed mean (AM)

i = length of the class interval

$AM = 35$

Class interval $i = 10$

$35 + [-20/100] 10 = 35 + [-0.2] 10$
 $= 35 - 2 = 33$

Steps:

- (i) One of the mid values is taken as an assumed mean. There is no set rule for assuming a mean. The best plan is to take the midpoint of an interval somewhere near the middle of the distribution, and if possible, the midpoint of that interval, which contains the largest frequency. In Example 3, two intervals 20–30 and 30–40 happen to be in the middle of distribution, but interval 30–40 holds the highest frequency. Hence, AM is taken to be 35 at the midpoint of this interval.
- (ii) Then we fill in the x' column. It donates the deviation of midpoints x from the assumed mean in units of class interval. Thus, the value of x' against the interval in which assumed mean has been supposed is zero. In Example 4, x' value is zero against midpoint 35. The remaining values of x' are fixed 1, 2, 3... to the increasing values of x than AM and –1, –2, –3, ... to the decreasing values of x than AM .
- (iii) After completing x' column has to be computed by multiplying each value of x' by the corresponding f value. All the values of fx' on intervals above the AM are positive and below are negative.

- (iv) Then the correction term $[\sum fx'/N]i$ is obtained. The sum of negative values of fx' is -60 and sum of positive values of fx' is -40 . $\sum fx'$ is the algebraic sum, i.e., $-60 + 40 = -20$ the correction term is obtained by multiplying -20 with i (10) and dividing by N (100). It came out to be -2 . Thus actual mean is $35 - 2 = 33$.

Median

Calculation of median when data are ungrouped: When ungrouped scores or measures are arranged in order of their size, the midpoint in the series is the median.

Median is the value of middle item of the series when it is arranged in ascending or descending order of the magnitude. The scores of seven students are

35, 30, 33, 37, 40, 38 and 43

If we arrange these seven scores in order of size.

30, 33, 35, (37), 38, 40, 43

The median is 37, as it is the middle value of the series.

If we have scores of six students arranged in ascending order as.

36

30, 33, 35, $\uparrow$ 37, 38, 40

Here the value of the middle item of the series lies half way between 35 and 37. Therefore, 36 is the median. Thus, the formula for finding median of a series of ungrouped scores is

$$\text{Median} = \left(\frac{N+1}{2} \right) \text{th term}$$

In our first example, the median is $(7+1)/2^{\text{nd}}$, i.e., 4^{th} term in the series, which is 37. In our second example, the median is $(6+1)/2^{\text{nd}}$ of 3.5^{th} term, i.e., mid way the 3^{rd} and 4^{th} term, which came out to be 36.

Calculation of Median in a Grouped Data

- (i) Find out the cumulative frequencies (cf).
- (ii) Median = $(N+1)/2^{\text{nd}}$ term.
- (iii) Now look at cf column and find the total equal to $(N+1)/2$ or next higher to that and determine the term correspond to it.

Example 4:

Marks	No. of Students	
Arranged in order	f	cf
0	7	50
75	8	43
70	14	35
68	11	21
65	6	10
52	4	4
	—	
	$N = 50$	

$$(N + 1)/2$$

$$= (50 + 1)/2$$

$$= 51/2$$

$$= 25.5\text{th term}$$

cf 35 means term 22nd to 35th are each 70.

So value of 25.5th term is 70

Thus, median = 70.

In a data grouped into frequency distribution, the value of median lies in a class interval. To obtain the definite value of the median, interpolation has to be done. On cumulative frequency we have to go half way starting from lowest or highest end. We have to find the value below which and above which there are 50 per cent of cases. In most of the problems, it would happen that 50 per cent or half of the cases are reached within a particular interval. Then median is calculated by the following formula.

$$\text{Median} = l + \left(\frac{N/2 - F}{f} \right) i$$

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

N = Total number of cases.

F = Cumulative frequency below the class interval in which median falls.

i = Length of the class interval

Example 5:

Class Interval	Frequency	c.f.
50–60	10	100
40–50	20	90
30–40	(30)	70
20–30	25	40 – F
10–20	10	15
0–10	5	5
	$N = 100$	

$$N/2 = 100/2 = 50$$

41st to 70th term l, i.e., in c.i. 30–40, therefore this class contains the median.

Here,

$$l = 30$$

$$F = 40$$

$$f = 30$$

$$i = 10$$

$$\begin{aligned} \text{Median} &= l + \left(\frac{N/2 - F}{f} \right) i \\ &= 30 + \left(\frac{50 - 40}{30} \right) 10 \\ &= 30 + 100/30 \\ &= 30 + 3.33 = 33.33 \end{aligned}$$

Mode

Mode is said to be a value that occurs most often in the data, that is, with highest frequency.

In the following ungrouped data,

25, 30, 32, 27, 38, 27, 28, 34, 27

the mode is 27 because it occurs thrice and no other score occurs more than twice. Thus, 27 is the most often occurring score.

The data in which two scores occur maximum number of times is known as bimodal.

For example, in the following data

40, 46, 45, 44, 43, 43, 44, 47, 46, 41, 48, 49

we find that each of the scores 44 and 46 occurs twice and all other scores only once.

Thus, we accept the two modal values, i.e., 44 and 46.

When calculating mode from a frequency distribution, we distinguish between mode and crude mode. Crude mode is usually taken to be the midpoint of that class interval, which contains the highest frequency. In Example 6, interval 30–40 contains the highest frequency. Thus, 35, midpoint of this interval is the crude mode. In Example 7, interval 25.29 contains the highest frequency and hence, 27, midpoint, is the crude mode.

The true mode is the point of greatest concentration in the distribution, that is, the point at which more measures fall than at any other point.

A formula for approximating the true mode, when the frequency distribution is symmetrical or at least not badly skewed is

$$\text{Mode} = 3 \text{ Mdn} - 2 \text{ Mean}$$

Example 6: (X) Find out the mean, median and mode of the following data

Class Interval	Midpoint X	c.f.	x'		xf'
40–44	42	9	3		27
35–39	37	16	2		32
30–34	32	18	1		18
					— +77
25–29	27	25			0
20–24	22	15		0	–15
15–19	17	12		–1	–24
10–14	12	5		–2	–15
		—		–3	—
			$N = 100$		

$$\text{Mean} = AM + \left[\sum fx'/n \right] i$$

$$= 27 + [23/100]5$$

$$= 27 + 1.15 = 28.15$$

$$\text{Median} = 28.1$$

$$\text{Mode} = 3 \text{ Median} - 2 \text{ Mean}$$

$$= 3 (28.1) - 2 (28.15)$$

$$= 84.3 - 56.3$$

$$= 28$$

Measures of Variability

The average is after all a single numerical value and may fail to reveal the entire data. Thus, after measuring the central tendency the next step is to find some measure of variability of the data. Variability is the spread or scatter of the separate scores around their central tendency.

The usefulness of a measure of variability can be seen from a simple example. Suppose a mathematics achievement test is administered to a group of boys and girls. The mean scores are same, i.e., 50 for both the groups, showing there by no difference in the achievement of boys and girls. But the boys' scores are found to range from 20 to 80 and girls' scores from 40 to 60. The difference in range shows that boys cover more territory and are more variable than girls. Thus, small variability means homogeneity in the group, whereas large variability means wide difference in the scores of individuals.

The common measures of variability of dispersion are as follows:

- Range
- Quartile deviation
- Mean deviation
- Standard deviation

Range

Range is defined as the interval between the highest and the lowest scores. This is the simplest possible measure of variability. It is generally a measure of spread or scatter of data.

$$\text{Range} = \text{Highest Score} - \text{Lowest Score}$$

Range is used for rough comparison of two or more groups. It is not reliable when N is small. It is not appropriate for comparison of the distributions, which are in different units.

In the above example range of the boys' scores is $80 - 20 = 60$ and the range of the girls' scores is $60 - 40 = 20$.

Quartile Deviation

The quartile deviation is one half the distance between the third quartile (Q_3) and the first quartile (Q_1) in a frequency distribution.

$$Q = \frac{Q_3 - Q_1}{2}$$

To find Q , we have to calculate Q_1 and Q_3 . First quartile Q_1 is the score on the scale, below which lies 25 per cent of the scores: Third Quartile Q_3 is the point on score scale below which lies 75 per cent of the scores Q_1 and Q_3 are the 25th and 75th percentiles, respectively. These statistics are found in exactly the same way as was the median. The median is 50th percentile or Q_2 .

$$Q_1 = l + \left(\frac{N/4 - F}{f} \right) i$$

$$Q_3 = l + \left(\frac{3N/4 - F}{f} \right) i$$

l = Exact lower limit of the interval in which the quartile falls.

F = Cumulative frequency below the particular interval in which quartile falls.

f = frequency of the interval which contains the quartile

i = The length of the class interval.

Example 7: Calculate quartile deviation.

Class Interval		Frequency
	f	c.f.
90–99	1	100
80–99	5	99
70–79	12	94
60–69	20	82
50–59	26	62
40–49	13	36
30–39	8	23
20–29	7	15
10–19	4	8
0–9	4	4
	—	
	100	

$$Q_1 = 39.5 + \left(\frac{25 - 23}{13} \right) 10$$

$$= 39.5 + 1.5 = 41.04$$

$$Q_3 = 59.5 + \left(\frac{75 - 62}{20} \right) 10$$

$$= 59.5 + 6.55 = 66$$

$$Q = \frac{Q_3 - Q_1}{2}$$

$$= \frac{66 - 41.04}{2}$$

$$= 24.96/2 = 12.48$$

Mean Deviation

Mean or average deviation is the arithmetic mean of the deviations of all the scores from mean. In an ungrouped data, mean deviation can be found by the formula.

$$MD = \Sigma |x| / N$$

where $x = X - M$ and $\Sigma |x|$ denotes the sum of the deviations from mean irrespective of sign.

Example 8: Calculate the mean deviation of the following data.

Scores	$x = X - M$	$ x $
34	4	4
34	4	4
33	3	3
31	1	1
30	0	0
29	-1	1
28	-2	2
28	-2	2
27	-3	3
26	-4	4
—		—
$\Sigma x = 300$		$\Sigma x = 24$

Mean

$$M = \Sigma x / N = 300/10 = 30$$
$$MD = \Sigma |x| / N = 24/10 = 2.4$$

Mean Deviation of Grouped Data

Find Q_1 MD and SD from the following data:

Class Interval	Midpoint X	F	fx	$x = X - M$	fx	fx^2
80–84	82	1	82	25	25	625
75–79	77	3	231	20	60	1200
70–74	72	5	360	15	75	1125
65–69	67	7	469	10	70	700
60–64	62	8	496	5	40	200
55–59	57	11	627	0	0	0
50–54	52	9	468	-5	-45	225
45–49	47	7	329	-10	-70	700
40–44	42	6	252	-15	-90	1350
35–39	37	2	74	-20	-40	800
30–34	32	1	32	-25	-25	625
		—	—		—	—
		$N = 60$	3420		$\Sigma x = 540$	$\Sigma fx^2 = 7550$

Mean = $\Sigma fx/n = 3420/60 = 57$

$$Q_1 = 44.5 + \frac{15-9}{7} 5$$
$$= 44.5 + 4.29 = 48.79$$
$$Q_3 = 64.5 + \frac{45-44}{7} 5$$

$$= 64.5 + 71 = 65.21$$

$$Q = \frac{Q_3 - Q_1}{2}$$

$$= \frac{65.21 - 48.79}{2}$$

$$16.42/2 = 8.21$$

$$MD = \Sigma |x| / N = 540/60 = 9$$

$$SD = \sqrt{\frac{\Sigma fx^2}{N}} = \sqrt{\frac{7550}{60}} = 11.22$$

Standard Deviation (SD)

Standard deviation *SD* is the root-mean square deviation measured from the average. One of the major limitations of *MD* is that it ignores the sign of deviation. In *SD*, we avoid this difficulty by squaring the separate deviations. *SD* is the square root of the arithmetic average of square of the deviations measured from the mean. In *SD*, deviations are always measured from mean of the distribution and not from median or mode. *SD* is denoted by letter 'sigma' = (σ)

Calculation of *SD* from Ungrouped Data

$$SD = \sqrt{\frac{\Sigma x^2}{N}}$$

where x is deviation of X values from the mean.

N is total number of cases.

Example 9:

Scores X	Deviations $x = X - m$	x^2
80	14	196
72	6	36
70	4	16
68	2	4
67	1	1
65	-1	1
64	-2	4
60	-6	36
58	-8	64
56	-10	100
$\Sigma x = 600$		—

$$\Sigma x^2 = 458$$

$$M = \Sigma X / N = 660/10 = 66$$

$$= \sqrt{\frac{\sum x^2}{N}} = \sqrt{\frac{458}{10}} = \sqrt{45.8} = 6.77$$

Calculation of SD from Grouped Data

In a data grouped into frequencies, the deviation of each item is not possible. So deviation of midpoint of each class interval is taken from the mean. Then, square of each deviation is weighted against its frequency. Formula for SD of a grouped data is:

$$SD = \sqrt{\frac{\sum fx^2}{N}}$$

Steps: Following are the steps of calculating SD.

- (i) Write column midpoint X' and frequency f . Then, calculate mean $M = \sum X'/N$.
- (ii) Write column x deviation, i.e., $X' - M$.
- (iii) Write column fx by multiplying x with f of the corresponding rows.
- (iv) Write column fx^2 by multiplying entries of column x with that of fx . Note that all the entries will be positive. The process of calculating SD from a grouped data is illustrated in Example 3.

Calculation of SD by Short Method

Short method is same as used in calculating mean. This method simplifies the calculation particularly when exact mean is in decimals. We use the AM, calculate deviations from AM and then apply the correction term. The formula for computing SD by the short method is:

$$SD = \sqrt{\frac{\sum fx^2}{N} - \left(\frac{\sum fx}{N}\right)^2}$$

Steps:

- (i) First AM is taken as in the case of mean.
- (ii) The column midpoint (x), frequency f , deviation (x') and fx' are written in the same way as in Example 3.
- (iii) Write column fx'^2 by multiplying the corresponding entries of fx' column with that of x' column. Note all the resulting entries will be positive.

Class Intervals	f	x'	fx'	fx'^2
195–199	1	5	5	25
190–194	2	4	8	32
185–189	4	3	12	36
180–184	5	2	10	20
175–179	8	1	8	8
170–174	10	0	0	0
165–169	6	–1	–6	6
160–164	4	–2	–8	16
155–159	4	–3	–12	36
150–154	2	–4	–8	32
145–149	3	–5	–15	75
140–144	1	–6	–6	36
	—		—	—
	$N = 50$		$\sum fx' = -12$	$\sum fx'^2 = 322$

$$\begin{aligned}
 SD &= \sqrt{\frac{\sum fx^2}{N} - \left(\frac{\sum fx}{N}\right)^2} \\
 &= 5\sqrt{\frac{322}{50} - \left(\frac{-12}{50}\right)^2} \\
 &= 5\sqrt{6.44 - 0.058} \\
 &= 5(2.256) \\
 &= 12.63
 \end{aligned}$$

Graphical Representation of Data

The data is first tabulated in a frequency distribution. Next step is to analyse the data. It can be by finding measures of central tendency and variability. But for quick and easy understanding the data can be represented graphically. Following are the methods of graphical presentation of a data.

Histogram

Histogram is the most popular and widely used method of presenting a frequency distribution graphically.
Steps:

- (i) Draw two mutually perpendicular lines intersecting at 0.
- (ii) Fix the horizontal line OX as x -axis and vertical line OY as y -axis. 0 is the origin.
- (iii) Mark the class intervals along x -axis starting from lowest and ending with the highest class interval of the frequency distribution. The class intervals in a histogram should be continuous. If they are discontinuous make them continuous.
- (iv) Mark frequencies along y -axis by selecting appropriate scale.
- (v) Frequency of each class interval is drawn against both the limits of the intervals, thus making the rectangles with base as interval length and height equal to the respective frequencies (Figure 13.1).

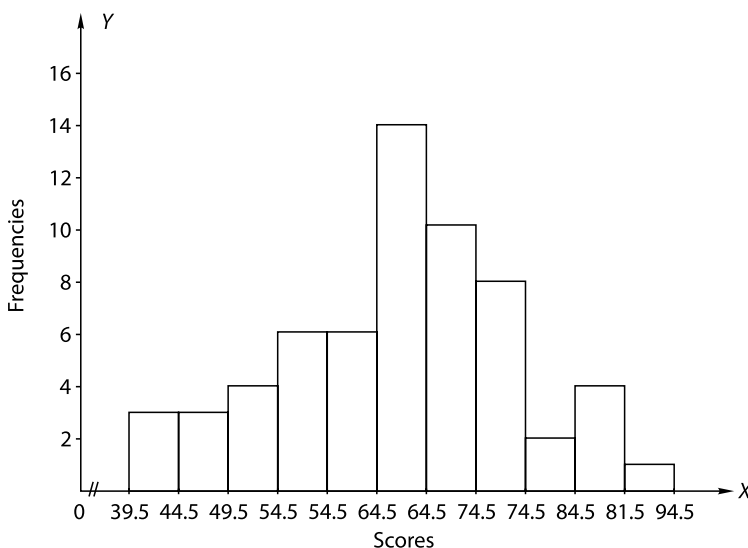


Figure 13.1 Frequencies and scores of histogram

Example 10: Represent the following data by means of a histogram.

Class Intervals	Frequency (<i>f</i>)
90–64	1
85–89	4
80–84	2
75–79	8
70–74	9
65–69	14
60–64	6
55–59	6
50–54	4
45–49	3
40–44	3
	—
	<i>N</i> = 60

Frequency Polygon

A frequency polygon is a figure representing the graph of a frequency distribution. In a frequency polygon, midpoint of the class interval represents the entire interval. The frequency of the interval is drawn against midpoint of the interval. The assumption is that all the scores are centred at the midpoint of the interval.

Steps of Construction. Following are the steps of construction:

- (i) Draw *x*-axis and *y*-axis.
- (ii) Mark class intervals along the *x*-axis.
- (iii) Marks frequencies along the *y*-axis. Scale of the axes should be chosen carefully so that entire height of *y*-axis is approximately 3/4th of the length of *x*-axis.
- (iv) Draw points representing frequencies against midpoints of the respective intervals. For example, midpoint of the first interval is 42 and the frequency is 3. So draw a point on the graph representing the coordinate point (42, 3). Similarly, draw points representing (47, 3), (52, 6), (57, 6) and so on.
- (v) Join all the points in regular order by straight lines.
- (vi) To complete the polygon we have to join it on both ends with the *x*-axis. We consider one extra interval 35–39 at the lower end and one extra interval 95–99 at the upper end of the distribution of the *x*-exits. The frequency against each of these intervals is zero (Figure 13.2).

Smoothing Frequency Polygon

Sometimes, we find irregularities in the frequency distribution or data on a small sample. The frequency polygon of such distributions is jagged. To remove the irregularities and get a more clear perception of the data, the frequency polygon may be smoothed as shown in Figure 13.3. To smooth the polygon running averages of frequencies are taken as new or adjusted or smoothed frequencies. To find

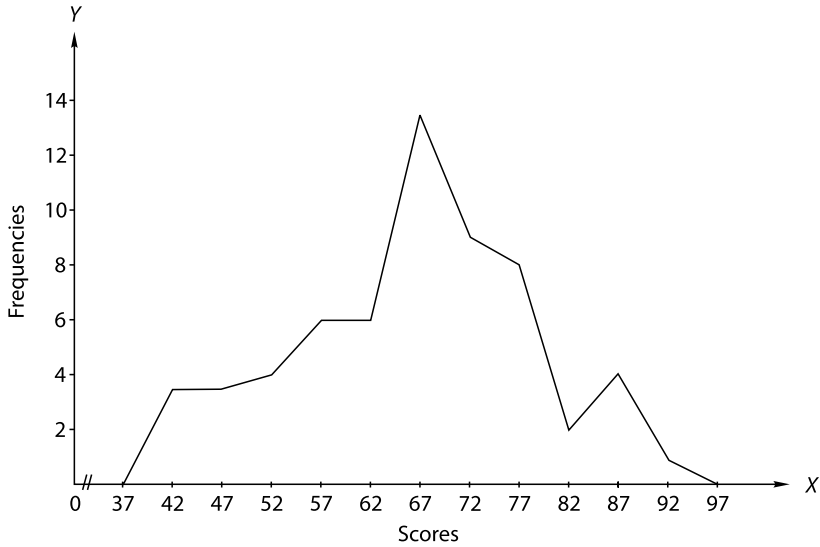


Figure 13.2 Frequencies and scores of polygon

the smoothed frequencies, we add the f on the given interval and the f 's of two adjacent intervals and divide. For example, the smoothed frequency of interval 45–49 is $(3 + 3 + 4)/3 = 3.33$.

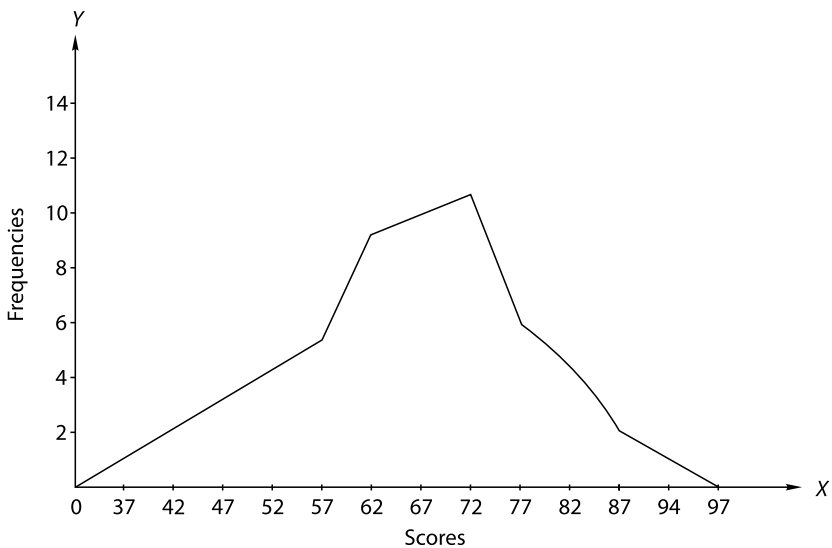


Figure 13.3 Smoothed frequencies and scores of polygon

The process is illustrated as under:

Class Intervals	Frequency (<i>f</i>)	Smoothed (<i>f</i>)
90–64	1	$(0 + 1 + 4)/3 = 1.66$
85–89	4	$(1 + 4 + 2)/3 = 2.33$
80–84	2	$(4 - 2 - 8)/3 = 4.66$
75–79	8	$(2 + 8 + 9)/3 = 6.33$
70–74	9	$(8 + 9 + 14)/3 = 10.33$
65–69	14	$(9 + 14 + 16)/3 = 9.66$
60–64	6	$(14 + 6 + 6)/3 = 8.66$
54–59	6	$(6 + 6 + 4)/3 = 5.33$
50–54	4	$(6 + 4 + 3)/3 = 4.33$
45–49	3	$(4 + 3 + 3)/3 = 3.22$
40–44	3	$(3 + 3 + 0)/3 = 2$

Cumulative Frequency Curve or Ogive

Cumulative frequency of an interval is found by adding to the frequency against it. It is the sum of all the frequencies against the intervals below it. We start from bottom for cumulating the frequency. Then, we plot the cumulated frequencies instead of respective frequencies against the intervals. It is to be noted that in a cumulative frequency curve each cumulative frequency is plotted against the upper limit of the intervals. The process of finding cumulative frequencies and drawing curve is illustrated below. The cumulative frequency curve starts at lowest interval touching the *x*-axis, it rises gradually and becomes almost parallel to *x*-axis after reaching the highest point (Figure 13.4).

Class Intervals	Frequency (<i>f</i>)	Cumulative Frequency (<i>c.f.</i>)
90–64	1	$59 + 1 = 60$
85–89	4	$55 + 4 = 59$
80–84	2	$53 + 2 = 55$
75–79	8	$45 + 8 = 53$
70–74	9	$36 + 9 = 45$
65–69	14	$22 + 14 = 36$
60–64	6	$3 + 3 + 4 + 6 + 6 = 22$
54–59	6	$3 + 3 + 4 + 6 = 16$
50–54	4	$3 + 3 + 4 = 10$
45–49	3	$3 + 3 = 6$
40–44	3	3
	—	
	<i>N</i> = 60	

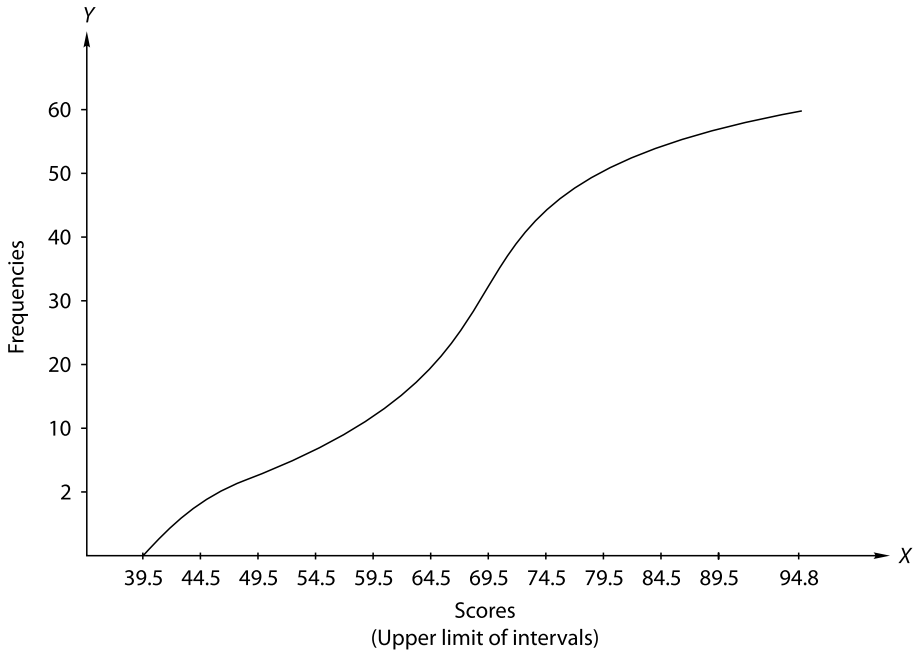


Figure 13.4 Cumulative frequency of curve

Normal Distribution

The earliest mathematical analysis of the theory of probability dates back to the eighteenth century. Abraham DeMoivre, a French mathematician, discovered that a mathematical relationship explains the probabilities associated with various games of chance. He developed the equation and the graphic pattern that describes it. It has been found to describe the fluctuations of chance errors of observation and measurement. Some understanding of the theory of probability and the nature of the curve of normal distribution is necessary for comprehension of many important statistical concepts, particularly in the end of standard scores, the theory of sampling and inferential statistics.

The law of probability and the normal curve is based on the law of chance or the probable occurrence of certain events. When any of observation conforms to this mathematical form, it can be represented by a bell-shaped curve with definite characteristics.

Normal Probability Curve (NPC)

Look at the frequency distribution of scores obtained by a group of 100 students on an English language test of speaking fluency given in Table 13.2. The columns III and IV of the table present midpoints and relative frequencies of the same frequency distribution. The distribution has also been depicted by a frequency-curve (dotted lines). In Figure 13.5 the frequency polygon is drawn on the midpoints on the axis of x and their corresponding relative frequencies of the axis of y .

Table 13.2 Frequency distribution of scores of English language test

Classes	Frequency	Midpoints	Relative Frequency
20–29	6	24.5	6/100
30–39	10	34.5	10/100
40–49	13	44.5	13/100
50–59	25	54.5	25/100
60–69	17	64.5	17/100
70–79	12	74.5	12/100
80–89	10	84.5	10/100
90–99	7	94.5	7/100

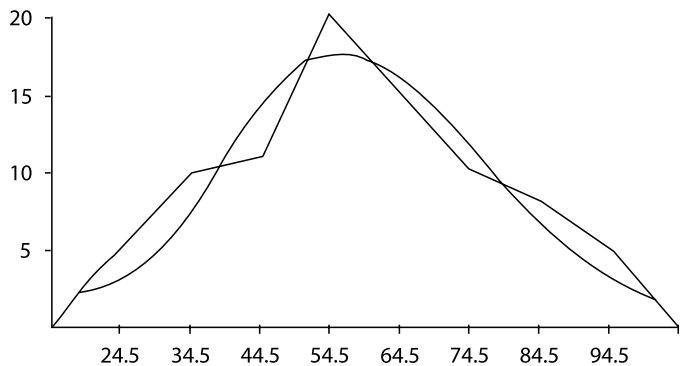


Figure 13.5 Frequency distribution of scores of English language test

The curve in Figure 13.5 is a relative frequency as it is drawn to plot midpoints and relative frequencies.

Probability is defined as a ratio of expected number of cases to the total number of cases in which an event can happen, when the total number of cases is innumerably large, i.e., infinite. So, for all practical purposes, consider a very large number in place of infinite.

Look at the relative frequencies in Table 13.2. The frequencies of a class are taken as the expected number of cases, in which a randomly selected case may fall in the class. The total frequencies are taken as the total number of ways in which a case may fall in any one of the given classes.

Thus, the idea of probability compares well with relative frequencies especially when the total number of frequencies of a distribution is very large. For practical purposes, as the number of cases increases the obtained relative frequency curve will become probability curve.

We should pay attention and make a note of the following aspects of the curve:

- a: Shape
- b: Extension on the x-axis
- c: Height of the curve

Thus, every probability curve of human characteristics obtained *may not be a normal probability curve*.

The normal probability curve is a strictly defined curve in its shape, slope and is perfectly symmetrical about an ordinate at the central point of the curve (Figure 13.6). It is a perfect curve, which is based on a mathematical model formulated as follows:

$$P(y) = \frac{N}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left\{\frac{X-M}{\sigma}\right\}^2}$$

where

y : Frequency

N : Total number of observations

e : 3.1416 (approx.)

π : 2.718 (approx.)

X : Scores

M : Mean of the distribution

σ : Standard deviation of distribution

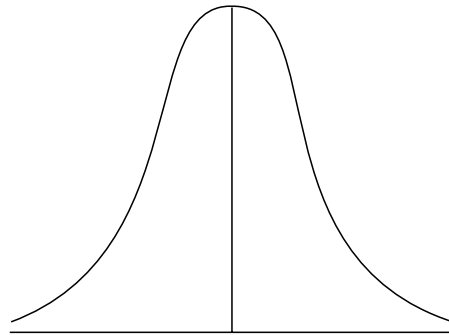


Figure 13.6 Normal probability curve

Since it is a distribution for very large number (infinite) of cases, it is called as population distribution. Most of the obtained probability curves of human characteristics approximately tend to resemble to the normal probability curve. Hence, it may be used as a measuring unit of the distributions of human characteristics. Because of this characteristic, the normal probability curve (NPC) is used very frequently in the research of social sciences for estimation, prediction and testing.

Characteristics of Normal Probability Curve

Look at the curve given in Figure 13.7 and try to identify some of its characteristics.

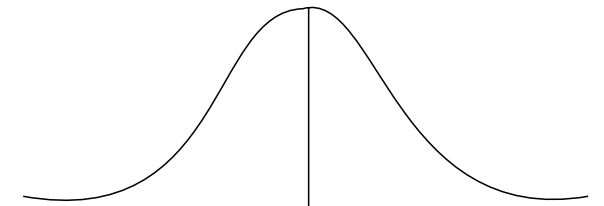


Figure 13.7 Normal probability curve

- NPC is a bell-shaped unimodal (having one mode) curve.
- It is perfectly symmetrical about the ordinate at the mean of the distribution.
- The curve extends from $-\infty$ to $+\infty$ on both the sides of the middle point of the curve.
- Regarding slope of the curve, it changes its curvature from concave (at the top) to convex (at the tails). P_1 and P_2 (Figure 13.8) are the points where the curve changes its curvature. These two points are known as points of Inflexion. If the ordinates are drawn on the base line from these two points, the points Z_1Z_2 at which the ordinates P_2Z_2 and P_1Z_1 cut the base line fall at 1σ distance on both the sides of the ordinate $MoMn$. Hence, it may be said that the points of inflexion of the curve fall at the $+1\sigma$ distance from the middle point of the curve.
- In addition to its character regarding shape, symmetry, size and slope, the NPC possesses a typical distribution of its area depicting corresponding probabilities.

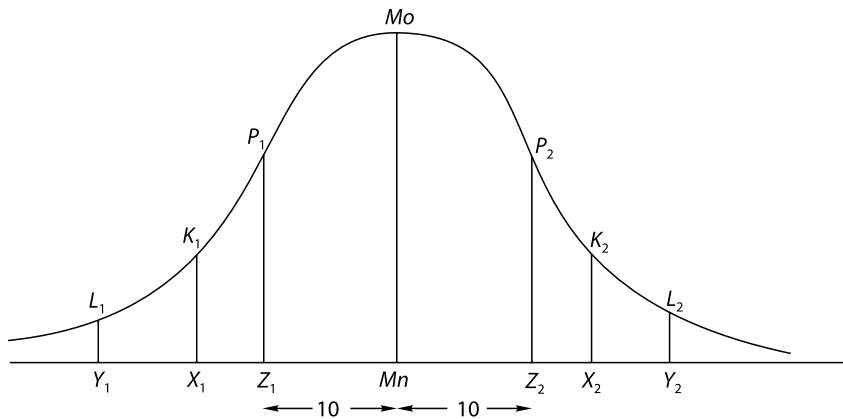


Figure 13.8 Normal probability curve

On a typical normal distribution the area covered between the two ordinates at $z = \pm 1.00$ is 6826. The area covered between the two ordinates at $z = \pm 1.96$ is 9500. The area covered between the two ordinates at $z = \pm 2.58$ is 0.9900. The area covered between the two ordinates at $z = \pm 3.00$ is .9974.

It can be observed through the above citation, though theoretically, that the NPC extends from $z = -\infty$ to $+\infty$, but practically 95 per cent of the total cases fall between the ordinates at $z = +1.96$ and -1.96 .

Ninety-nine percent of the total cases fall between the ordinates at $z = +2.58\sigma$ and -2.58σ . Virtually, the functional extension of the NPC is from $z = +3\sigma$ to -3σ as only 26 out of 10,000 cases will fall beyond $x = \pm 3\sigma$.

The probability function of the curve is a complex function of z (unit normal variate), which formulates as:

$$P(y) = \frac{N}{\sigma\sqrt{2\pi}} e^{-\frac{x^2}{2\sigma^2}}$$

The desired probability values are obtained by integrating the probability function for each value of z .

In order to facilitate the researchers, the values of the probability functions for each value of z are computed up to four places of decimal points, and arranged in a two-way contingency table (Table 13.3).

Table 13.3 Fractional parts of the total area (taken as 10,000) under the normal probability curve, corresponding to distances on the baseline between the mean and successive points laid off from the mean in units of standard deviation

Example: Between the mean and a point 1.38σ ($x/\sigma = 1.38$) are found 41.62 per cent of the entire area under the curve.

Table 13.3 Between the mean and point per cent of area under curve per cent

x/σ	00	0.01	0.03	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0000	0040	0080	0120	0160	0199	0239	0279	0319	0359
0.1	0398	0438	0478	0517	0557	0596	0636	0675	0714	0753
0.2	0793	0832	0871	0910	0948	0987	1086	1064	1103	1141
0.3	1179	1217	1255	1293	1331	1368	1406	1443	1480	1517
0.4	1554	1591	1628	1664	1700	1736	1772	1808	1844	1879
0.5	1915	1950	1985	2019	2054	2088	2123	2157	2190	2224
0.6	2257	2291	2324	2357	2380	2422	2454	2486	2517	2549
0.7	2580	2611	2642	2673	2704	2734	2761	2794	2820	2852
0.8	2881	2910	2939	2967	2995	3023	3051	3078	3106	3133
0.9	3159	3186	3212	3238	3264	3290	3315	3340	3365	3389
1.0	3413	3438	3461	3485	3508	3531	3554	3577	3599	3621
1.1	3643	3665	3686	3708	3729	3749	3770	3790	3810	3830
1.2	3849	3869	3888	3907	3925	3944	3962	3980	3997	4015
1.3	4032	4049	4066	4082	4099	4115	4131	4147	4162	4177
1.4	4138	4209	4222	4236	4251	4265	4279	4292	4306	4319
1.5	4332	4345	4357	4370	4383	4394	4406	4415	4429	4441
1.6	4452	4463	4474	4484	4495	4505	4515	4525	4535	4545
1.7	4554	4564	4573	4582	4591	4599	4608	4616	4625	4633
1.8	4641	4649	4656	4664	4671	4678	4686	4693	4699	4706
1.9	4713	4719	4726	4732	4738	4744	4750	4756	4761	4767
2.0	4772	4778	4783	4788	4793	4798	4803	4808	4812	4817
2.1	4821	4826	4830	4834	4838	4842	4846	4850	4854	4857
2.2	4861	4864	4868	4871	4875	4878	4881	4884	4887	4890
2.3	4893	4896	4898	4301	4904	4906	4909	4911	4913	4916
2.4	4918	4920	4922	4925	4927	4929	4931	4932	4934	4936
2.5	4938	4940	4941	4943	4945	4946	4948	4949	4951	4952
2.6	4953	4955	4956	4957	4959	4960	4961	4962	4963	4964
2.7	4965	4966	4967	4968	4969	4970	4971	4972	4973	4974
2.8	4974	4975	4976	4977	4977	4978	4979	4979	4980	4981
2.9	4981	4982	4982	4983	4984	4984	4985	4985	4986	4986

(Continued)

Table 13.3 (Continued)

x/σ	00	0.01	0.03	0.03	0.04	0.05	0.06	0.07	0.08	0.09
3.0	4986.5	4968.9	4987.4	4987.8	4988.2	4988.6	4988.9	4989.3	4989.7	4990.0
3.1	4990.3	4990.6	4991.0	4991.3	4991.6	4991.8	4992.1	4992.4	4992.6	4992.9
3.2	4996.129									
3.3	4995.166									
3.4	4993.631									
3.5	4997.674									
3.6	4998.409									
3.7	4998.922									
3.8	4999.519									
4.0	4999.683									
4.5	4999.966									
5.0	4999.997133									

Normal Probability Curve Table

The areas of the normal curve in terms of the table assume a normal distribution whose standard deviation is equal to 1.00 and whose area under the curve is equal to 1.00. It is already know that on a normal curve, size of the ordinate y is maximum, i.e., 3989 at the middle point of the curve. It decreases as one goes away from the middle on both sides on the x -axis. Now you will learn how to make use of the normal probability curve table.

Study the table and note the following four observations:

- *Observation 1:* Although different normal probability tables give probability/area starting from different reference points the normal probability table measures area/probabilities starting from the ordinate at the mean (origin or the middle point of the curve on the x -axis). Look at the above table. There are 10 different values in each row below the head value 00, 0.01, 0.02, 0.03..., 09, respectively. Against a value 1.00 on the first column, 1.00 and below 0.03 is 0.3485 (see in the body of the table). This reads as area/probability corresponding to $z = (1.00 + 0.03)$, i.e., 1.03 is 0.3485. Here tables give values starting from the ordinates at $z = 0$. The area corresponding to $z = 1.03$ is the area lying between the two ordinates, one at $z = 0.00$ and another at $z = 1.03$. This area can be seen as the shaped area in Figure 13.9. We can try our hand for tracing the areas corresponding to $z = 1.97$ and 2.35 as 0.4756 and 0.4906, respectively.

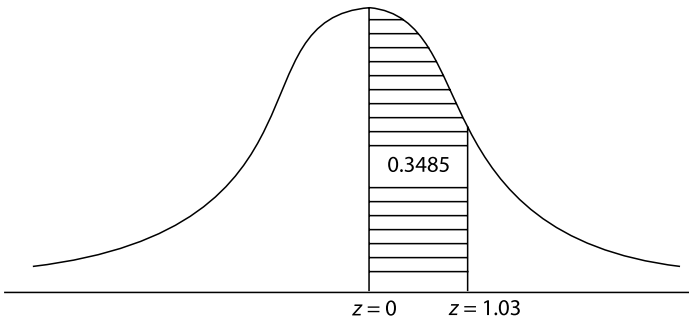


Figure 13.9 Shaped are of NPC

- **Observation 2:** From the table you can read areas/probabilities corresponding to given values of z and vice versa. Look at the NPC Table 13.4 p. no. 39–40. Consider the area, for example, 3888. Locate that value in the table. The area corresponds to two values as 1.20 and 0.02. The former can be located on the extreme left-hand column, and later at the top row, then z -value corresponding to a value 3888 of area will be $z = 1.20 + 0.02 = 1.22$.

Consider another value 4902. This value you could not locate in Table 13.4 as such. I hope, you must have located 4901 and 4904. These are two near values corresponding to 0.03 and 0.04, respectively, on the two row and 2.30 on the extreme left-hand column. In such a situation, out of 4901 and 4904, select one which is nearest to the value of 4902. On this criterion the value of z corresponding to a value of 4901 will be taken for 4902. This value is $z = 2.30 + 0.03 = 2.33$.

Try some more examples of similar nature by tracing values of z corresponding to areas 4902 and 4505.

- **Observation 3:** It is already told that each value of area is computed out of 10,000 cases in total. A statement that the area between the two ordinates, at $z = 0$ and 1.03 is 3485 means that out of 10,000 cases 3485 cases lie in between the two ordinates. But we talk in terms of probability, which is just $3485/10,000 = 0.3485$.

Assuming the total area of the curve as unity, it can be said that the area lying between the two ordinates is 0.3485. If the cases are assumed to be 100, then in between the two ordinates will lie $100 \times .3485$ cases. It will read as 34.85 per cent cases would lie between the ordinates at $z = 0$ and 1.03.

- **Observation 4:** The NPC table covers the distribution of probability only on the positive arm of the curve. By the property of the symmetry of the curve, the other half also follows the same distribution. A simple corollary to this is if the area corresponding to $z = 1.00$ is 3413, then the area corresponding to $z = 1 = -1.00$ will also be 3413. The area is never negative.
- **Observation 5:** Again your attention is invited to the NPC table. You see that the area corresponding to $z = 1.96$ is 0.4750. It indicates that the number of cases falling between the ordinates at $z = 0$ and 1.96 will be $4750 \times 100 = 47.50$ per cent.

The number of cases falling between the ordinates at $z = 1.96$ and -1.50 will consist of two fragments of area (see Figure 13.10).

- Area falling between the ordinates $z = 0$ and 1.96 will be equal to 0.4750
- Area falling between the ordinates at $z = 0$ and -1.50 will be 0.4332 (by the property of symmetry).

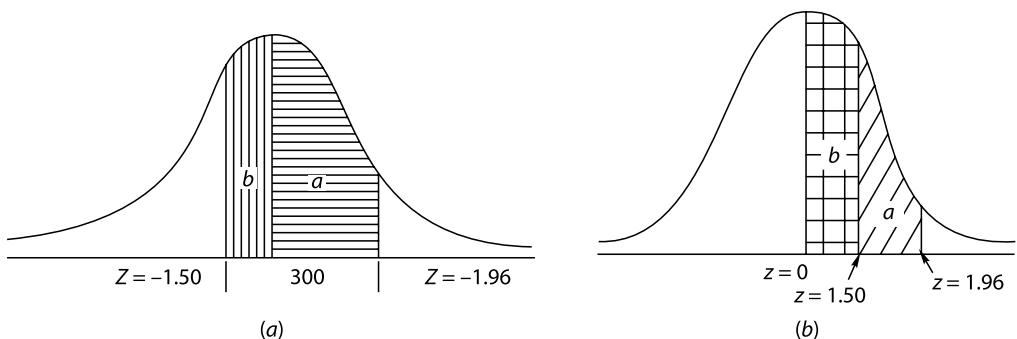


Figure 13.10 (a) Area falling between the ordinate of NPC and
(b) Cases falling between the two ordinates of NPC

So the per cent number of cases falling between the ordinates at $z = 1.96$ and 1.50 will be

$$\begin{aligned}
 &= 100 \times (a + b) \\
 &= 100 \times [0.4750 + 0.4332] \\
 &= 100 \times 0.9082 \\
 &= 90.82 \text{ per cent}
 \end{aligned}$$

In a similar situation, the number of cases falling between the ordinate at $z = 1.96$ and 1.50 will be of two fragments a and b where

- (i) The area falling between the ordinates at $z = 1.96$ and 0 will be 0.4750 .
- (ii) The area falling between the ordinates at $z = 1.50$ and 0 will be 0.4332 .

So the per cent number of cases falling between the two ordinates $z = 1.96$ and 1.50 will be

$$\begin{aligned}
 &= + 100 \times (a - b) \\
 &= 100 (0.4750 - 0.4332) \\
 &= 100 (0.0418) \\
 &= 4.18
 \end{aligned}$$

■ **Observation 6:** You have seen that the area corresponding to $z = 1.96$ is 0.4750 . The area above the ordinate at $z = 1.96$ would be the total area falling on the right side of the ordinate. As you know the area between $z = 0$ and 1.96 is 0.4750 .

- (i) The total area of the curve is 1 . The area on the right of the ordinate at $z = 0$ would be 0.5000 . So the area above/beyond the ordinate at $z = 1.96$ indicated in Figure 13.11 would be $= 0.5000 - 0.4750 = 0.0250$.

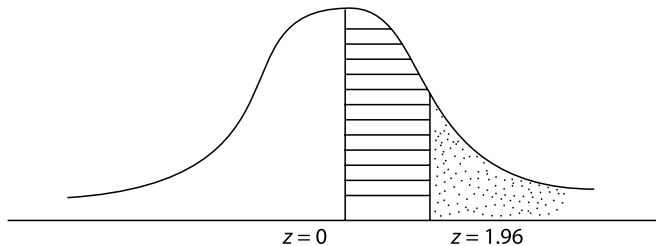


Figure 13.11 The total area of the NPC

The number of cases falling above $z = 1.96$ would be 2.5 per cent.

- (ii) The area falling below the ordinate at $z = 1.96$ would be determined by adding the area falling between the ordinates $z = 0$ and 1.96 to the area falling in the lower half of the curve, which is equal to 0.5000 . The area falling below the ordinate at $z = 1.96$ indicated in Figure 13.12 would be $= 0.5000 + 0.4750 = 0.9750$. The percentage cases falling below the ordinate at $z = 1.96$ would be 97.50 .

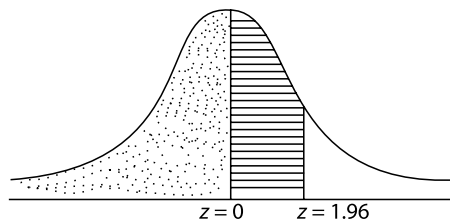


Figure 13.12 The percentage cases falling between ordinate of NPC

Applications of NPC

Let us now learn some of the applications of NPC with the help of problem-examples:

Problem I

Assuming, normality of a distribution of 230 cases with mean $M = 48.00$ and $\sigma = 8$, find out the number of cases that would fall between the scores 44 and 64 on the distribution.

Note: Though the problem can be solved in more than one way, here the model solution is demonstrated in three steps.

Solution:

Step 1: Transform raw scores on to z -scale (where mean is 00 and SD is 1σ).

The number of cases that are expected to fall between the two scores 44 and 64 are required. The formula for the transformation of X -values (raw values) on a standard scale is $Z = \frac{X - M}{\sigma}$ where X is the value of raw obtained score (Figure 13.13).

M represents the standard deviation of X -distribution. The z -scale value for the raw score $x = 44$ is given by $z = \frac{44 - 48}{8} = \frac{-4}{8} = -0.50$.

Similarly z -scale value for the raw score $X = 64$ would be

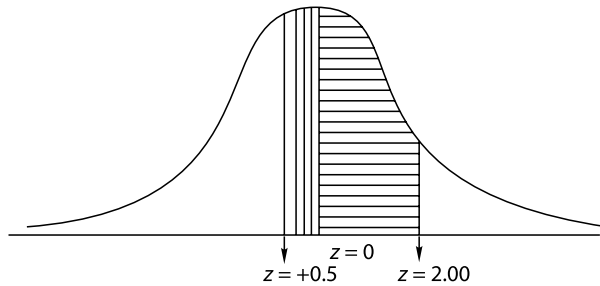


Figure 13.13 The scale value for the raw score of NPC

Step 2: Locate the required area on the normal probability curve and process the constituent segments of the areas.

The area corresponding to $z = +0.5$ is 0.1915 and 2.00 is 0.4772. By the property of symmetry the area corresponding to $z = -0.50$ is also 0.1915 with the only difference that this area falls on the left half of the NPC and the area corresponding to $z = 2.00$ lies on the right side.

Therefore, the proportion of cases confined between the two ordinates at $z = 0.05$ and 2.00 will be equal to the area at the right segment + area at the left segment = $0.1915 + 0.4772 = 0.6687$.

Step 3: Compute the required number of cases. The total number of cases in the distribution is 250. The proportion of cases confined between 44 and 64 are 0.687. Therefore, number of cases confined between 44 and 64 are = $250 \times 0.6687 = 167.1750 = 167$ approximately.

Measures of Relationship

Correlation is the relationship between two or more paired variables or two or more sets of data. The degree of relationship is measured and represented by the coefficient of correlation. The most widely

used measure of correlation is the Pearson's product moment correlation coefficient (r). This measure is used where the variables are quantitative, i.e., of the interval or ration scale. Other methods of correlation have been developed for the use with nominal and ordinal variables. One measure commonly used to describe the relationship between two nominal variables is the contingency coefficient. The technique, which is used for ordinal variables is rank order correlation.

‘Whenever two variables of the same group are so related that the increase or decrease corresponds to the increase or decrease to another or conversely, increase or decrease corresponds to the decrease or increase to another, they are said to be correlated’.

Generally, correlation is of two types:

- (i) Positive correlation (+) and
- (ii) negative correlation (-).

Perfect—positive correlation Perfect—negative correlation

- (i) *Positive correlation* means that the increase of one variable corresponds to the increase of another variable or the decrease of one variable corresponds to the decrease of another variable. It has been shown with help of Figure 13.14.

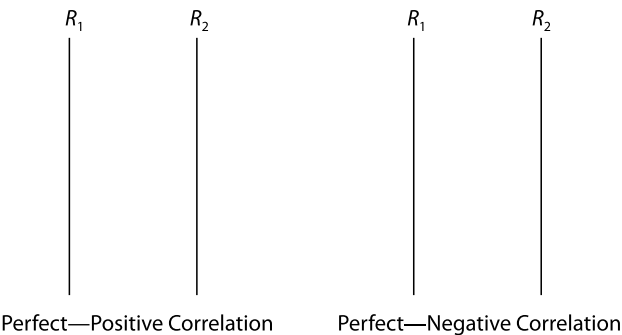


Figure 13.14 Positive and negative correlation

- (ii) *Negative correlation* means that the increase of one variable corresponds to the decrease of another or the decrease of one variable corresponds to the increase of another variable. It is shown in Figure 13.15.

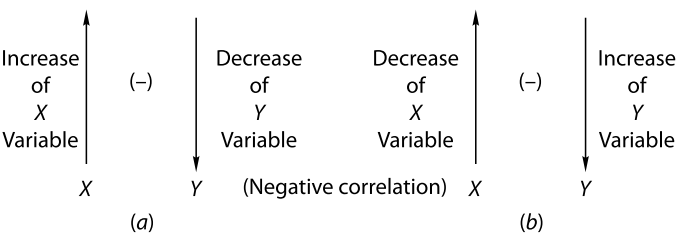


Figure 13.15 Negative correlation

The relations of this kind may be described by plotting the paired (X and Y) measurements on a graph paper, which is represented by a point. This type of plotting is known as *scatter diagram* or *scatter plot*. The scatter diagram provides the degree or extent of relation between two variables.

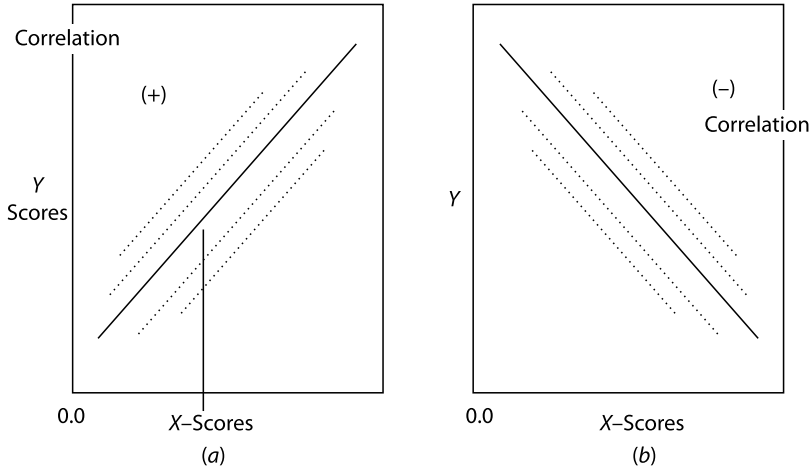


Figure 13.16 Scatter diagram of relation between two variables

Figure 13.16(a) is a graphical presentation of high positive relation, where the points of X and Y pairs fall very close to a straight line. If the points lie exactly on a straight line, it will indicate perfect positive $(+1)$ relation between X and Y variables.

Figure 13.16(b) is a graphical presentation of high negative relation, where the points of X and Y pairs fall very close to a straight line. If all points lie exactly along a straight line, it will indicate perfect negative (-1) relation between X and Y variables.

If there is no systematic plotting of the points on the graph, it indicates zero relation or poor relation between X and Y . As the points distribution deviate from the diagonal, the degree or coefficient of correlation decreases. The correlation indicates the trends and patterns of bivariate distribution (Figure 13.17).

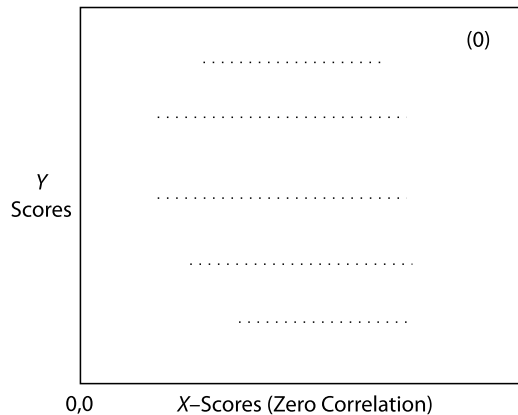


Figure 13.17 Bivariate distribution of correlation

Correlation Between Paired Observation

Suppose a sample consists of N subjects. The measure-ment or data are obtained on two variables X and Y for each subject. The data are written symbolically and ranks are assigned to each score of X and Y separately as follows:

Subject	Variates		Positive Relation		Negative Relation	
	X	Y	R_x	R_y	R_x	R_y
1	X_1	Y_1	2	2	2	8
2	X_2	Y_2	4	3	4	10
3	X_3	Y_3	1	4	1	N
4	X_4	Y_4	3	1	3	11
-	-	-				
-	-	-	‘		‘	
-	-	-	.	.	.	‘
.	’	.	’	.	.	.
’	’	’	.	N	.	.
.	.	.	N	.	N	.
.	.	.	‘	‘	.	I
N	X_N	Y_N	5	6	5	18

The data of X variable are assigned ranks in order of magnitude on X_1 to X_N . The highest rank 1 is assigned to X_3 and lowest N. Similarly, the ranks are assigned in order of magnitude on Y_1 to Y_N . In positive relation more or less same ranks are obtained for paired data of a subject. In negative relation, reverse ranks are obtained in the paired measurement. The highest rank 1 on X, while rank N on Y of the same subject and so on.

Between the two extreme arrangements, the maximum positive and negative relations are re-presented as shown in the above table.

In education and psychology there is not a single variable, which exists alone in the vacuum. Each of them is related to many other variables. Researchers in these fields have been interested in knowing how one variable is related to another, for example, how intelligence is related to students achievement, how motivation is related to performance of a group of individuals, how socio-economic status is related to mental development of children and so on. if we consider the marks of a group of students in science and mathematics, it may be found that there is some relation between them. To establish these relationships researchers have used mathematical methods known as correlation methods. These methods have played a very important role in many educational and psychological researches. There are several methods of finding out correlations, which are as follows.

Product-moment method, sometimes known as Bravias-Pearson method. Bravias, French Statistician of the nineteenth century first used the idea of product moment and Galton improved his work; Karl Pearson (1857–1925) is regarded as the successor of the latter.

- Rank order correlation
- Biserial correlation
- Point-biserial correlation
- Tetrachoric correlation

- Sheppard's coefficient (S)
- Yule's coefficient of association (Q)
- Phi (ϕ) correlation
- Contingency coefficient of correlation (C)
- Yule's w (coefficient of colligation)
- Correlation ratio (r_1) or eta correlation
- Partial correlation (r_{123})
- Multiple correlation (R)

Product-moments method and rank order correlation methods are very well known as they are taught to students right from the graduate level to postgraduate level. In this chapter an effort is made to introduce to the readers precisely the other methods of correlation, each of which is used in a specific situation. Their importance lies in the fact that in many situations of investigation scores are not obtainable. What is obtainable is the ranks, categories, classes or grades. This is mostly the case in vocational and applied psychology and in the field of evaluation of student's measurement of personality, attitudes and test construction. Also, there are situations in which the relationship between variables is found to be non-linear in which case product-moment r cannot be used. It is these situations which call for the use of methods other than the product moment r . Some of these methods are described in this chapter in addition to partial r and multiple R .

Biserial Correlation

Situation in Which It Is Used

It is used in a situation in which data on one variable is obtained in the form of two categories, classes or groups while on the other variable in the form of scores. In other words, when one variable can be measured and the other variable can only be classified into two categories, i.e., dichotomized, the method to be used for finding out correlation between them would be the biserial r . Such dichotomies may be intelligent–unintelligent, adjusted–maladjusted, favorable–unfavorable, above mean–below mean, high–low on any trait, high achievers–underachievers and so on. But the condition distributed otherwise, i.e., if more information is made available, it would be normally such man-made dichotomies that if this variable is measured on a large sample, it would be normally distributed. Dichotomous variable simply means a variable cut into two parts, groups or categories. Thus, the dichotomous variable in case of biserial r must satisfy the assumption of normal distribution.

Computation of Biserial r

The formula, used for computing biserial r is:

$$r_{b4s} = \frac{M_p - M_q}{\sigma} \times \frac{pq}{u} \text{ in which}$$

M_p = Mean of the one part of the dichotomized group

M_q = Mean of the second part of the dichotomized group

M_T = Mean of all the scores (entire group)

p = Mean of all the scores (entire group)

q = Proportion in one group

u = Height of normal curve ordinate separating p and q from the table given here (Table 13.4)

Example: Below are given scores on intelligence test (grouped) of 155 students, the entire sample and the scores of 124 high achievers and 31 low achievers out of the same group of 155 students. What is the correlation between intelligence and achievement?

Solution: Biserial r has to be computed from the Table 13.4.

Table 13.4 Scores on intelligence of 155 students—124 high achievers and 31 low achievers

Class Intervals (Scores on Intelligence) (1)	High (p) Achievers (2)	Low (p) Achievers (3)	Total Group (4)
130–139	16	11	27
120–129	27	6	33
110–119	16	2	18
100–119	6	5	11
90–99	21	0	21
80–89	19	1	20
70–79	19	6	25
N	124	31	155

$$M_T = 106.371 \quad p = 0.20 \quad v = 0.280, \text{ height of ordinate}$$

$$M_p = 113.21 \quad q = 0.80 \quad \text{separating } 0.20 \text{ and } 0.80 \text{ in a unit}$$

$$M_q = 104.66 \quad \sigma_1 = 21.46 \quad \text{normal distribution}$$

$$\begin{aligned}
 r_{bis} &= \frac{M_p - M_q}{\sigma} \times \frac{pq}{v} \\
 &= \frac{113.21 - 104.66}{21.46} \times \frac{20 \times 0.80}{0.280} \\
 &= \frac{8.55}{21.46} \times \frac{0.16}{0.28} \times 0.571 = 0.227
 \end{aligned}$$

Explanation:

On achievement two dichotomous groups, high achievers and low achievers, are formed by taking top 40 per cent and bottom 40 per cent or in any other way. Taking their scores on intelligence frequency distributions are shown in Table 13.4 in columns (2) and (3). Column (4) shows frequency distribution of the entire group of 155 students on intelligence.

M_T is the mean of the entire group of 155 students on intelligence, which is found to be 106.371.

M_p is the mean of the high achievers, which is found to be 113.21.

M_q is the mean of the low achievers, which is found to be 104.66.

σ is the standard deviation of the total group, which is found to be 21.46.

p is the proportion of low achievers which comes to be 0.20.

q is the proportion of high achievers which comes to be 0.80.

v is the ordinate, which comes to be 0.280 found from Table 13.4 at 0.30 ($80 - 50 = 30$ per cent from the mean) equal to v of 0.80 as show in Figure 13.18.

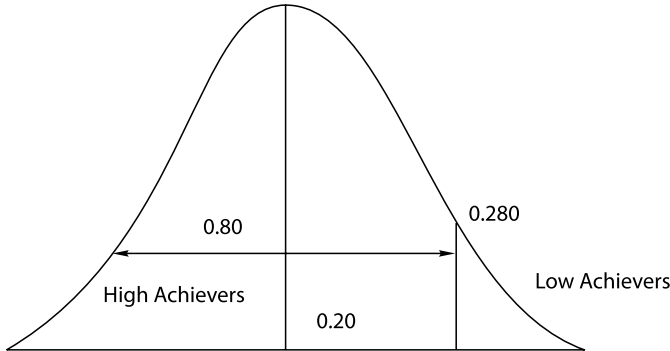


Figure 13.18 High and low achievers of scores on intelligence frequency.

Alternative Formula for r_{bis} . This is more convenient and is as follows:

$$r_{pbis} = \frac{M_p - M_q}{\sigma} \frac{pq}{v}$$

All the values of M_p , M_q , σ , p and v have already been calculated. Substituting these values in the above formula

$$\begin{aligned} &= \frac{113.21 - 106.371}{2.46} \times \frac{20}{0.280} \\ &= \frac{6.839}{21.46} \times 714 \end{aligned}$$

Characteristics of r_{bis}

Following are the characteristics and assumptions of r_{bis} :

- It is a good estimate of product-moment r if its assumptions are met.
- Assumptions are:
 - (a) Continuity in the dichotomized variable.
 - (b) Large N .
 - (c) Normality of distribution underlying the dichotomy.
 - (d) Dichotomy not too extreme—better close to the mean.
- It cannot be used in a regression equation.
- It is not confined within the limit of ± 1.0 . Hence, it cannot be compared with other correlations.

Point Biserial r (r_{pbs})

Situation in Which It Is Used

When the assumptions of biserial r are not satisfied, an alternative method of finding correlation is point-biserial method of correlation. When it is found that on one of the two variables instead of continuous scores natural (genuine) dichotomies are available, for example, the entire group on one variable can be split into two parts such as male-female, boys-girls, blind and normal, pass-fail, right-wrong and so on while on another variable scores are obtainable, the point biserial r is more appropriate. In this situation normality under the dichotomy on that variable cannot be assumed. The dichotomy is true, not man-made as is the case with biserial r .

Computation of Point Biserial r

The formula used for computing point-biserial r is

$$r_{\text{obs}} = \frac{M_p - M_q}{\sigma} \times \sqrt{pq} \quad \text{in which}$$

- (i) M_p and M_q are the means of the two dichotomized groups.
- (ii) p is the proportion in one dichotomized group.
- (iii) q is the proportion of another dichotomized group.
- (iv) σ is the standard deviation of the total group.

Example: There are 20 students whose scores are shown in Table 13.5 on achievement motivation (X) and pass-fail data of annual examination (Y) only are available. Is there any relationship between achievement motivation and school achievement?

Solution: Find out point biserial r as the data on variable school annual examination (Y) is available only in the form of true dichotomy of pass and fail, which may be given scores of 1 for pass and 0 for fail.

Steps:

- (i) Find out M_p , M_q , σ and pq from the table to be prepared as follows:
- (ii) Prepare the table as follows:

Table 13.5 Achievement motivation score

S. No.	X	Y	X^2	Y^2	XY
1	20	0	400	0	0
2	25	1	625	1	25
3	25	0	625	0	0
4	30	1	900	1	30
5	35	1	1225	1	35
6	40	1	1600	1	40
7	30	0	900	0	0
8	25	0	625	0	0
9	20	0	400	0	0
10	35	1	1225	1	35
11	30	1	900	1	30
12	25	0	625	0	0
13	20	0	400	0	0
14	25	1	625	1	25
15	30	1	900	1	30
16	40	1	1600	1	40
17	45	0	2025	0	0
18	50	1	2500	1	50
19	30	1	900	1	30
20	40	1	1600	1	40
$N = 20$	62	12	20,600	20	410

- (i) $M_p = 410/12 = 34.16$ (number passing)
(ii) $M_q = (620-410)/8 = 210/8 = 26.25$ (number falling)
(iii) $M_r = 620/20 = 31.0$
(iv) $p = 12/20 = 0.6$
(v) $q = 1 - 0.6 = 0.4$
(vi) $\sigma = \frac{20600 \times 20 - 620 \times 620}{20} = 8.307$
(vii) $r_{pbis} = \frac{M_p - M_q}{\sigma} \times \sqrt{pq}$

$$= \frac{34.16 - 26.25}{8.307} \times \sqrt{0.6 \times 0.4}$$

$$= \frac{7.91}{8.307} \times \sqrt{0.24} = 0.952 \times 0.4898 = 0.466$$

There is substantial relationship between achievement motivation and school achievement of these students.

Point biserial r is product-moment correlation. This can be shown by calculating product-moment r by applying the formula given below.

$$\begin{aligned}
 r &= \frac{(N \Sigma XY) - (\Sigma X \Sigma Y)}{\sqrt{[(N \Sigma Y^2 - (\Sigma Y)^2)][N \Sigma X^2 - (\Sigma X)^2]}} \\
 &= \frac{20 \times 410 - 620 \times 12}{\sqrt{[20 \times 12 - (12)^2][20 \times 20600 - (620)^2]}} \\
 &= \frac{8200 - 7440}{\sqrt{(240 - 144)(412000 - 384400)}} \\
 &= \frac{760}{\sqrt{96 \times 27600}} = \frac{760}{\sqrt{2649600}} = \frac{760}{\sqrt{1627.76}}
 \end{aligned}$$

It is the same as found by applying the point biserial method.

Characteristics. Following are the chief characteristics of point biserial correlation:

- It is more dependable than and preferable to r_{bis} .
- It makes no assumption about the distribution underlying the dichotomized variable.
- It is always within the range of ± 1.00 unlike the biserial r , which is not confined within this limit.
- It can be used in regression equation while r_{bis} cannot be used so.
- It is always lower than r_{bis} .
- Its standard error can be determined exactly.
- It can be used in item analysis like r_{bis} and is more valid as compared to r_{bis} . But r_{pbis} has an advantage over r_{bis} in that it can be quickly read from tables already prepared and available when percentage passing a given item in upper and lower groups are known.

Tetrachoric Correlation (r)

Situation in Which It Is Used

This correlation is used when both the variables are dichotomized; but the dichotomies are not natural. Rather they are man-made. The variables are not measurable in scores; but each of them can be separated into two categories such as above and below the mean. We then, have a 2×2 or fourfold table, which is used for computing the tetrachoric r (r_1).

Computation

(i) First a fourfold table is prepared as shown in Figure 13.19.

$- +$ B	$+ +$ A
$- -$ D	

Figure 13.19 First a four fold table of computation

The variables X and Y are shown to be dichotomized as above and below the mean. That is, a score below the mean on X and above the mean on Y will have a tally in the cell B . Similarly, a score above the mean on X and below the mean on Y will go to mark a tally in the cell C . In this way frequencies are filled in all the four cells. If the number of frequencies in cells A and D is more than the frequencies in cells B and C , then the correlation (r_1) is positive. If the frequencies in cells B and C are more, then the correlation is negative. Equal number of frequencies in each of the four cells means zero correlation.

The formula used for computing r is

$$r_1 = \cos \left(\frac{180\sqrt{BC}}{AD + \sqrt{ABC}} \right)$$

This gives only an approximate r_1 .

The value of r is read from Table 2 of the Appendix. This table gives the cosines of angles from 0° to 90° .

When BC is greater than AD , in the numerator we put $\sqrt{AD}$ instead of $\sqrt{BC}$, and the correlation, then, is negative.

Example: In order to find out the validity of a 20-item job satisfaction questionnaire, it was correlated with ratings by the principals of teachers. Both the questionnaire and the principals rating used three-point rating system. The scores obtained are shown in the following table. Find out the validity of the job satisfaction questionnaire by calculating the tetrachoric r (Figure 13.20).

S. No. of Teacher	Score on JSQ	Score on Rating
1	20	1
2	25	1
3	25	1
4	30	1
5	36	3
6	40	3
7	30	1
8	25	1
9	20	1
10	35	3
11	30	3
12	35	1
13	35	1
14	25	3
15	30	1
16	40	3
17	35	3
18	40	3
19	30	3
20	35	3

Mean = 20/20
= 31.00

Tabled-D
2 × 2 Table

	(-)	(+)
+	B (2)	A (8)
Y	D (7)	C (3)

Figure 13.20 Validity of job satisfaction questionnaire of table

$$r_1 = \cos \left[\frac{180\sqrt{BC}}{\sqrt{AD} + \sqrt{BC}} \right] = \cos \left[\frac{180 \times \sqrt{6}}{\sqrt{56} + \sqrt{6}} \right]$$

$$= \cos \left[\frac{180 \times 2.449}{7.483 + 2.449} \right] = \cos \pi \left[\frac{440.82}{9.932} \right]$$

$$= \cos 44.384$$

or $\cos 44$

The table value of $\cos 44 = 0.719$

Hence, the $r_1 = +0.719$

Characteristics

Tetrachoric r has the following special features:

- It assumes that the two dichotomized variables are continuous and normally distributed.
- It is a variety of product moment r .
- Dichotomies underlying both variables are man-made, not true or natural.
- Its formula given earlier gives more accurate result when it is large and the split on both variables is not far removed from 0.50. Extreme cut is not advisable. The split should be within the 0.40 – 0.60 range.
- Cherise-Thurstone computing chart may also be used, which is available from University of Chicago Bookstore, Chicago.
- A quick approximation of r can be obtained by dividing AD by BC and then entering Table 3 (Appendix) with this ratio. For example, in the present example $AD/BC = 56/6 = 9.33$, which is equivalent to r of 0.71.

Sheppard's Coefficient of Correlation (S)

This is also known as method of unlike signs and is due to Sheppard. Its formula is:

$$S = \cos 180^\circ \frac{U}{L+U}$$

U = Percentage of the sum of the unlike signs in the fourfold table

L = Percentage of like signs

$U + L = 100$ (as U and L are percentages). Hence, the formula may also be written as

$$S = \cos 180^\circ \frac{180^\circ \times U}{100} \text{ or } \cos 1.8 \times U$$

Applying this formula to the data under 2×2 table—C used for computing r_1 , S comes to be

$$S = \cos 1.8 \times \text{percentage of unlike signs}$$

$$= \cos 1.8 \times 5/20 \times 100 = 1.8 \times 25 = \cos 45^\circ$$

which means correlation of 0.707 (Table 2).

Yule's Coefficient of Association (Q)

$$\text{Using the tetrachor table } Q = \frac{ad - bc}{ad + bc}$$

Using the same data as in Table D

$$Q = \frac{8 \times 7 - 3 \times 2}{8 \times 7 + 3 \times 2} = \frac{56 - 6}{56 + 2} = \frac{50}{62}$$

$$= 0.806$$

This method produces a generous estimate of r .

Phi Coefficient

Phi coefficient of correlation is also based on fourfold table of frequencies.

Situation in Which It Is Used

This method is used when the data obtained on both variables are in the form of genuine dichotomies and the normal distribution underlying these dichotomies cannot be assumed. The classification is truly discrete and the variable can take only one of the two values.

This method, however, can be used even in case of continuous variables, provided the split is done at the median point.

Computation: The correlation is computed by applying the following formula:

$$\phi = \frac{AD - BC}{(A + B)(C + D)(B + D)(A + C)}$$

where A , B , C and D are frequencies in the fourfold table prepared and used as follows:

Example: An achievement test was correlated with the criterion, a standardized test to establish its validity. Taking their scores as above and below the median, a four-fold table was prepared as follows. Find out phi coefficient of correlation (Figure 13.21).

		2 × 2 Table		
		Criterion test		
		(-)	(+)	
		(Median)		
+Mdn Ach. test (Median)	-Mdn	B 25	A 35	60
	+Mdn	D 25	C 15	40
		50	15	100

Figure 13.21 Phi coefficient of correlation

Substituting the values of A , B , C and D in the previous formulae we get

$$\begin{aligned}\phi &= \frac{35 \times 25 - 25 \times 15}{\sqrt{(35 + 25)(15 + 25)(25 + 25)(13 + 15)}} \\ &= \frac{875 - 375}{\sqrt{60 \times 40 \times 50 \times 50}} \\ &= \frac{500}{\sqrt{600000}} = \frac{500}{2559.5}\end{aligned}$$

Characteristics

The characteristics are as follows:

- It is a kind of product-moment r .
- It is most useful in item-analysis of a test, in finding out item correlation, item-test correlation, finding out test's reliability and validity.
- It is related to χ^2 (chi square) by the following equation

$$X^2 = M\phi^2$$

- By converting ϕ into χ^2 , its significance for 1 df can be tested by consulting the chi square table. In the present example, $0 \text{ of } 0.204 = 100 \times (0.204)^2 = 100 \times 0.0416 = 4.16$, which is significant at 0.05 level (by χ^2 -table).
- It cannot be equal to 1.0 unless the cuts in the X and Y are the same, i.e., unless $p = q$.

Contingency Coefficient of Correlation (C)

Contingency coefficient of correlation (C) is related to χ^2 and can be found by applying the formulae

$$C = \sqrt{\frac{X^2}{N + X^2}}$$

In the previous example χ^2 was found to be 4.16 when N was 100. This chi square value may be converted into C as follows:

$$C = \sqrt{\frac{4.16}{100 + 4.16}} = \sqrt{\frac{4.16}{104.16}} = \sqrt{0.0399} \\ = 0.1997 \text{ or } 0.2$$

Characteristics

It has the following characteristics:

- It is a good estimate of r when the grouping is fine, i.e., 5×5 or still finer, the sample is large, the assumption of normality is satisfied.
- Assumption of normality is, however, not essential—Any type of distribution may be utilized.
- It does not remain constant for the same data when the number of categories varies.
- Its maximum value is determined by the number of categories. For example, if it is 4×4 table, then

by applying the formula $\frac{\sqrt{K-1}}{K}$ it.

- A too fine classification is not advisable as in that case frequencies in cells may come to be less than 5 in which case C will not be stable.
- It is not entirely a satisfactory statistic.

Yule's Coefficient of Colligation (w)

It is a modification of the formula used for computing tetrachoric r . It gives a conservative (or even modest) idea of the intensity of association. Its formula is:

$$w = \frac{\sqrt{AD} - \sqrt{BC}}{\sqrt{AD} + \sqrt{BC}}$$

Applying this formula to the table under phi-coefficient of correlation it is found that

$$w = \frac{\sqrt{25 \times 35} - \sqrt{25 \times 15}}{\sqrt{25 \times 35} + \sqrt{25 \times 15}} = \frac{29.58 - 19.36}{29.58 + 19.36} = \frac{10.22}{48.94}$$

= 0.2088, which is slightly higher to the phi coefficient previously calculated.

Correlation Ratio (η , eta)

When the lines of regression are straight, correlations are linear. But, linear correlations are not a universal fact. There are situations when correlations between certain variables are non-linear or 'curvilinear'.

Quantities met within psychology do not always correlate in this way. For instance, Webb's character factor w known as persistence of motive or consistency of action resulting from 'will' correlates with perseverance (p) in a curvilinear way. Both high and low preservations tend to have low character scores and the highest character scores are associated with moderate preservation.

In such situations it is advised to use correlation ratio η (eta) which is given by the following formula

$$\eta = \sqrt{1 - \frac{\sigma_x^2}{\sigma_y^2}}$$

in which $6x$ and $6y$ are standard errors of estimate (the standard deviations of x and y variables).

In psychophysics there are several situations in which non-linear relationship is found. In experiments dealing with fatigue, practice, forgetting and learning, we, generally, get curvilinear correlations, though most of the psychological tests when administered to large samples yield linear relationship. For this reason it is not of much use in education. It is not, therefore, described in detail. Those who are more interested may consult Lindquist (1970: 239–41).

According to Nunnally (1975), 'for a variety of reasons biserial, tetrachoric and other estimates of r should not be employed in most research. These coefficients frequently provide very poor estimates of the r that would be actually obtained when both distributions are approximately normal' (p. 168).

Partial Correlation (r_{123})

Situation in Which It Is Used

In education and psychology there are many situations in which correlation between two variables is required to be computed after eliminating the contaminating effect of a third variable. For example, it is attempted to know how intelligence and school achievements are correlated when the effect of socio-economic status is eliminated. In such situations it is partial correlation which is computed.

Computation

The formula used for computing partial r (r_{123}) is

$$R_{123} = \frac{r_{12} - r_{23} \times r_{13}}{\sqrt{1 - r_{23}^2} \times \sqrt{1 - r_{13}^2}}$$

in which r_{12} , r_{13} , and r_{23} are correlations between variables 1, 2 and 3 taken in pairs. The correlation r_{123} means correlation between variables 1 and 2 after keeping variable 3 constant, i.e., controlled or eliminated. If the variables are x , y , z , and the effect of the variable z is eliminated, then it is written as $r_{xy \cdot z}$. If y is controlled, then it would be written as $r_{xz \cdot y}$. The variable written next to the dot is the variable, which is eliminated (C).

Example:

Suppose (i) $r_{xy} = 0.6$, (ii) $r_{xz} = 0.4$, (iii) $r_{yz} = 0.2$

Find out correlation between x and y after eliminating the effect of z .

Solution: Find out partial correlation between variables x and y after partialling out variable z . In other words, find out $r_{xy \cdot z}$ as follows:

$$r_{xy \cdot z} = \frac{r_{xy} - r_{xz} \times r_{yz}}{\sqrt{1 - r_{xz}^2} \times \sqrt{1 - r_{yz}^2}} = \frac{6 - 4 \times 2}{\sqrt{1 - 0.4^2} \times \sqrt{1 - 0.2^2}}$$

$$\begin{aligned}
&= \frac{0.6 - 0.8}{\sqrt{1 - 0.16} \times \sqrt{1 - 0.04}} = \frac{0.6 - 0.8}{\sqrt{0.84} \times \sqrt{0.96}} \\
&= \frac{0.52}{0.916 \times 0.979} = \frac{0.52}{0.897} = 0.5797
\end{aligned}$$

If y is partially led out, it would be written as r_{xyz} and would be calculated as follows:

$$\begin{aligned}
&= \frac{r_{xz} - r_{xy} \times r_{yz}}{\sqrt{1 - r_{xy}^2} \times \sqrt{1 - r_{yz}^2}} = \frac{0.4 - 0.2 \times 0.6}{\sqrt{1 - 0.2^2} \times \sqrt{1 - 0.6^2}} \\
&= \frac{0.16 - 0.12}{\sqrt{1 - 0.04} \times \sqrt{1 - 0.36}} = \frac{0.6 - 0.8}{\sqrt{0.94} \times \sqrt{0.64}} \\
&= \frac{0.04}{0.979 \times 0.8} = \frac{0.04}{0.784} = 0.051
\end{aligned}$$

Similarly, r_{yzx} will be

$$\begin{aligned}
r_{yzx} &= \frac{r_{yz} - r_{xz} \times r_{xy}}{\sqrt{1 - r_{xz}^2} \times \sqrt{1 - r_{xy}^2}} = \frac{0.2 - 0.4 \times 0.6}{\sqrt{1 - (0.2)^2} \times \sqrt{1 - (0.6)^2}} \\
&= \frac{0.2 - 0.24}{\sqrt{0.84} \times \sqrt{0.664}} = \frac{-0.04}{0.916 \times 0.8} \\
&= -0.04 \\
0.733 &= 0.051
\end{aligned}$$

Characteristics

Main characteristics are the following:

- Partial correlation is very useful for finding out relationship between two variables when the contaminating effect of some other variable or variables is required to be eliminated. Hence, it is used in controlling extraneous variables in experimental research.
- It is also used in computing multiple correlation between the criterion variable and a few other variables put together.

Multiple Correlation (R)

Situation in Which It Is Used

Multiple correlation (R) is used in situation, in which one requires to know what will be the relationship of two, three or more variables combined together with another single variable, generally, called the criterion variable. For example, a researcher may want to know what will be the correlation of intelligence + motivation + previous school marks put together with the performance of a group of students in the next final examination or some competitive examination. In this situation next final examination or competitive examination will be the criterion variable (variable 1) and intelligence (e.g., variable 2). Motivation (variable 3) and previous school marks (variable 4) will be the predictor variables combined together. In this case the multiple correlation will be indicated as R_{2341} . It is always written as capital R . The criterion variable is put after the dot, while all the variables to be combined precede the dot. If variables are x , y and z and R is the criterion, then it will be written as R_{xyz} . There may be more than three or any number of variables to be combined and multiple R written accordingly as R_{23451} , R_{yzspk} and so on.

Characteristics

The main characteristics are as follows:

- It is very useful when some criterion variable is to be predicted on the basis of the composite score obtained by combining scores from several other tests.
- Prediction is the phenomenon, which very frequently uses multiple R .
- It constitutes the basis of multiple regression analysis.
- It helps in finding out best weights to be given to different tests to be selected and put together for constructing a battery of tests to be used for selection purposes (Table 13.6–13.8).

Table 13.6 Ordinates (u) for given areas measured from the mean of a normal distribution with total area of 1.00

Area from the Mean	Ordinates (u)	Area from the Mean	Ordinates (u)
0.00	0.399	0.26	0.311
0.01	0.399	0.27	0.304
0.02	0.398	0.28	0.296
0.03	0.398	0.29	0.288
0.04	0.397	0.30	0.280
0.05	0.396	0.31	0.271
0.06	0.394	0.32	0.262
0.07	0.393	0.33	0.253
0.08	0.391	0.34	0.243
0.09	0.389	0.35	0.233
0.10	0.386	0.36	0.223
0.11	0.384	0.37	0.212
0.12	0.381	0.38	0.200
0.13	0.378	0.39	0.188
0.14	0.374	0.40	0.176
0.15	0.370	0.41	0.162
0.16	0.366	0.42	0.149
0.17	0.362	0.43	0.134
0.18	0.358	0.44	0.119
0.19	0.353	0.45	0.103
0.20	0.348	0.46	0.086
0.21	0.342	0.47	0.068
0.22	0.337	0.48	0.048
0.23	0.331	0.49	0.027
0.24	0.324	0.50	0.000
0.25	0.318		

Example: Suppose that $r_1 = \cos 45^\circ$, then $\cos 45^\circ = 0.707$, and $r_1 = 0.71$ (to two decimals)

Table 13.7 Values of r , taken as the cosine of an angle

Angle	Cos	Angle	Cosine	Angle	Cosine
0°	1.000	41°	0.755	73°	0.292
		42	0.743	74	0.76
5	0.996	43	0.7311	75	3259
		44	0.719	76	0.242
10	0.985	45	0.707	7	0.225
		46	0.695	78	0.208
15	0.966	47	0.682	79	0.191
16	0.961	48	0.69	80	0.174
17	0.956	49	0.656		
18	0.951	50	0.643	81	0.156
19	0.946			82	0.156
		51	0.629	83	0.122
		52	0.616	84	0.105
21	0.0934	53	0.6.2	85	0.087
22	0.927	54	0.588		
23	0.921	55	0.574	90	0.00
24	0.914	56	0.559		
25	0.906	57	0.545		
26	0.899	58	0.530		
27	0.891	59	0.515		
28	0.883	60	0.500		
29	0.875				
30	0.866	61	0.485		
		62	0.469		
31	0.857	63	0.454		
32	0.848	64	0.438		
33	0.839	65	0.423		
34	0.829	66	0.407		
35	0.819	67	0.391		
36	0.809	68	0.375		
37	0.799	69	0.358		
38	0.788	70	0.342		
7	39	0.777			
40	0.766	71	0.326		
		72	0.309		

Table 13.8 Estimate values of r_1 corresponding to values of the ratio, AD/BC

AD/BC	r_1	AD/BC	r_1	AD/BC	r_1
0–10	0.00	2.23–2.38	0.31	5.81–6.03	0.61
1.01–1.03	0.01	2.29–2.34	0.32	6.04–6.28	0.62
1.04–1.06	0.02	2.35–2.41	0.33	6.29–6.54	0.63
1.07–1.08	0.03	2.42–2.48	0.34	6.55–6.81	0.64
1.09–1.11	0.04	2.49–2.55	0.35	6.82–7.10	0.65
1.12–1.14	0.05	2.56–2.63	0.36	7.11–7.42	0.66
1.15–1.17	0.06	2.64–2.71	0.37	7.43–7.75	0.67
1.18–1.20	0.07	2.72–2.79	0.38	7.76–8.49	0.69
1.21–1.23	0.08	2.80–2.87	0.39	8.12–8.49	0.69
1.24–1.27	0.09	2.88–2.96	0.40	8.50–8.90	0.70
1.28–1.30	0.10			8.91–9.35	0.71
		2.97–3.05	0.41	9.36–9.82	0.73
1.31–1.33	0.11	3.06–3.14	0.42	9.83–10.33	0.74
1.34–1.33	0.12	3.15–3.24	0.43	10.34–10.90	0.75
1.38–1.40	0.13	3.25–3.24	0.44	10.91–11.51	0.76
1.41–1.44	0.14	3.35–3.45	0.45	11.52–12.16	0.77
1.45–1.48	0.15	3.46–3.56	0.46	12.17–12.16	0.78
1.49–1.52	0.16	3.57–3.68	0.47	12.90–13.70	0.79
1.53–1.56	0.17	3.69–3.80	0.48	13.71–14.58	0.80
1.57–1.60	0.18	3.81–3.92	0.49	14.59–15.57	0.81
1.61–1.64	0.19	3.93–4.08	0.50		0.82
1.65–1.69	0.20				0.83
				15.58–16.65	0.84
		4.07–4.20	0.51	16.66–17.88	0.85
1.70–1.73	0.21	4.21–4.34	0.52	17.89–19.28	0.86
1.74–1.78	0.22	4.35–4.49	0.53	19.29–20.85	0.87
1.79–1.83	0.23	4.50–4.66	0.54	20.86–22.68	0.88
1.84–1.88	0.24	4.67–4.82	0.55	22.69–24–76	0.89
1.89–1.93	0.25	4.83–4.99	0.56	24.77–27.22	0.90
1.91–1.93	0.26	5.00–5.18	0.57	27.23–30.09	0.91
1.99–2.04	0.27	5.19–5.38	0.58	30.10–33.60	0.92
2.05–2.10	0.28	5.39–5.59	0.59	33.61–37–79	0.93
2.11–2.15	0.29	5.60–5.80	0.60		0.94
2.16–2.22	0.30			37.80–43.06	0.95
				43.07–49.93	0.96

(Continued)

Table 13.8 (Continued)

AD/BC	r_1	AD/BC	r_1	AD/BC	r_1
				49.84–58.79	0.97
				58.80–70.95	0.98
				70.96–89.01	0.99
				89.02–17.54	100
				117.55–169.67	
				169.68–293.13	
				923.13–923.97	
				923.98–	

Factor Analysis

Factor analysis is a multivariant analysis method. The inter-correlations are analysed to extract the factors. The Pearson’s correlation is used in factor analysis. It is an application of Pearson’s correlation and also is an extension of this technique. It is mainly used for estimating psychological validity of test. The test scores are interpreted in terms of mental domain, i.e., the factors or abilities are operating in the test. The theories of intelligence have been formulated with the help of factor analysis technique.

The factor analysis method was laid originally by the early work of San Francis Gallon and Spearman. Gallon is credited with introduction of Bivariate Analysis, i.e., correlation, which is the basic of all methods of factor analysis. Charles Spearman introduced a method of factor analysis f irst time in 1904, which is known as Tetrad Equation. The psychological basis is represented by ‘Two Factor Theory of intelligence. Spearman has identified two factors: general (g) and specific (s). The general factors are common in all tests while specific factors are deferent in different tests.

The measurement in psychology and education is indirect. All the variables or traits are measured with the help of behaviour. There is no single behaviour, which is related to one variable or one trait. The behaviours are common in different variables. Therefore, for most of the variables, test scores are inter-correlated in positive direction. The inter-correlations are analysed by factor analysis to extract the factors underlying the tests, which is known as factorial validity of the test. Thus, the factor analysis is used to analyse the factorial validity and formulating theories of intelligence.

The behaviours are expressed with the help of the abilities of person. The ability or factor is a power, which helps in performing the activities. This fact may be shown demonstrated in the process of testing situations with the helps of the following diagram.

When the test scores are analysed and interpreted in terms of mental abilities or traits, it is the validity of the test. Thus, factor analysis technique is used for extracting these mental factors to estimate the psychological validity of the test. The mental abilities included in the test are expressed through the behaviours. The mental abilities are also called ‘factors’. The structure of factors included in the test is termed as factorial validity. The relationship in two tests and variables is due to the third variable. The factor is the determinant of their relationship (Figure 13.22).

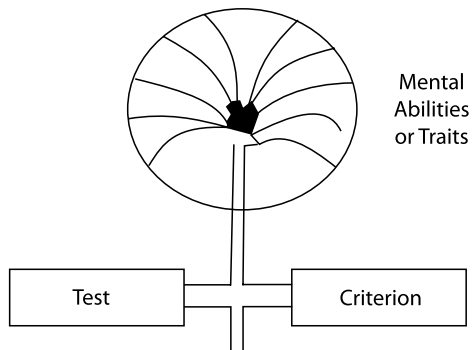


Figure 13.22 Relationship of tests

Example: The coefficient of correlation between height and weight is 0.70. Age is the determinant factor of their relationship. If age increases, height and weight also increase (Figure 13.23).

$$r_{12}^2 = 0.70^2 = 0.49$$

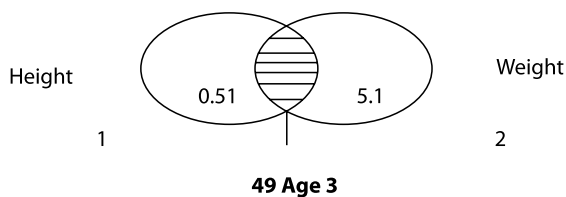


Figure 13.23 Correlation between height and weight

The age factor contributes 49 per cent variance of height and weight and remaining 51 per cent variance may be contributed to some unknown factors or not common factors. The statistics may be organized into a tabular form.

Variable	r_{12}	r_{122}	Specific	Variance
1. Height	0.70	0.49	0.51	...
2. Weight	0.70	0.49	...	0.51

It shows that there is a determinant for correlation. In this example age is the determinant, which contributes 49 per cent variance, which is common.

Meaning and Definition of Factor Analysis

The term *factor analysis* is composed of two words: *factor* and *analysis*. Therefore, we should understand these terms separately.

The *factor* is the determinant of correlation between two variables or bivariate relationship.

‘Factor is the underlying *force* in the relationship, usually, variables, which are related to one another, but factors are independent or orthogonally correlated’.

‘Factor analysis is the technique of isolating a factor or factors from the huge obtained data’.

‘Factor analysis is useful in isolating factors or abilities from a vast data and make them meaningful interpretation, but undue faith is not warranted’.

‘Factor analysis gives you back what you have already put in it’.

Lee J. Cronbach has defined the term *factor analysis* comprehensively, which is given as under:

Factor analysis is a systematic method for examining the meaning of a test by studying its correlation with other variables. It provides the information about the nature and organization of individual characteristics and classified what any given test measures. It is used in the studies of interests, attitude and personality as well as the study of human abilities.

This definition has emphasized the following aspects of factor analysis:

- (i) It is a systematic method for estimating the purposiveness or validity of a test.
- (ii) It indicates the individual characteristics, the nature and organization or structure of abilities.
- (iii) It classifies what any given test measures.
- (iv) It is used in the studies of interests, attitude, personality structure and the organization of human abilities.

According to M. Varma, ‘unfortunately from the very beginning, factor psychology has been associated with esoteric if not cabalistic practices, which on account of the formidable sets of numbers with decimal fractions have tended to keep away the less adventurous.’

Thurstone (1950) ‘assumes that a variety of phenomena within a domain are related and that they are determined, at least in part, by a relatively small number of functional rarities or factors’. If the human mind or any human work or situation is structured at all, then factor analysis is an attempt to describe the underlying structure. In Kendall’s scheme (1950), ‘factor analysis is classified as a ripe of inter-dependency analysis’. The start in this method of scientific investigation is math with an observed set of relationships and factors interior to and underlying those relationships are uncovered and identified. This attempts to derive deep lying fundamental and naturally fewer entities from the observations of what is in the main surface phenomena has been figuratively described by Thurstone as an attempt to lift ourselves by our boot straps.

Factor analysis is based on the coefficient of correlation, which is originated by San Francis Gallon. He is known as the father of correlation. Charles Spearman has developed the statistical technique, which is known as Tetrad Equation. Spearman has evolved the first method of factor analysis in (1940). He is considered as originator of factor analysis. Later on, several techniques have been developed by different psychometricians.

Methods of Factor Analysis

Factor analysis technique is quite statistical or mathematical. It is also termed as mutlivariate analysis technique. The factors are extracted from the inter-correlations matrix of a test. Recent methods of factor analysis have been summarized as in Table 13.9.

Table 13.9 Recent methods of factor analysis and their exponents

Methods	Exponents
Tetrad equation (1927)	Charles Spearman
Centroid method (1947)	L. L. Thurstone
Summation method (1939)	Cyril Burt
Principle axes method (1928)	T. L. Kellye
Cluster method (1937)	Tryon
Principle components (1933)	Hotelling

Several books are available on this topic of Factor Analysis. The varimax method of factor analysis is commonly available online. Several designs have been developed for computer analysis. It is difficult to discuss all the methods of factor analysis. The *Centroid method* of Thurstone has been discussed in detail.

Centroid Method of Factor Analysis of L. L. Thurstone

This method was developed by L. L. Thurstone in 1947. It is a most popular method of factor analysis. Thurstone tried to understand the nature of intelligence. He could evolve and formulate the *multiple factor theory* (primary mental abilities [PMA]) of intelligence. Guilford has discussed this method in his book of statistics. Thurstone did not agree with formulations of Spearman. He assumed that there are *primary factors* of human abilities. He tried to verify his hypothesis empirically. He identified 53 intelligence behaviours and constructed 53 tests for measuring them.

He administered these 53 tests on the same group and calculated

$$\left(\frac{53 \times 252}{2} = 1378 \right) \text{ intercorrelations and organized them into a matrix table. He applied his } \textit{centroid}$$

method of factor analysis. He could extract six factors, which are known as *primary mental abilities* (PMA). It is also termed as *multifactor theory* of intelligence.

Rotation method is used to obtain the simple structure for naming the factors in this method of factor analysis. Other methods do not employ this *rotational* technique.

It is based on algebraic matrix. The inter-correlations are organized into a matrix table. The rows and columns are equal in the matrix as shown in Table 13.10:

Table 13.10 Correlation matrix table

Test	T_1	T_2	T_3	T_4
T_1	—	r_{21}	r_{31}	r_{41}
T_2	r_{12}	—	r_{32}	r_{42}
T_3	r_{13}	r_{23}	—	r_{43}
T_4	r_{14}	r_{24}	r_{34}	—

The number of rows or columns are equal to the tests. The diagonal values are estimated to complete the matrix. After completing matrix, centroid method is applied to extract the factors. A factor matrix table (Table 13.11) is also prepared to check the result.

Table 13.11 Factor matrix table

Test	Factor Loadings		Variance		h_2 Diagonal ($a_1^2 + a_2^2$)
	a_1	a_2	a_1^2	a_2^2	
T_1	a_{11}	a_{21}	a_{11}^2	a_{21}^2	h_1^2
T_2	a_{12}	a_{22}	a_{12}^2	a_{22}^2	h_2^2
T_3	a_{13}	a_{23}	a_{13}^2	a_{23}^2	h_3^2
T_4	a_{14}	a_{24}	a_{14}^2	a_{24}^2	h_4^2

The coefficients of correlations are given in the factor matrix. The variance shows the loadings of the factors on the tests. Factor matrix has the positive and negative correlations, but the variances become positive. The factors are rotated orthogonally and obliquely to obtain the simple structure, means all the

correlations turn to positive. The rotation procedure helps in naming the factors easily.

The procedure of factor analysis can be easily understood with the help of assumptions of this technique. The assumptions have been discussed in the following paragraphs.

Preliminary Concept of Factor Analysis

Factor analysis is basically used in psychology and education to identify the factor, which is measured by a test. Test psychological validity is estimated by this technique. It is also used for the factorial validity of tests. The inter-correlations between the tests are attributable by these factors. In most of the books, it has been stated that the meaningfulness of tests and their inter-correlations are in the factor analysis.

Example: A sample is of 100 students, their height, weight and age are measured and its inter-correlations are calculated and obtained as: 1, height; 2, weight and 3, age.

$$r_{12} = 0.50, r_{13} = 0.40, r_{23} = 0.00$$

and multiple correlations

$$R_{123} = 0.60, R_{213} = 0.50, \text{ and } R_{312} = 0.40$$

The coefficient correlations have been presented diagrammatically in Figure 13.24.

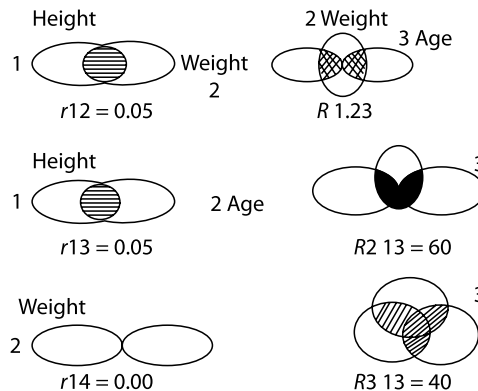


Figure 13.24 Coefficient correlations

Intercorrelation. Height and weight are related to the extent of 0.50. This relationship may be attributed by a third variable, i.e., age. Weight and age are not related; it means nothing is common in between them. The multiple correlation does not indicate this type of interpretation. The multiple correlations are always positive. It indicates the extent of joint relationship of two or more variables with the criterion variable. These factors are extracted by employing factor analysis technique. It is also termed as multivariate analysis technique.

Basic Assumption of Factor Analysis.

Assumption no. 1: All the factors are orthogonal or uncorrelated.

It accepts the division of obtained scores variable with true and error components. This essentially a new step is to be assumed that true variance can be further broken down into additive components. These components are the common factor (h^2) variance plus possible specific variance (s^2). If we express each of this contribution in term of a component score we may write the following basic equation

$$Z_1 = aZ_a + bZ_b + cZ_c + \dots qZ_q + sZ_s + Z_e$$

where Z_t = total standard score form.

$a, b, c, \dots, q$ = coefficient or weights to be applied to the variance of components scores.
Where there are common factors,

$$\begin{aligned} Z_a Z_b Z_c \dots Z_q &= \text{Standard score in common factors A to Q tests} \\ Z_s &= \text{Standard score in the specific component with its weight} \\ Z_e &= \text{Standard for the error component} \end{aligned}$$

The equation applies to the score of a single subject in a given test. Each term in equation, if no coefficient is zero, contributes to the total variance of the obtained score.

$$\begin{aligned} \sigma_1^2 &= \sigma_a^2 + \sigma_b^2 + \sigma_c^2 + \dots + \sigma_q^2 + \sigma_s^2 + \sigma_e^2 \\ &= \frac{\sigma_a^2}{\sigma_1^2} + \frac{\sigma_b^2}{\sigma_1^2} + \frac{\sigma_c^2}{\sigma_1^2} + \dots + \frac{\sigma_q^2}{\sigma_1^2} + \frac{\sigma_s^2}{\sigma_1^2} + \frac{\sigma_e^2}{\sigma_1^2} \end{aligned}$$

Substituting the simpler term for the proportions

$$1 = a_x^2 + b_x^2 + c_x^2 \dots + q_x^2 + s_x^2 + e_x^2$$

where $a_x^2 + b_x^2 + c_x^2 \dots + q_x^2$ are the proportions of the variance, which contributes to score in test score X by common factors A to Q tests, respectively.

S_x^2 and e_x^2 are proportions contributed by specific and error components.

$(1 - e_x^2) = (a_x^2 + b_x^2 + c_x^2 \dots + q_x^2) = h^2 + s_x^2$ reliability $= 1 - e_x^2 = h^2 + S^2 h^2 =$ common factors variance or commonality.

$$1 = h^2 + S^2 + e^2, \text{ uniqueness of the test} = U^2$$

a_1^2	a_2^2	a_3^2	a_4^2	S^2	e^2

Uniqueness
 U^2

Common variance
 h^2

specific error
var. var.

$$(h^2 + S^2) = \text{reliability of the test}$$

There are three alternative values for commonalities.

- (i) $(h^2 + S^2 + e^2) = 100$ Kelly has used this value
- (ii) $h^2 + S^2$ Reliability variance
- (iii) h^2 Thurstone and Burt have used this value

where: $h^2 = (a^2 + b^2 + c^2)$ or commonality

where: a^2, b^2, c^2 are factors variance of the test.

Commonality is defined as the proportion of common factor variance in the test scores.

$$h_x^2 = a_x^2 + b_x^2 + c_x^2 + \dots q_x^2$$

It is the proportion of true variance minus the proportions of specific variance.

$$r_{tt} = h^2 + S^2 = \text{reliability coefficient}$$

$$h^2 = r_{tt} - S^2$$

The commonality of variables is the sum of its independent common variances and is represented by the symbol h^2 .

- (i) An assumption of factor analysis is that a battery of inter-correlated variable has common factors running through it and that the scores of an individual can be represented more economically in terms of these factors.

- (ii) An individual's score on a test is dependent upon two things: the particular abilities assessed by the test and the amount of each of these abilities possessed by him.
- (iii) The additive nature of the factor analysis is that total variance is the sum of common, specific and error variances.

True variance ($h^2 + S^2$) is the proportion of reliable variance of the test.

Common variance (h^2): is the proportion of the factors variance, which correlates with other variables. It is also termed as *commonality*. The values of commonality are used for the diagonal cells, for a closed matrix.

Error variance (e^2): is the chance variance, which is the proportion of total variance, not the portion of reliable variance. It is due to the errors of sampling, measurement, testing conditions and psychological changes within the individual, which may contribute to unreliability of the test. It is not correlated to reliable variance.

Specific variance (S^2): is the portion of reliable variance, which does not correlate with any other variable.

$$h^2 + s^2 + e^2 = 1$$

$$h^2 + s^2 = \text{reliability variance or true variance}$$

$$\text{Reliability} = (h^2 + s^2) = \frac{\sigma_t^2}{\sigma_x^2} = \frac{\text{Factor Variance}}{\text{Total Variance}}$$

$$\text{Validity} = h^2 = \frac{\sigma_{cf}^2}{\sigma_x^2} = \frac{\text{Factor Variance}}{\text{Total Variance}}$$

Specificity: The proportion of specific variance in a test is known as its specificity, i.e., $s_x^2 = r_{tt} - h^2$.

Uniqueness: The specificity plus error variance is called uniqueness of the test, i.e., $U^2 = S^2 + e^2$.

Uniqueness is the complement of the commonality.

The uniqueness of variable is that portion of the total variance, which does not have in common with any other variable and symbol is U^2 .

$$h^2 + U^2 = 1$$

$$\text{Commonality} + \text{uniqueness} = 1$$

Uniqueness includes everything that this test does not have in common with any other known measure.

$$U^2 = 1 - h^2 = S^2 + e^2$$

Factor loadings: Each common factor can be illustrated in terms of equation. It gives the proportions of total score variance determined by the factors. The square roots of these terms, i.e., $a_x b_x c_x \dots q_x$ are the factor loadings.

Factor loadings are also the coefficient of correlation between the respective factors and the total scores.

Assumption no. 2: Correlation between two tests is the sum of the cross products of their common factor coefficient or factor loadings.

$$r_{xy} = a_x a_y + b_x b_y + c_x c_y + \dots, q_x q_y \quad \dots(1)$$

where r_{xy} is the correlation coefficient of two tests X and Y.

$a_x b_x c_x \dots q_x$ common factor coefficient of X test.

$a_y b_y c_y \dots q_y$ common factor coefficient of Y test.

If the two tests X and Y have zero loadings in any one of these common factors that factor contributes nothing to their intercorrelation, the factor loading is factors that the tests have in common the greater than intercorrelation.

$$a_1^2 + a_2^2 + a_3^2 = h_2$$

where a_1 a_2 a_3 are factor loadings or commonality. Intercorrelation can also be given in a geometric interpretation.

The second assumption may be illustrated in the following manner as shown in Figure 13.25. There are two tests X and Y, which are related to each other.

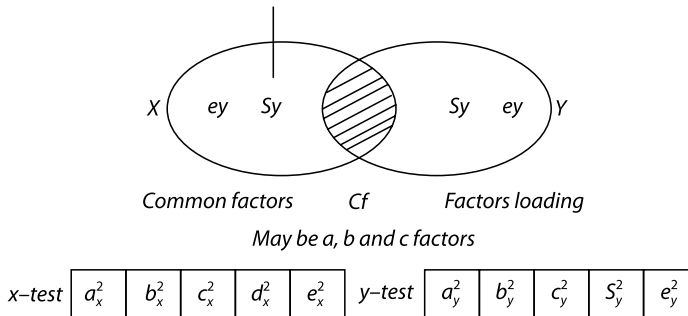


Figure 13.25 Assumption 2

The coefficient of correlation r_{xy} may be shown according to this assumption:

$$r_{xy} = a_x a_y + b_x b_y + c_x c_y$$

where:

$$a_x = 0.70, b_x = 0.50, c_x = 0.40; a_y = 0.60, b_y = 0.40, c_y = 0.50$$

$$\begin{aligned} r_{xy} &= 0.7 \times 0.6 + 0.5 \times 0.4 + 0.4 \times 0.5 \\ &= 0.42 + 0.20 + 0.20 \\ &= 0.82 \end{aligned}$$

If the factor loadings are zero, the intercorrelation may tend to be zero. It may not contribute to inter-correlations. The sum of variance of the factor loadings provides common variance or commonalities of the matrix.

The common variance or commonalities of the matrix (Figure 13.26).

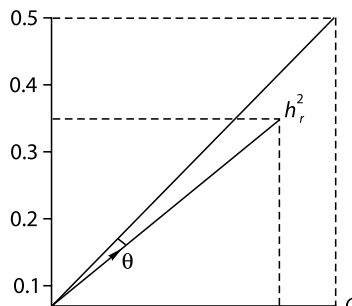


Figure 13.26 Common variance of matrix

The common variance of test X

$$a_x^2 + b_x^2 + c_x^2 = b_x^2$$

$$0.49 + 0.25 + 0.16 = 0.90$$

Similarly the common variance of test Y

$$a_y^2 + b_y^2 + c_y^2 = h_y^2$$

$$0.36 + 0.16 + 0.25 = 0.77$$

The common variance of factor loadings of test X is higher than test Y. The inter-correlation between the tests may be interpreted in term of geometrical notations.

	Test	Factors
	a^2	b^2
X	0.49	0.25
Y	0.36	0.16

$$r_{xy} = h_x h_y \cos \theta$$

The angle θ is represented between X and Y. h_x and h_y are the vectors.

$$r_{ij} = h_i h_j \cos \theta_{ij}$$

where r_{ij} = correlation between test i and j .

$h_i h_j$ = lengths of vector for test i and j .

θ_{ij} = angle of separation between vector i and j .

Vector is a term having a given length and dimension or direction.

By reflecting we mean that each test vector retains its same length, but it extends in the opposite direction. Commonality is the lower bond of reliability.

$$h^2 = r_{tt} - S^2$$

If we start extracting factor loadings by putting the value of h^2 , we obtain a^1 and a^2 factor loadings or (h_1^2) .

Thus we have $a_1^2 + a_2^2 = h_1^2$

Differences $(h^2 - h_1^2) = 0$ approximately.

- (i) If we put the value of the diagonal $h^2 + S^2 + e^2$ or 1.00, the commonality is called closed model. We extract the factors, which have equal number of variables, but some of them are not significant or meaningless factors.
- (ii) If we use h^2 commonality that is called open model commonality (used in centroid method), but how we get h^2 is factor loadings, extracted factors may not have equal number of variables. Here both are inter-dependent. If we put reliability in the diagonal cells that will give the maximum limit. We start with a guess to have the balance between sum of variance of factor loadings and commonality value. This is known as a process of interaction.

Factor Matrix

- (i) As many rows as there are tests or variables, but only as many columns as there are extracted factors from the correlation matrix.
- (ii) The elements of the factor matrix are correlation of tests with the factors, where the factors are always orthogonal or uncorrelated.

Correlation Matrix

- As many rows as columns as there are tests in a study.
- The elements of correlation matrix are intercorrelation among the tests.

- Number of correlation matrix are equal.

$$N_{c2} = \frac{\text{no. of tests} \times (\text{no. of tests} - 1)}{2}$$

Problem for obtaining diagonal cells values: A matrix table is prepared with the help of intercorrelation of the tests. The rows and columns of the matrix table are equal to the number of tests. The coefficients of correlation are entered into the respective cell, but diagonal cells values are obtained. It is the serious problem to complete the matrix table. There are three ways for estimating diagonal cell values.

- (i) $h^2 + S^2 + e^2 = 1$ closed matrix
 - (ii) $(h^2 + S^2)$ or reliability index
 - (iii) h^2 common factor variance or commonalities
- (i) If $h^2 + S^2 + e^2 = 1$ is entered in the diagonal cells, it is known as closed model. Some of the extracted factors are usually meaningless. The factors may be equal to the number of tests. It is difficult to locate which one of the factors are meaningless. Some of the methods of factor analysis use the value for diagonal cells.
 - (ii) If $h^2 + S'$ = reliability index is used for the diagonal cells. In this situation, some factors may be extracted for specific variance. Some factors are not meaningful. More factors are obtained than real factors.
 - (iii) If h^2 = commonality values are entered into the diagonal cells, the actual factors may be extracted. How the h^2 value is to be obtained? It is a problem. The guessing method is used, than a *process of interaction* to arrive at 11^2 values for the diagonals cell. *Spearman's tertrad equation* is also used for the diagonal cells values.

1. Spearman's tertrad equation is used for diagonal cells values, cross-product is done.

$$\begin{aligned} r_{11} \times 0.56 &= 0.72 \times 0.63 \quad r_{11} = 0.81 \\ r_{22} \times 0.63 &= 0.72 \times 0.56 \quad r_{22} = 0.64 \\ r_{33} \times 0.72 &= 0.63 \times 0.56 \quad r_{33} = 0.49 \end{aligned}$$

Matrix table (incomplete form)

Test	1	2	3
1	r^{11}	0.72	0.63
2	0.72	r^{22}	0.56
3	0.63	0.56	r^{33}

How the matrix table may be completed by entering the diagonal cells values.

Matrix table (complete form)

Test	1	2	3
1	0.81	0.72	0.63
2	0.72	0.64	0.56
3	0.63	0.56	0.49

Extraction of first factor from matrix table

Test	1	2	3	
1	0.81	0.72	0.63	
2	0.72	0.64	0.56	$\sqrt{T} = 2.42$
3	0.63	0.56	0.49	$1\sqrt{T} = 0.413 = m$
E	2.16	1.92	1.69	$T = 5.86$
$mE = a$	0.90	0.80	0.70	

First factor matrix table

	0.90	0.80	0.70
0.90	0.81	0.72	0.63
0.80	0.72	0.64	0.56
0.70	0.63	0.56	0.49

The error variance is not taken into consideration. It is the main limitation of this procedure.

Test	Factor	Variance	Specific	Variance	Total	
	a_1	a_1^2	S_1^2	S_2^2	S_3^2	Variance
1	0.90	0.81	0.19	—	—	1.00
2	0.80	0.64	—	0.36	—	1.00
3	0.70	0.49	—	—	0.51	1.00

(iv) If h^2 value is obtained and entered into the diagonal cells, then it is called *open model* system. Usually h^2 value is estimated and entered into the diagonal cells. The factor analysis is done till h^2 value is obtained, which is equal to the extract value of commonalities. This process of factor analysis and estimating h^2 is known as ‘*Process of iteration*’. The process is helpful for estimating true values of commonalties.

Minimum number of factors to the number of variables: Some formulae are used for estimating the number of factors from a matrix table. The accuracy can be ascertained by these formulae:

$$a = \frac{2n + 1\sqrt{(8n + 1)}}{2}$$

where n = number of tests or variables

a = number of extracted factors

Table for the estimation of factors:

n	3	5	6	8	9	10	12	13	14	15
a	1	2	3	4	5	6	7	8	9	10

Problem of Rotation

Another problem that is closely related to the common factor model is the much disputed problem of rotation. Thurstone’s well-known volume (26) lays great emphasis on the importance of rotation to *simple structure*, as he calls it. If it can be accomplished, such a rotation transforms the factor coefficients secured by the initial and somewhat arbitrary solution into coefficients that presumably are much easier to interpret. For instance, a successful rotation generally results in only zero or positive coefficient, rather than the bi-polar values usually characteristic of an initial solution, and highlights the variables that are related to only one of the common factors (i.e., complexity one). A subsidiary aspect of this problem is the distinction between orthogonal and oblique rotation, as Thurstone shows, for some problems only an oblique rotation achieves this simple structure.

An oblique rotation implies correlated common factors, and there is disagreement as to whether or not these are desirable. A recent example of different rotations of the same initial solution suggests some of the choices that may be made. The development of analytic methods of rotations has been stimulated to some extent by the availability of machines for computations. Kaiser’s article outlines

and relates several of these analytic methods. Wrigley and others have illustrated the virtues of an analytic approach.

The school of thought, which favours rotations points out that the obtained factor axis is more average and represents nothing more than the common elements among the tests on which it is based. It certainly does not represent any identifiable psychological entity. They think that on rational and empirical judgment the tests offer a much more meaningful and concrete example of mental functions in operation. If the axes are shifted to positions, which can be given a clearer, purer psychological meaning in the light of the tests, they can acquire tentatively a psychological status and can be evaluated as a function that underlies the actual experimental tests.

Another argument for rotation is based on the fact that in factors, after the first, tests show minus signs. It is against the known economy of nature that there should be any mental traits, which are favourable to achievement in certain activities and positively hinder success in others. This result is due to Thurstone's reflection-of-axes procedure and has necessarily no reference to real psychological entities. Those who do not favour rotation have actually carried out an analysis, the utility of which is very much in question.

M. Varma is of the view that all factorization aims at simplification of explanatory concepts in the sphere of achievement and ability, and once committed to analysis we must go to the whole hog to secure a better understanding, if not of the abilities to man, at least of the nature of the experimental tests. If one is not willing to rotate on any principal that never one had, better not factorize at all. Because the factors themselves are more mathematical artefacts both as to signs they carry and the size of the loadings. The only thing completely determined by the data and invariant in the situation is the complex web of mutual relationships among tests in references to the common factor axes.

The basic real thing in the analysis is the scatter of test point on a graph paper. These have come to occupy their places because of the two common elements (factors) they differently shared, which account for their intercorrelations in good part and are represented in the arms of the factor axes I and II. Factors are unknown *centres of gravity* and acquire definition and psychological meaning in the light of the known and concrete tests. Therefore, without rotation, they remain more mathematical entities of no more than theoretic interest, whereas the real purpose of analysis is to identify unitary, if not also primary and basic mental functions.

The difficulty about rotations is not their justification but their unique solution, because the researches is wholly free to rotate them to any position they like. Thurstone (1935) has furnished a criterion of good rotation in his concept of simple structure, if our aim is to define factors uniquely; this demands rotation, which may leave every axis at right angles to at least as many tests as these factors, and every test at right angles to at least one axis (Thomson 1951). Being at right angles means that the loading for the test in the factor is zero. The requirement, therefore, is that in the rotated position: (1) No test may include in its factorial structure all the factors, i.e., it must miss out at least one factor; (2) no factor can show a loading through all the tests, i.e., there should be no general factor. Thurstone held that the *simple structure* concept is in agreement with the principle of parsimony in explanatory hypothesis.

Thurstone is willing to move his factor axes to oblique positions to achieve his simple structure. In doing so, a situation is created, where the factor loadings are no longer. The correlation between factors and tests is equal to the cosine of the angle between their vectors. We also create a new kind of axes known as the primary vectors, which are not the same as the rotated factor axes known as *reference vectors*. This departure from the orthogonal position also leads to the factors losing their independence and getting correlated to the extent of the cosine of the angle between them. Since

factors are correlated we can get a matrix of factor intercorrelations. This is again factorized and leads to what are known as second-order factors. It would seem as if in this way we are back to ‘g’ or general factor of Spearman. These primary abilities themselves are being correlated. The main difference between Spearman’s original position and Thurstone’s point of view is a difference in emphasis. Spearman by all means at his disposal would maximize a first general factor; Thurstone would maximize instead the PMA type of group factors and through their obliquity arrive at a minimum of second-order factor like ‘g’ or general factor.

Extraction of Centroid Factor

There may be two types of problems:

- (i) Commonalities are known
- (ii) Commonalities are not known

If we know the commonalities and we may take the advantage of that fact and use them.

Problem I

When commonalities are known: The factors are extracted by simplified method, but the essential steps are present. The steps are listed under four main stages.

Stage I

Extraction of the first centroid factor:

Step 1: With commonalities entered in the diagonal cell, sum of the columns, entering the row headed by E.

Step 2: Sum of rows and to see that the check with the sums of the columns.

Step 3: Sum the sums in rows E and those in check sum columns, must be equal, sum of the elements in the matrix, denoted by T (grand total).

Step 4: Take the square root of T and its reciprocal or inverse, $m = 1 / \sqrt{T}$ value is multiplied by cells value of E rows $1 / \sqrt{T}$ constant multiplied by m

$$mE = a_1 \text{ and } mT = \sqrt{T}$$

$$a_1 = \text{first factor loadings and } T = \text{grand total.}$$

Step 5: Check the last step. The sum of the factor loadings should be equal to $\sqrt{T}$.

Extraction of the First Centroid Factor							
Test	1	2	3	4	5	6	Check
1	(0.81)	0.72	0.00	0.27	0.00	0.63	2.43
2	0.72	(0.68)	0.16	0.40	0.12	0.56	2.64
3	0.00	0.16	(0.64)	0.64	0.48	0.00	1.92
4	0.27	0.40	0.64	(0.73)	0.48	0.21	2.73
5	0.00	0.12	0.48	0.48	(0.36)	0.00	1.41
6	0.63	0.56	0.00	0.21	0.00	(0.49)	1.89
E1	2.43	2.64	1.92	2.73	1.44	1.89	13.05 = T
$m_1E_1 = a_1$	0.67	0.73	0.53	0.76	0.40	0.52	$\sqrt{T} = 3.6125$
							$1\sqrt{T} = 0.277 = m_1$

Stage II

Computation of the first factor residuals: The first factor accounts for much of the original inter-correlations. It can be seen by applying the equations.

$$r_{ij} - a_i a_j = b_i b_j + c_i c_j + \dots q_i q_j$$

$$p_{ij} = r_{ij} - a_i a_j \dots \text{first factors residuals}$$

can be written as

$$p_{ij} = r_{ij} + a_i (-a_j)$$

Step 6: Prepare first factor matrix a_1 ($-a_1$) like the table and add respective cell with the correlation matrix. The obtained table may contain the residuals.

Step 7: Add to each element in matrix R .

Residual matrix is obtained by subtracting the matrix from factor matrix:

Second Factor Extraction							
a1	-0.67	-0.73	-0.53	-0.76	-0.40	-52	
0.67	0.357	0.228	-0.357	-0.239	-0.269	0.278	
0.73	0.228	0.146	-0.228	-0.153	-0.172	0.178	
0.53	-0.357	-0.228	0.358	0.239	0.268	0.278	
0.73	-0.239	-0.153	0.239	0.158	0.178	-0.185	
0.40	-0.269	-0.172	0.268	0.178	0.201	-0.209	
0.52	0.278	-0.178	-0.278	-0.185	-0.209	0.216	
Σ	-0.002	-0.001	0.002	-0.002	-0.003	-0.000	-0.006
E_2	1.728	1.105	1.728	1.152	1.297	1.344	$8.354 = T$
$m_2 E_2 = a_2$ $\sqrt{T} = 0.346$	-0.598	-0.382	0.598	0.399	0.449	0.465	
a2 $1/\sqrt{T} = 0.346$	-0.60	-0.38	+0.60	0.40	0.50	0.47	1
							$m_2 = 34$

Residual After Second Factor Extraction (Residual is Zero)							
	0.598	0.382	-0.598	-0.399	-0.499	-0.465	
-598	-0.001	0.000	0.001	0.000	0.000	0.000	
-0.382	0.000	0.000	0.000	-0.001	0.000	0.000	
0.598	0.001	0.000	0.000	0.000	-0.001	0.000	
0.399	0.000	-0.001	0.000	0.000	-0.001	0.001	
0.449	0.000	0.000	-0.000	-0.001	-0.001	0.000	
0.465	0.000	0.000	0.000	0.001	0.000	0.000	
Σ	0.000	-0.000	0.000	-0.001	-0.003	0.001	-0.004

Test	Factor Loading		Factor Variance	Obtained		Commonalities Difference	
	a_1	a_2		a^2	h^2	$'h^2$	
1	0.67	-0.60	0.45	0.36	0.81	0.81	0.00
2	0.73	-0.38	0.53	0.15	0.68	0.68	0.00
3	0.53	0.60	0.28	0.36	0.64	0.64	0.00
4.	0.76	0.40	0.57	0.16	0.73	0.73	0.00
5	0.40	0.45	0.16	0.20	0.36	0.36	0.00
6	0.52	0.47	0.27	0.22	0.49	0.49	0.00
Total			2.27	1.44	3.71		0.00
Percentage			61	38	100		

The sum of factor variances is equal to the commonalities values.

$$a_1^2 + a_2^2 = h^2 \text{ cr } 2.27 + 1.41 = 3.68$$

It is also a check for the accuracy of the procedure of factor analysis. The specific and error variance is not included in commonalities. All the extracted factors are relevant and meaningful.

Naming of the Extracted Factors

The factor analysis technique is helpful in extracting the factor loadings only. What are those factors? Its naming is one logically. There is scope of subjectivity or personal error in naming the extracted factors. The error can be minimized by rotating the factor to have the 'simple structure'. There are two ways of naming the factors.

- By observing the nature of item and included behaviours therein

By observing the simple structure of factor by rotation. The rotation is done in two ways:

- (i) Orthogonal rotation
- (ii) Oblique rotation

By using both the ways simultaneously, the nature of the factors can be identified. In the above example six tests or six variables have been included, which are as follows:

- (i) General awareness test
- (ii) Language Test
- (iii) General arithmetic test
- (iv) Aptitude test
- (v) Mental abilities test
- (vi) Interest test

The first extracted factor is positively related to all the six tests. It has high correlation with the second test and lowest correlation with the sixth test. By observing the nature of other tests, it appears that the first factor is the '*Verbal factor*'.

Second factor is negatively related to the first two tests. There is no item, which is based on arithmetic abilities. The remaining four tests have some items of arithmetic abilities. It seems to be the '*Numerical factor*'.

- Orthogonal rotation of factors for 'simple structure'

The rotation procedure may be used for naming the factors more objectively. The rotation procedure provides the '*simple structure*'. The purpose of orthogonal rotation is to convert the negative loadings into positive. It provides another look for the factor loadings. The positive loadings are much more helpful and easier for naming the factors.

A graph paper is used for orthogonal rotation. Two factor loadings are plotted on the graph paper first on x -axis and second on y -ordinate. A scale is to be adopted.

Extracted Factors Loading Table							
Test Factor		1	2	3	4	5	6
a1	0.67	0.73	0.53	0.76	0.40	0.52	on x -axis
a2	-0.60	-0.38	0.60	0.40	0.45	0.47	on y -ordinate

Scale 1 cm, = 0.10, coefficient of correlation or loadings (Figure 13.27)

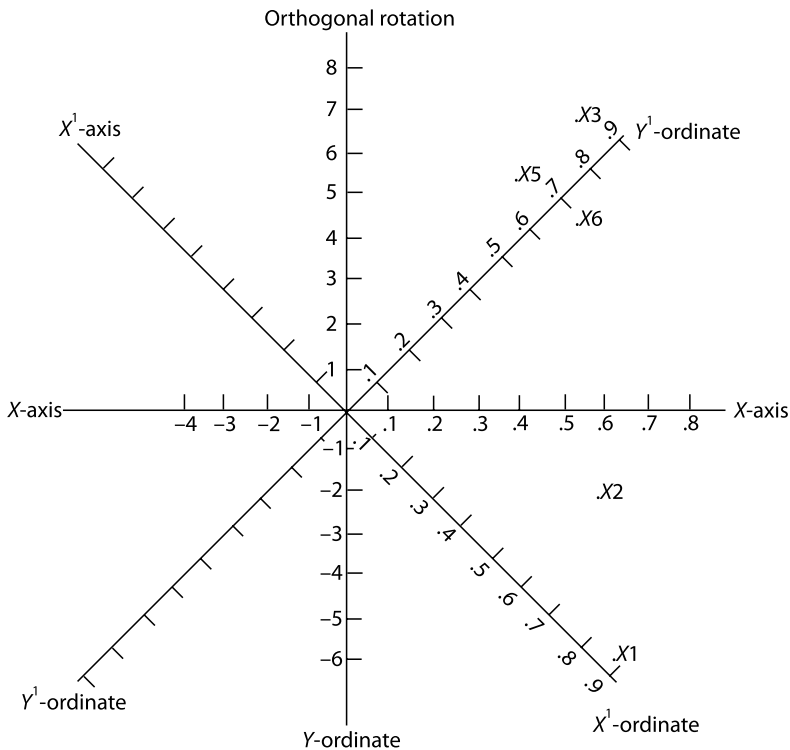


Figure 13.27 Coefficient of correlation or loadings

Factor Loadings After Orthogonal Rotation						
Test Factor	1	2	3	4	5	6
a1	0.95	0.84	0.03	0.34	0.02	0.011
a2	0.00	0.21	0.80	0.79	0.59	0.68

The orthogonal rotation is done so that all the negative loadings become positive. The table indicates that loading on first test is increased to 0.95 and it becomes 0.00 of the second factor. The first factor is the *verbal* and the second is the *numerical*. Therefore, it is not related. The fifth test is of mental abilities.

Non-verbal and reasoning items, thus, has negligible relation or loading with verbal factor. General awareness implies memory and language comprehension and it does not require numerical ability. The verbal factors have 61 per cent loading while numerical factor has 39 per cent loadings on the tests. It has been verified with help of orthogonal rotation, converting all loadings in positive direction, that extracted factors are verbal and numerical abilities.

Some Facts About Factor Analysis

Following are some facts about factor analysis:

- It is a general comment about the factor analysis.
- Factor analysis gives back what we have already put in it.
- It is the significant statement regarding the technique of factor analysis. The statement is true in two ways:
 - (i) Entering the communalities value in the diagonal cells
 - (ii) Including the types of items in the tests

Entering the communalities values: It has already been discussed under the heading 'communalities values'.

- (i) In *closed model* $h^2 + s^2 + e^2 = 1$ values are entered into the diagonal cells. This type of matrix may yield the factors equal to the tests. Some of the factors are irrelevant.
- (ii) If the reliability index of the test $h^2 + s^2 = r_{tt}$ values are entered into the diagonal cells. Some additional factors than actual factors may be extracted from the matrix due to specific variance (s) for additional value in the diagonal cells.
- (ii) If (h) commonality values are entered into the diagonal cells, it is known as *open model* of the matrix. Each cell has its own commonality value as per loading of the factors. Actual number of factors is extracted in this model.

It is evident that the number of factors dependent on the commonality values is entered into the diagonal cells. The diagonal cell values are entered so that number of factors is extracted.

Types of items included in the tests: It has been discussed in naming of the factors that the nature of the items are observed. Types of abilities or behaviours are included into test items; these can only be extracted by employing this technique. It cannot extract beyond that. If numerical ability is not included in the tests, the factor analysis would not extract numerical ability.

Factor analysis gives you back what you have already put into the test item. Thus, factor analysis can extract only those factors, which have been included already in the test items.

Thurstone could extract six primary mental abilities (PMA) as he had included in his tests of intelligence behaviour. Secondly, he had entered communalities values (h^2) as the open model. Thus, undue faith is not warranted on this technique of factor analysis. Naming of the factor involves the personal error.

Recent Trends in Factor Analysis Methods

- (i) Mental measurement in a nebulous state till about 1930 has been given a solid theoretical foundation through the precise methods of factor analysis.
- (ii) 'A natural corollary to our attempt to perfect psychological tests.' Godfrey Thomson—one of the test exponents of factorial techniques.
Spearman is the father of analytic cognitive psychology and the founder of factor analysis.

- (iii) Initial development of factor methods
 - (a) Spearman's *Two Factor Theory* (bifactor) of principle of tetrad differences.
 - (b) L.L. Thurstone in his books.
The Vectors of Mind (1935)
Primary Mental Abilities (1938) or PMA
- (iv) Factor analysis in cognitive psychology
 - (a) Factor analysis is initially developed for use in cognitive psychology.
 - (b) The problem of *structure of human ability*—the most important problem, which factor analysis had been called upon to tackle.
 - (c) Notable landmarks in this field.
- (v) Spearman's *Two-factor Theory* (1927)
- (vi) Alexander's thesis: Intelligence concrete and abstract (1935)

[CLL Thurstone's *The Vectors of Mind* (1935), *Primary Mental Abilities* (DMA) (1938) and *Multiple Factor Analysis* (1947)].

With the later development of Thurstone's second factor, the divergence between the viewpoints of Spearman and Thurstone have tended to narrow down.

Methodological Development

- (i) T.L. Kelley, 'Cross-Roads in the Minds of Men' (1928) and 'Statistical Method' (1923).
- (ii) Hotelling, by his method of 'Principle Components' (1933).
- (ii) Aitkens, by his method of 'Pivotal Condensation' (1937).
- (iii) D.N. Lawley, by his method of 'Maximum Likelihood' (1943).
- (iv) M.C. Nemer (1942) and M.S. Bertlett (1950) by their tests of significance in factor analysis.
- (v) Raymond B. Cattell has developed the 'Principle Axis Technique' (1947).
- (vi) William Stephenson, the 'Q-Technique of Factor Analysis'.
- (vii) Sir Godfrey Thomson and Sir Cyril Burt, 'Factor Analysis of Human abilities'—his monumental work (1939) revised in (1951).
- (viii) Burt's 'Mental and Scholastic Tests'.
- (ix) Tests of 'Educable Capacity' (1924).
- (x) 'Factors of the Mind'.

Factor analysis methods on the personality side

- (i) Webb as early as 1915 attempted to isolate personality factors on the basis of correlations.
- (ii) Raymond B. Cattell, 'Description of Measurement of Personality' (1946).
- (iii) H. J. Eysenk, 'The Structure of Human Personality' (1953).

They claim a degree of success in their attempt to isolate personality traits by this technique. For example, traits like extraversion-introversion, neuroticism and emotional maturity have been claimed to be established.

External Criticism of Factor Methods

- (i) From pure mathematicians: They have doubted it as mathematical technique.
- (ii) Psychologists (other than psychometricians) have criticized its fundamental bases. Zangwill, in his book *An Introduction to Modern Psychology* (1950), says:

The objectivity derives from uniformity of technique rather than from any exceptional understanding of intelligence.

According to E.Q. Chambers, 'too often mathematical psychologist build elegant and dizzy numerical edifices. Forgetting in their architectural zeal the flimsy foundations upon which their fabrics stand.'

A.H. Heim, in her work *The Appraisal of Intelligence* (1954), has felt very doubtful of the possibility of the ultimate contribution of factorial techniques to our understanding of the cognitive make up on the mind.

- (i) When a link-up of their mathematical results with psychological entities is sought to be established, there ultimately remains no way of doing so except by introspective procedures. In spite other much wanted objectivity, the method is ultimately subjective.
- (ii) Achievements are confirmation or perhaps requirement of certain tentative hypothesis already available rather than the creation of a scientific hypothesis.

Use of factor analysis: The following are the main uses:

- This approach has been widely used in the domain of intelligence.
- It has also been used in the study of interest, personality temperament, attitudes and abilities.
- Factor analytical studies are useful in
 - (i) The structure of human abilities
 - (ii) Scientific vocational and educational guidance
 - (iii) Selection, classification and prognosis as well
- This helps to know the underlying psychological factors in clinical psychology and gives an idea of traits of another description.
- Factor analysis has been applied in an objective analysis of psychological findings and in places of greatest usefulness, implication in important but difficult psychological problem.

▲ List of Factorial Studies

- Types of domain-variable in human abilities, *The Structure of Human Abilities* by R.E. Vernon V: *ed and k: m* and Thurstone (PMA).
- Field most likely to gain by factorial method: vocational, administration, organization psychology.
- The factorial approach deals with some important problems: age difference, sex difference, racial difference, organization of abilities at different ages or development of stages.

▲ Evaluation of Factor Analytical Approach

- Cronbach suggests that factor analysis is not comparable to a chemist, search for elements but to the photographer trying to picture a building as revealingly as possible.
- Thurstone believes that the factors are something *very basic and simple like elements* in a mixture. This view has now been proved fallacious.
- The factor analysis wants to have an idea about the fundamental abilities involved in the task. But the abilities discovered by various research workers are different.
- It is not an objective device, but naming of factor is based on the subjectivity of a researcher.
- Factor analysis gives you back what you have already put in it.

Evaluate Yourself

- (i) Determine the mean, median and range of this distribution:
88, 86, 85, 80, 77, 75, 71, 65, 60, 56
- (ii) Compute the variance (σ^2) and standard deviation (σ) for this set of scores: 27, 27, 25, 24, 20, 18, 16, 16, 14, 12, 10, 7
- (iii) Amita was ranked 27th in an MBA class of 367. What was her percentile rank?
- (iv) Assuming a normal distribution of scores, a test has a mean score of 100 and SD of 15 per cent. Compute the following scores: (a) score that cut off the top 10 per cent; (b) score that cut off the lower 40 per cent; (c) percentage of scores above 90; (d) score limit of the middle 68 per cent
- (v) Using the spearman rank order coefficient correlation method, compute p.
- | S. N. | | X variable | Y variable |
|-------|-----------|------------|------------|
| 1. | Rajesh | 1 | 3 |
| 2. | Geeta | 2 | 4 |
| 3. | Neelam | 3 | 1 |
| 4. | Amita | 4 | 2 |
| 5. | Rekha | 5 | 7 |
| 6. | Abhilasha | 6 | 5 |
| 7. | Vaibhav | 7 | 6 |
- (vi) Given the following information, predict the Y score from the given X, when $X = 90$ and
- | | |
|-----------------|-----------------|
| (a) $r = +0.60$ | (b) $r = -0.60$ |
| $X = 80$ | $S_x = 12$ |
| $Y = 40$ | $S_y = 8$ |
- (vii) Compute the standard error of estimate of Y from X when
- $S_y = 6.20$
 $R = +0.60$

Summary

- Statistical analysis is the mathematical process of gathering, organizing, analysing and interpreting numerical data, and is one of the basic phases of the research process.
- Descriptive statistical data analysis involves the description of a particular group.
- Data are often organized in arrays in ascending and descending numerical order.
- Measures of central tendency (mean, median and mode) describe data in terms of sort of average.
- The range, deviation, variances, standard deviation, percentile and sigma score are useful measures of position, spread or dispersion.
- Measures of relationship describe the relationship of paired variables, quantified by a coefficient of correlation.
- The coefficient of correlation is useful in educational research in standardizing tests and in making predictions when only some of the data are available.
- Factor analysis is a multivariant analysis method. The inter-correlations are analysed to extract the factors.

Key Words

- *Descriptive Data Analysis*: It involves the description of a particular group.
- *Parametric Data*: Data of this type are measured data, and parametric statistical tests assume that the data are normally or nearly normally distributed.
- *Central Tendency*: The central or average value of a variable.
- *Measures of Dispersion*: Measures the scatterdness from the central value.
- *Quartiles*: Divide the whole distribution into four equal parts.
- *Variance*: The average of the squares of deviation of the observations from the arithmetic mean.
- *Percentile*: A point in a distribution of scores or value below which a given percentage of the cases occur.
- *Skewness*: A curve is said to be skewed when the distribution, mean and median lie at two different points and balance is shifted to one side or the other.
- *Kurtosis*: The term is applied to peakedness and flatness of the curve.
- *Correlation*: Relationship between two variables.
- *NPC*: Normal probability curve. It is the bell-shaped, smooth symmetrical curve.
- *Factor Analysis*: It is a multivariant analysis method.

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Inferential statistical data analysis always involves the process of sampling and the selection of a small group that is assumed to be related to the population from which it is drawn. The small group is known as the sample, and the large group is known as the population. Drawing conclusions about populations based on observations of samples is the purpose of inferential analysis.

▲ Parametric Treatment of Data

Parametric tests the most powerful tests for testing the significance or trustworthiness of the computed sample statistics and are very useful. Their use is based on certain assumptions. These tests should be used for the following:

- When the variables described are expressed in interval or ratio scales and not in nominal or ordinal scales of measurement.
- When the population values are normally distributed.
- When the samples have equal or nearly equal variances. This condition is known as equality or homogeneity of variances and is particularly important to determine when the samples are small.
- When the selection of one case in the sample is not dependent on the selection of any other.

Inferences Regarding Means of Large Samples

Suppose that we wish to measure the general intelligence of the tribal high-school adolescents of MP by means of a nonverbal test of intelligence developed for tribal adolescents of the state. It would be a difficult, if not an impossible, task to measure the general intelligence of all the tribal high-school adolescents of the state and hence we must usually be satisfied with a sample drawn from this population. This randomly drawn sample should be as large as possible to represent adequately all the tribal high-school adolescents of the state. If we select a large number of random samples of 100 tribal adolescents each from the population of all tribal high-school adolescents in MP, the mean values of general intelligence for all samples would not be identical. A few would be relatively high, and a few would be relatively low, but most of them would tend to cluster around the population mean. This variation of sample means is known as sampling error. The sample mean will not only vary from sample to sample, but will also deviate from the population mean. Each of these sample means can be treated as a single observation and their frequency distribution can be set. This distribution is known as sampling distribution of the means.

According to the central limit theorem, large-sized samples, greater than 30 in size, are selected at random from an infinite population.

- The distribution of the sample means is normal and it possesses all the characteristics of a normal distribution.
- The average value of the sample means will be the same as the mean of the population.
- The distribution of the sample means around the population mean has its own standard deviation. This standard deviation is known as the standard error of the mean and is denoted as SE_M or σ_M .

The standard error of the mean gives a clue as to how far such sample means may be expected to deviate from the population mean. If the mean of a particular sample may be taken as an estimate of the population mean, any deviation of such a sample mean from the population mean may be regarded as an error of estimation. The standard error of a mean explains how large the errors of estimation are in any particular sampling situation.

The formula for the standard error of the mean in a large sample is:

$$SE_M \text{ or } \overline{\sigma_M} = \frac{\bar{\sigma}}{N}$$

where $\bar{\sigma}$ is the standard deviation of the population and N is the number of cases in the sample.

This formula requires the knowledge of the parameter (i.e., standard deviation of the population) in order to compute the standard error of the mean. Since the value of j is not known, the estimate of this standard error should be made.

After computing the mean (M) and standard deviation (σ) of a large sample, the estimation can be made by the formula

$$\bar{\sigma}_M = \frac{\sigma}{\sqrt{N}},$$

where G is the standard deviation of the sample and N is the number of cases in the sample.

To illustrate the use of the formula, let us assume that the mean of the intelligence test score of a sample of 100 tribal high-school adolescents is 30 and the standard deviation is 5. The standard error of the mean is:

$$SE_M = \sigma_M = \frac{5}{\sqrt{100}} = 0.05$$

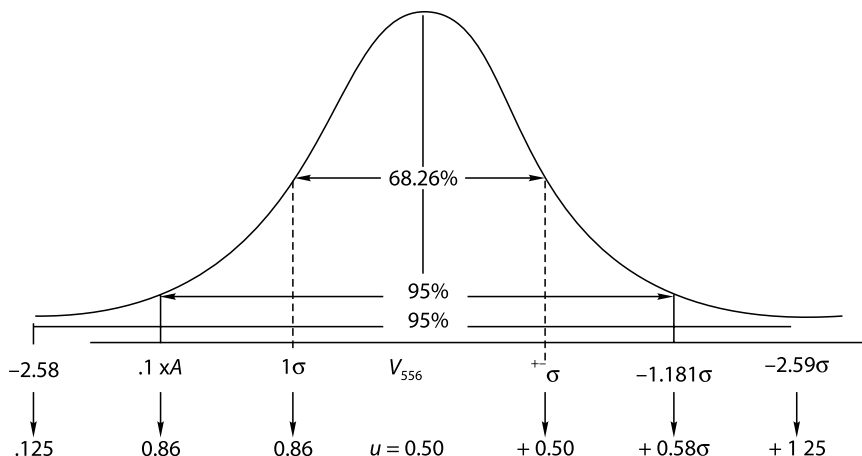


Figure 14.1 Sampling distribution of means showing variability of obtained means around population mean in terms of σ_M

The normal curve in Figure 14.1 illustrates that this sampling distribution is centred at the unknown population mean with its standard deviation 0.50. Often the sample means fall equally on the positive and negative sides of the population mean. About two-thirds of our sample means (exactly 68.26 per cent) will like with $\pm 1.00 \sigma_M$ of the population mean, i.e., within a range of $\pm 1 \times 0.50$ or ± 0.50 . Furthermore, 95 out of 100 sample means will like with $\pm 2.00 \sigma_M$ (more exactly $\pm 1.96 \sigma_M$) of the population mean, i.e., 95 of 100 probability (P) is 0.95, therefore, that our sample mean of 30 does not miss the population mean (M_{pop}) by more than ± 0.98 and the probability is 0.05 that the sample mean does miss the M_{pop} by more than ± 0.98 . Also, 0.99 of the sample means will be within ± 3.00 (more exactly $\pm 2.58 \sigma_M$) of the population mean, i.e., 99 of the sample means will lie within $\pm 2.58 \times 0.50$ or ± 1.29 of the population mean. The probability (P) is 0.99, therefore, that our sample mean of 30 does not miss the M_{pop} by more than ± 1.29 . The magnitude of the probable deviation of a sample mean from its population mean is a measure of the probability with which it is possible to estimate the M_{pop} from the sample mean.

Confidence Intervals and Levels of Confidence

Suppose a large sample is drawn from a population to obtain measures of a variable (e.g., test score) and has computed the mean M for the sample. Using the central limit theorem and the normal-curve concept, it can be said that the sample M has 95 per cent chance of being within 1.96 standard error units of M_{pop} . In other words, a mean for a random sample has a 95 per cent chance of being within $1.96 \sigma_M$ units of M_{pop} . It may also be said that there is a 99 per cent chance that the sample mean lies within $2.58 \sigma_M$ units of M_{pop} more specifically, and can be stated that there is a 95 per cent probability that the limits $M \pm 1.96 \sigma_M$ spans the population means M_{pop} . By the same reasoning it can be said that there is a 99 per cent probability that the limits $M \pm 2.58 \sigma_M$ encloses M_{pop} . Such limits are called as confidence intervals. These limits are also called M_{pop} as fiduciary limits and the confidence placed in the interval defined by the limits as containing the M_{pop} is called the fiduciary probability (Firsher 1935). These limits help in adopting two levels of confidence. One is known as 5 per cent level or 0.05 level, and the other as 1 per cent or 0.01 level. The 0.05 level of confidence indicates that the probability is 0.95, i.e., M_{pop} lies within the interval of $M \pm 1.96 \sigma_M$ and .05 indicates that it falls outside these limits. By the same reasoning, 0.01 level of confidence indicates that the probability is 0.99 and that M_{pop} lies within the interval of $M \pm 2.58 \sigma_M$ and 0.01 indicates that it falls outside these limits.

By way of illustration, let us apply the concept to the previous problem. Taking the limits as $M \pm 1.96$, we have $30 \pm 1.96 \times 0.50$ or a confidence interval marked off by the limits 29.02 and 30.98. The confidence that this interval contains M_{pop} is expressed by a probability of 0.95. If a higher degree of confidence is required, take the 0.99 level of confidence, for which the limits are $M \pm 2.58 \sigma_M$ or a confidence interval given by the limits 28.71 and 31.29. It is quite confident that M_{pop} is not lower than 28.71 or higher than 31.29, i.e., the chances are 99 in 100 that the M_{pop} lies between 28.71 and 31.29.

Inferences Regarding Means of Small Samples

When the number of cases of the sample is less than 30, the value of σ can be estimated by the formula

$$= \frac{S}{\sqrt{N}},$$

where S is the standard deviation of the small sample and N is the number of cases in the sample.

The formula for computing S is

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

where Σx^2 is the sum of the squares of deviations in the sample and N is the number of cases in the sample.

For small sample, it should not be assumed that the sampling distribution of means is distributed normally. It was in about 1815 when William Seely Gosset, a consulting statistician for Guinness Breweries of Dublin, Ireland, developed the concept of small sample size. He found that the distribution curves of small sample means were somewhat different from the normal curve.

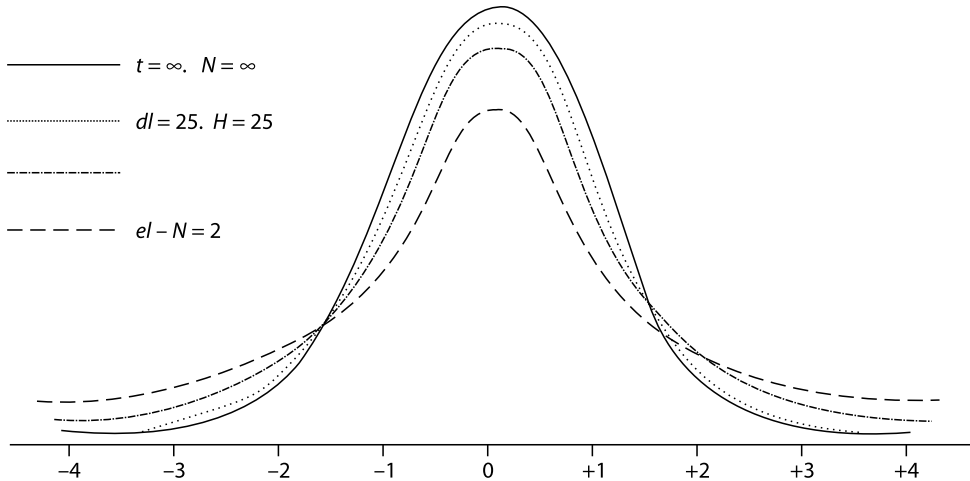


Figure 14.2 Distribution of t for degrees of freedom from 1 to ∞ (when df is very large, the distribution of t approaches normal)

Such a distribution is named as t -distribution. When size of the sample is small, the t -distribution lies under the normal curve, but the tails or ends of the curve are higher than the corresponding parts of the normal curve. Figure 14.2 shows that the t -distribution does not differ greatly from the normal unless the size is quite small, and that as sample increases in size the t -distribution approaches closely to the normal curve.

For small samples, it is necessary to make use of selected points reproduced in Table C of the Appendix. As the sample size increases, the t -values approach the Z values of the normal probability table. In the use of t -values, make use of important concept of degree of freedom and it is necessary to introduce the reader to this concept.

Degrees of Freedom

For finding the standard deviation of small samples, make use of $(N - 1)$ in the denominator in the formula in place of N used in the basic formula for standard deviation. The difference between the two formulae seems very slight, especially when N is reasonably large, but there is a very important difference in the meaning. In the formula, $N - 1$ is known as the number of degrees of freedom, and is denoted by the symbol df . By freedom, we mean freedom to vary.

A numerical illustration will make it clear as to why the df used here is $N - 1$. Assume that there are seven scores 4, 6, 7, 8, 10, 12 and 16, the mean of which is 9. Now use this value as estimate of the population mean. The deviations of the scores from the mean 9 are $-5, -3, -2, -1, +3$, and $+7$. A mathematical requirement of the mean is that the sum of these deviations is zero. Of the seven deviations

only six, i.e., $(N - 1)$ can be chosen freely (i.e., independently) as the condition that the sum equal to zero restricts the value of the seventh deviate. With this condition we can arbitrarily change any six of the deviates and thereby fix the seventh. Take the first six deviates as $-7, -5, -4, +3$ and $+1$, which would mean that for the sum to be equal to zero the seventh has to be $+8$. Similarly, any other changes can be tried and if the sum is to remain zero, one of the seven deviations is automatically determined. Hence, only six, i.e., $(7 - 1)$ are free to vary within the restrictions imposed.

When a statistics is used to estimate a parameter, the number of degrees of freedom depends upon the restrictions placed. One df is lost for each restriction imposed. Therefore, the number of degrees of freedom will vary from one statistics to another. In estimating and computing population mean (M_{pop}) from the sample mean (M), for example, 1 df is lost and so the number of degrees of freedom is $N - 1$.

By way of illustration, determine the 0.95 and 0.99 confidence intervals for the population mean (M_{pop}) of the scores 5, 5, 7, 4 and 6 obtained by five children in a test of perception, i.e., mean of the scores is $\frac{5+5+7+4+6}{5} = \frac{27}{5} = 5.4$ or 5.40. Using formula, compute the standard deviation as:

x	$x = X - M$	x^2
5	-0.4	0.16
5	-0.4	0.16
7	1.6	2.56
4	-1.4	1.96
6	0.6	0.36
	$\Sigma x = 0$	$\Sigma x^2 = 5.20$

$$S = \sqrt{\frac{\Sigma x^2}{N-1}} = \sqrt{\frac{5.20}{5-1}} = 1.14$$

From this formula compute $SE_{M'}$, which is to be $\frac{1.14}{\sqrt{5}}$ or 0.51.

For estimating the M_{pop} from the sample mean of 5.40, determine the value of t at the selected points using appropriate number of degrees of freedom. The df available for determining t is $N - 1$ or 4. Entering Table C with 4 df note that $t = 2.78$ at the .05 point and 4.60 at the .01 point. From the first t -value, it can be seen that 95 of the 100 sample means will lie within ± 2.78 SEM or $\pm 2.78 \times 0.51$ of the population mean and that 5 out of 100 fall outside these limits. The probability (P) is .95, therefore, the sample mean 5.40 does not miss the M_{pop} by more than $\pm 2.78 \times 0.51$ or ± 1.42 . From the second t -value, it is observed that 99 per cent of the sample means will lie between M_{pop} and $\pm 4.60 SE_M$ or $\pm 4.60 \times 0.51$ and that 1 per cent fall beyond these limits. The probability (P) is 0.99. Therefore, the sample mean of 5.40 does not miss the M_{pop} by more than $\pm 4.60 \times 0.51$ or ± 2.35 .

Taking as the limits $M \pm 2.78 - SE_{M'}$, we have $5.40 \pm 2.78 \times 0.51$ or 3.98 and 6.82 as the limits of the 0.95 confidence interval. The probability (P) is 0.95 that the M is not less than 3.98 or greater than 6.82. Taking the limits $M \pm 4.60$ PoP SE, we have $5.40 \pm 4.60 \times 0.51$ or 3.05 and 7.75 as the limits or 0.99 confidence interval, and the probability (P) is 0.99 that M_{pop} is not less than 3.05 or greater than 7.75.

In educational research, building generalization on the basis of small samples should be avoided as it is difficult ensure that a small sample adequately represents the population from which it is drawn. Furthermore, conclusions drawn from small samples are usually unsatisfactory because of great variability from sample to sample.

Significance of Difference Between Means

Some investigations require the use of a statistical technique to determine whether a true difference exists between population means of two samples. Suppose we wish to determine whether the population of 13-year-old boys and girls differ in abstract reasoning. First we would draw a large random sample of boys and girls. Next, we would administer a test of abstract reasoning on the samples, compute the means of the two groups, and find the difference between them. Let the mean of the boys be 30 and that of the girls is 28. Then, it has to be ascertained if the difference of 2 between the means is large enough to be taken as real and dependable, i.e., not due to only sampling errors or chances. It cannot be categorically concluded that the mean of boys is large than the mean of girls and the difference of 2 between the two means is significantly large to be taken as dependable. In order to test the significance of an obtained difference, first have a standard error of the difference of the two means as it is reasonable to expect that the difference between two means will be subject to sampling errors. Then from the difference between the sample means and its standard error, it can be determined whether a difference probably exists between the population means.

Significance of Difference Between Independent Means in Large and Small Samples

Means are said to be independent or uncorrelated when computed from samples drawn at random from totally different and uncorrelated groups.

Large Samples

We have already found that the frequency distribution of large sample means drawn from the same population falls into a normal distribution around M_{pop} as their measure of central tendency, and it is reasonable to expect that the frequency distribution of the difference between the means computed from samples drawn from two different populations will also tend to be normal, with a means of zero and a standard deviation that is called the standard error of the difference means. Such a standard error is denoted by σ_{DM} and can be estimated from the standard errors of the two means σM_1 and σM_2 . The formula is

$$\sigma d_M = \sqrt{\sigma_{M1}^2 + \sigma_{M2}^2},$$

where σM_1 is the SE of the mean of the first sample, σM_2 is the SE of the mean of the second sample, N_1 is the number of cases in the first sample and N_2 is the number of cases in the second sample.

By way of illustration, let us apply this formula to a typical problem. Two groups, one of 95 boys and the other of 64 girls of the tenth grade, were given the same word-building test. The results are summarized in Table 14.1.

Samples:

Table 14.1

Statistics	Boys	Girls
<i>N</i>	95	64
Mean (<i>M</i>)	24.5	23.4
Standard deviation (σ)	5.12	4.07

Assuming that the samples are random, it is to be ascertained whether the difference between the means 24.5 and 23.4 is significant.

Using this formula, compute the standard error of the difference

$$\begin{aligned}\Sigma d_m &= \sqrt{(5.12)^2 / 95 + (4.07)^2 / 64} \\ &= 0.73\end{aligned}$$

The obtained difference between the means of the boys and the girls is 1.1 (i.e., 24.5 – 23.4); and the SE of this difference (σd_m) is 0.73.

As a first step in determining whether the boys and girls actually differ in word-building ability, a null hypothesis should be set up. This hypothesis asserts that the difference between the population means of boys and girls is zero and that, except for sampling errors, mean difference from sample to sample will all be zero. In accordance with the null hypothesis, assume a sampling distribution of differences to be normal with the mean at zero, or at $M_{\text{pop}}(\text{boys}) - M_{\text{pop}}(\text{girls}) = 0$, the deviation of each sample difference, $M_{\text{boys}} - M_{\text{girls}}$ from this central reference point is equal to $[M_{\text{boys}} - M_{\text{girls}}] - [M_{\text{pop}}(\text{boys}) - M_{\text{pop}}(\text{girls})]$, of $[M_{\text{boys}} - M_{\text{girls}}] = 0$, the deviation of each sampled difference given in terms of standard measure would be the deviation divided by the standard error, which gives a Z-value in terms of a general formula.

$$\bar{Z} = \frac{M_1 - M_2}{\sigma dm}$$

Figure 14.3 shows a sampling distribution of $\bar{Z}$ ratios.

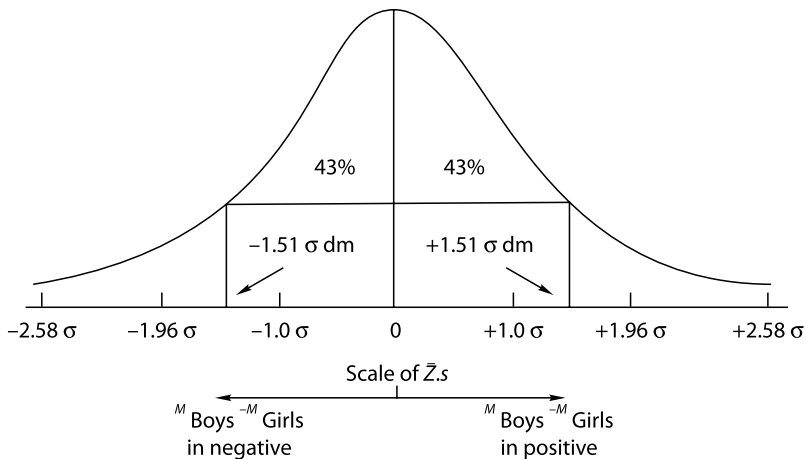


Figure 14.3 Sampling distribution of with a mean of zero

Using this formula

$$\bar{Z} = \frac{M_1 - M_2}{\sigma dm}$$

From Table A of the Appendix, it is known that 43 per cent $\times$ 2 or 86 per cent of the cases in a normal distribution fall between the mean and $\pm 1.51_M$ and 14 per cent of the cases fall outside. This means that under null hypothesis we can expect Zs as large as or larger than ± 1.51 to occur 'by chance' 14 times in 100 comparisons of means of samples of tenth-grade boys and girls on the word-building test.

Levels of Significance

For the sake of convenience, the researchers have 0.05 and 0.01 levels of significance as two arbitrary standards for accepting or rejecting a full hypothesis. From Table A it can be read that $\pm 1.96\sigma$ mark off points along the base line of a normal distribution to the left and right of which lie 5 per cent (2.5 at each end of the curve) of the cases. When a value is 1.96 or more, a null hypothesis at 0.05 level of significance is rejected. The Z value of 1.51 in our problem falls short of 1.96, i.e., does not reach 0.05 level. Accordingly, we retain the null hypothesis and conclude that tenth-grade boys and girls actually do not differ in mean performance on word-building test.

Furthermore, from Table A it is known that $\pm 2.58\sigma$ mark off points to the left and right of which lie 1 per cent (0.5 at each end of the curve) of the cases in a normal distribution. If Z value is 2.58 or more, the null hypothesis is rejected at 0.01 level and the probability (P) is that not more than once in 100 trials would a difference of this size arise if the true difference ($M_{\text{pop1}} - M_{\text{pop2}}$) is zero.

Two-tailed and One-tailed Tests of Significance

Suppose a null hypothesis was set up that there was no difference, other than a sampling error difference, between the mean test anxiety score of high-school boys and girls, we would be concerned only with a difference, and not in superiority or inferiority in test anxiety of either group. To test this hypothesis we apply two-tailed test as the difference between the obtained means may be as often in one direction (plus) as in the other (minus from the difference of zero; and in determining probabilities we take both tails of sampling distribution.

For a large sample two-tailed test, we make use of a normal distribution curve. The 5 per cent area of rejection is divided equally between the upper and lower tails of this curve and we have to go out ± 1.96 on the base line of the curve to reach the area of rejection (Figure 14.4).

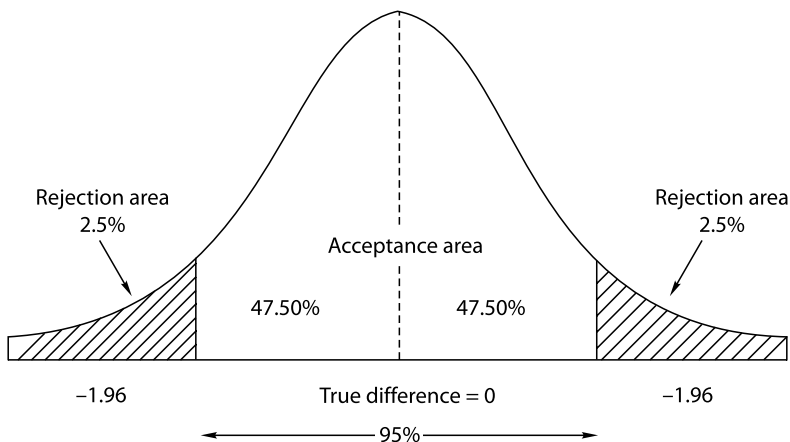


Figure 14.4 A two-tailed test at 0.05 level (2.5 per cent at each level)

Similarly, we have 0.5 per cent area at each end of the normal curve when 1 per cent area of rejection is to be divided equally between its upper and lower tails and its rejection is as shown in Figure 14.5.

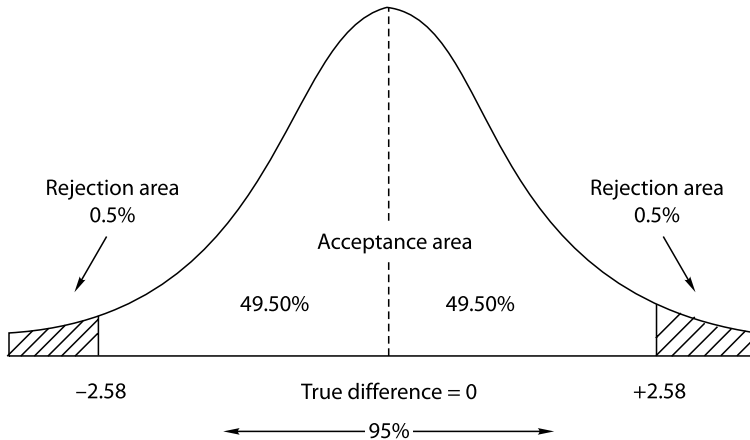


Figure 14.5 A two-tailed test at 0.1 level (0.5 per cent at each level)

For a small sample two-tailed test, we make use of t -distribution. The t -critical values necessary for the rejection of the null hypothesis are determined from Table C of the Appendix with the help of degrees of freedom. For example, in comparing the significance of mean test anxiety score difference between samples of 10 high-school boys and 15 high-school girls, the number of degrees of freedom is $N_1 + N_2 - 2$ or $10 + 15 - 2$ or 23. From Table C at 23 df the t -critical values necessary for the rejection of the null hypothesis at 0.05 and 0.01 levels are 2.07 and 2.81, respectively.

In the above problem, if we change the null hypothesis as: high-school boys do not have higher test anxiety than high-school girls; and high-school boys do not have lower test anxiety than high-school girls; then each of these hypotheses indicates a direction of difference. When we are hypothesizing a direction of difference, rather than the mere existence of a difference, we make use of one-tailed test. For such test, the 5 per cent area or 1 per cent area of rejection is either at the upper tail or at the lower tail of the curve. For given degrees of freedom the 0.5 level is read from the 0.10 column ($P/2 = 0.05$) and the 0.01 level from 0.02 column ($P/2 = 0.01$). In the one-tailed test, for 23 df t -critical values at .05 and .01 levels, as read from the 0.10 and 0.02 columns of Table C are 1.71 and 2.50, respectively.

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

$$= \frac{M_1 - M_2}{\sqrt{\left(\frac{\sum X_1^2 + \sum X_2^2}{N_1 + N_2 - 2} \right) \left(\frac{N_1 + N_2}{N_1 N_2} \right)}}$$

where M_1 and M_2 are means of the two samples, $\sum X_1^2$ and $\sum X_2^2$ are the sums of squares of the deviations from the means in the two samples and N_1 and N_2 are the number of cases in the two samples.

The appropriate t -critical value for acceptance or rejection of the null hypothesis would be found for $N_1 + N_2 - 2$ degrees of freedom, using Table C of the Appendix.

There are some conditions that must be met to justify the use of t -test for small samples. Guilford (1965: 184–85) presents the undermentioned conditions that should be fulfilled in the use of t -test.

The population distribution should be normal. If the population distribution is seriously skewed, t -tests should not be used. For skewed distribution, a number of distribution-free tests are available, some of which are described in nonparametric tests.

The two samples under investigation should have the same variances. This condition is known as homogeneity of variances. Bartlett's test of homogeneity determines whether or not two sample variances are significantly different, which is described later in this chapter in the 'technique of analysis of variance'.

To illustrate the use of formula let us test the significance of the difference between the means of interest test scores of five boys and eight girls (13-year old) presented in Table 14.2.

$$N_1 + N_2 - 2 = 5 + 8 - 2$$

Using this formula

$$t = \frac{26 - 25}{\sqrt{\left\{ \frac{104 + 226}{5 + 8 - 2} \right\} \left\{ \frac{5 + 8}{5 \times 8} \right\}}}$$

Table 14.2 Scores of five boys and eight girls on interest test

Boys		($N_1 = 5$)	Girls	($N_2 = 8$)	
	X_1	X_1^2	X_2	X^2	X_2^2
20	−6	36	34	9	81
22	−4	16	25	0	0
30	4	16	16	−9	81
32	6	36	30	+5	25
26	0	0	22	−3	9
—		—			
		$\sum x_1^2 = 104$	27	2	4
$M_1 = \frac{\sum X_1}{N_1}$			20	−5	25
= 130/5			$\sum X_2 \frac{26}{200}$	1	$\sum x_2^2 = \frac{1}{226}$
			$M_2 = \frac{\sum X_2}{N_2}$		
= 26			= $\frac{220}{8}$		
			= 25		

This is a two-tailed test, and the t -critical values for rejection of null hypothesis in Table C of the Appendix of (5 + 8 − 2) or 11 df are 2.20 at 0.05 and 3.11 at .01 levels. Since the obtained t -value is 0.32, it does not equal or exceed the t -critical value necessary for rejection of the null hypothesis at the 0.05 level for 11 df , the null hypothesis is accepted and we conclude that there is no significant difference in the mean interest scores of 13-year-old boys and girls.

Significance of Difference Between Dependent Means in Large and Small Samples

Means are said to be dependent or correlated when obtained from the scores of the same test administered to the same sample upon two occasions or when the same test is administered to equivalent samples in which the individuals who make up the groups have been matched person for person, by one or more characteristics.

Suppose we have administered a test to a group of students and three weeks later the test was repeated.

The formula used for testing the significance of the difference between means obtained in the initial and final testing is

$$= \frac{M_1 - M_2}{\sqrt{\sigma^2 m + \sigma^2 m - 2r_{12}\sigma_{M1}\sigma_{M2}}}$$

where σ_{M1} is the standard error of the initial test mean, σ_{M2} is the standard error of the final test mean and r_{12} is the correlation between the scores on initial and final testing.

The following example will illustrate the use of this formula. Twelve students of eighth grade of a certain school were administered an achievement test in arithmetic and then all the students were provided remedial instruction in arithmetic. Three weeks later, the test was administered for the second time. To test the hypothesis that the remedial instruction increases the test scores of students, we would test the significance of the difference between the means of the scores for the first and second trials of the test as shown in Table 14.3.

Table 14.3 Scores of 12 students of eighth grade on trial 1 and trial 2 of an achievement test in arithmetic

Trial 1 (X_1)	Trial 2 (X_2)
33	45
57	67
50	58
65	79
36	46
55	63
37	47
30	25
21	30
46	56
38	35
45	57
—	—
$EX_1 = 512$	$EX_2 = 608$

Computing from the scores, we have

$$\begin{array}{ll} M_1 = 42.66 & M_2 = 50.66 \\ \sigma_1 = 12.63 & \sigma_2 = 15.74 \\ \sigma_{M1} = 3.65 & \sigma_{M2} = 4.54 \\ r_{12} = 0.94 & \end{array}$$

Using formula

$$t = \frac{142.66 - 50.661}{\sqrt{(3.65)^2 + (4.54)^2 - 2 \times 0.94 \times 3.65 \times 4.54}} = 4.92$$

Since there are 12 students, we have 12 pairs of scores and 12 differences, the df becomes $12 - 1$ or 11. To test the hypothesis that remedial instruction in arithmetic increases test score of students, we would make use of one-tailed test. In the one-tailed test, for 11 df the .05 level is read from 0.01 column ($P/2 = 0.05$) to Table C to be 1.80 and the 0.01 level from the .02 column ($P/2 = 0.01$) is 2.72 since t of 4.92 is much larger than the 0.01 level of 2.72 it may be concluded that the gain from Trial 1 to 2 is significant and the hypothesis that the remedial instruction in arithmetic increases the test score is accepted.

A procedure called the difference method is also used to test the significance of the difference between the means of test scores obtained from administration of the same test to the same sample upon two occasions. This method is quicker and convenient when the sample is small. The formula used in this method is

By way of illustration, let us apply the difference method to the data of 12 students in Table 14.3.

$$t = \frac{M_D}{SE_{MD}},$$

where

MD is the mean of difference and SEMD is the standard error of mean of difference method to the data of 12 students in Table 14.4.

Table 14.4 Trial and difference

Trial 1	Trial 2	Difference (D)	$d = (D - M_D)$	$d^2 (2 - 1)$
1	2	3	4	5
33	45	+12	4	16
57	67	+10	2	4
50	58	+8	0	0
65	79	+14	6	36
36	46	+10	2	4
55	63	+8	0	0
37	47	+10	2	4
30	25	-5	-13	169
21	30	+9	1	1
46	56	+10	2	4
37	35	-2	-10	100
45	57	+12	4	16
		$\Sigma D = 96$		$\Sigma d^2 = 354$

$$\text{Mean of difference} = MD = \frac{\sum D}{N} = \frac{96}{12} = 8$$

$$\text{Standard deviation of difference} = SD_D = \sqrt{\frac{\sum d^2}{N - 1}}$$

$$\begin{aligned} &= \sqrt{354/11} \\ &= 5.67 \end{aligned}$$

Standard error of mean of difference = $SE_{MD} = \frac{SD_D}{\sqrt{N}}$

Using formula $= \frac{5.67}{\sqrt{12}}$

$$\begin{aligned} t &= \frac{8}{1.64} \\ &= 4.88 \end{aligned}$$

The result found by using the difference method has come out to be the same as before within the error of computation.

In some experimental situations, equivalent groups were set up using matching technique. One group acts as the experimental group and the other as the control group. Pairs initially do the matching so that each person in the first group has a match in the second group. In such situations we also make use of the formula for testing the significance of the difference between the means of the variable under study for the two groups.

The following problem is typical of many in which the equivalent group technique is useful.

Two groups, A and B, of seventh-grade students were matched for initial ability in a test of general science. Group A was taught by the lecture method and group B by the lecture-demonstration method. Data are given in Table 14.5.

To test the significance of the difference between the mean final scores, 56.35 and 62.40, on the general science test, we make use of two-tailed test.

$$\begin{aligned} t &= \frac{56.35 - 62.40}{\sqrt{\left(\frac{6.00}{50}\right)^2 + \left(\frac{7.31}{50}\right)^2 - 2 \times 0.54 \times \frac{6.00}{\sqrt{50}} \times \frac{7.51}{\sqrt{50}}}} \\ &= 6.61 \end{aligned}$$

There are 50 pairs, and the degrees of freedom to be used in testing this are (50 – 1) or 49. Entering Table C of the Appendix with 49 *df*, we find that *t* at 0.01 level to be 2.68. Since *t* of 6.61 is much larger than the 0.01 level *t* of 2.68, we may reject the null hypothesis and conclude that the mean of group B (experimental) is significantly higher than the mean of group A (control).

Table 14.5 Initial and final scores of students in control and experimental groups on the general science test

	Group A (Control)	Group B (Experimental)
Number of students	50	50
Mean initial score on the general science test	45.30	45.67
SD of initial scores on the general science test	4.26	4.20
Mean final score on the general science test	56.35	62.40
SD of final scores on the general science test	6.00	7.31
Correlation between final scores on the general science test	0.54	—

At times, it is impracticable or impossible to set up groups in which subjects have been matched person for person. In such situations, it is desirable to match the subjects in terms of mean and the standard deviation of the matching variable.

Suppose that X is the variable under study and Y is the variable in terms of which the groups have been matched for mean and standard deviation. If r_{xy} is the correlation between X and Y in the population from which our samples have been drawn, the formula for testing the significance of difference between means is

$$t = \frac{1Mx_1 - Mx_2}{\sqrt{(\sigma^2_{Mx1} + \sigma^2_{Mx2})(1 - r_{xy}^2)}}$$

where σ^2_{Mx1} is the standard error of the mean of the scores in X variable for the first group, σ^2_{Mx2} is the standard error of the mean of the scores in X variable for the second group and r_{xy} is the correlation between the variable under study and the variable in terms of which the groups have been matched for mean and SD.

To illustrate the use of formula, suppose two groups, A and B, of high-school students were matched for mean and SD upon a group test of general intelligence for their comparison in comprehension of humour. The groups were administered a test in comprehension of humour and the data are given in Table 14.6.

Table 14.6 Mean and standard deviation of scores on comprehension in humour test of matched groups

	Group A	Group B
Mean on comprehension in humour test	45.20	52.27
SD on comprehension in humour test	10.00	13.00
Numbers of students	60	70

The correlation between the scores in group test of general intelligence and comprehension of humour test for the high-school students was found to be 0.50.

To test the significance of the difference between the means 45.20 and 52.27 for the two groups, we make use of two-tailed test. Using formula

$$t = \frac{145.20 - 52.271}{\sqrt{[(10)^2/60 + (13)^2/70][1 - (0.50)^2]}}$$

The degrees of freedom to be used in testing this t are $(N_1 - 1) + (N_2 - 1) - 1$, or $(60 - 1) + (70 - 1) - 1$ or 127. Entering Table C of the Appendix with 127 df , we find that t -value of 4.04 is larger than the entry of 2.62 at the 0.01 level, and therefore, the null hypothesis that the two groups do not differ in comprehension of humour is rejected. Since the mean of group B is larger than that of group A, we may conclude that group B has performed better in the test of comprehension of humour than group A.

Analysis of Variance

We use Z and t -tests to determine whether there is any significant difference between the means of two random samples. Suppose we have six random samples and we want to determine whether there are any significant differences among their means, we have to use

$$\frac{6(6-1)}{2} = 15$$

t -tests to determine the significance of the difference between the six means by taking two means at a time. This procedure is cumbersome and time consuming. The technique of analysis of variance would make it possible to determine if any two of the six means differ significantly from each other by a single

test, called *F*-test, rather than 15 *t*-tests. The *F*-test enables us to determine whether the sample means differ from one another (between group variance) to a greater extent than the test scores differ from their own sample means (within group variance) using the ratio: variance between groups

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

The significance of *F*-ratio is determined from Table D of the Appendix. This table indicates the *F*-critical values necessary to reject the null hypothesis at selected levels of significance.

Assumptions of Analysis of Variance

Analysis of variance has certain basic assumptions underlying it. Johnson (1961) presents certain assumptions, which should be fulfilled in the use of this technique

- The population distribution should be normal. This assumption, however, is not especially important. Eden and Yates showed that even with a population departing considerably from normality, the effectiveness of the normal distribution still holds. Besides the findings of Eden and Yates, the study of Norton cited by Guilford (1965: 300–01) also points out that *F* is rather insensitive to variations in the shape of population distribution.
- All the groups of a certain criterion or of the combination of more than one criterion should be randomly chosen from the subpopulation having the same criterion or the same combination of more than one criterion. For instance, if we wish to select two groups in a school population, one of the third grade and the other of the fourth grade, we must choose randomly from respective subpopulations. This assumption is the key stone of the analysis of variance technique. Failure to fulfil this assumption gives biased results.
- The subgroups under investigation should have the same variability. This assumption should be tested before running through the analysis of variance. Otherwise, a false interpretation of the results may follow. This assumption is tested either by applying Bartlett’s test of homogeneity or by Hartley’s test.

Analysis of Variance for a Randomized Group Design (One-Way Analysis of Variance)

In a learning experiment, 28 subjects were randomly assigned to each of the three groups. Each group performed the same task but under slightly different experimental treatments. The outcomes of the experiment are given in Table 14.7.

Table 14.7 Data of the groups obtained under three experimental treatments

Treatment 1 (<i>X</i> ₁)	Treatment 2 (<i>X</i> ₂)	Treatment 3 (<i>X</i> ₂)	
15	13	20	
17	18	28	
16	18	18	
11	13	11	
19	16	16	
16	14	15	

Table 14.7 (Continued)

Treatment 1 (X_1)	Treatment 2 (X_2)	Treatment 3 (X_3)	
15	20	16	
18	21	19	
18	18	11	
18	13	9	
14	14	14	
18	19	15	
11	14	14	
11	22	14	
14	16	12	
11	16		
17	12	19	
20	21	24	
18	16	14	
12	13	16	
12	17	21	
21	20	20	
11	12	9	
17	18	18	
16	15	14	
12	15	17	
12	13	16	
9	15	8	
ΣX 419	452	448	1319
ΣX^2 6561	7532	7726	21819

To test the hypothesis that the group do not differ in mean performance the technique of analysis of variance can be applied.

The basic assumptions underlying this technique are as follows:

Assumption of normality. In the light of the findings of Eden and Yates (Johnson 1961) and Norton (Guilford 1965: 300–301) the assumption of normality may not be considered important for the data of the experiment.

Assumption of randomness. The requirement of randomness has been amply fulfilled in this experiment as the subjects were randomly assigned to three experimental groups from the same pool sample.

Assumption of homogeneity of variance. This assumption may be tested by applying Bartlett's test of homogeneity of variance to the data of the three groups in the following manner.

Table 14.8 Bartlett’s test of homogeneity of variance for the data of the groups obtained under three experimental treatments

Treatment (K)	df (N – 1)		ΣK^2	$\log SK^2$
1	27	290.96	10.78	1.0326
2	27	235.43	8.72	0.9405
3	27	558.00	20.67	1.3153
			$\Sigma SK^2 = 40.17$	$\Sigma \log SK^2 = 3.2884$

where

$$\Sigma XK^2 = \Sigma X^2 - \frac{(\Sigma X)^2}{N}$$

$$SK^2 = \frac{\Sigma XK^2}{N - 1}$$

Computations

$$\log \frac{\Sigma XK^2}{K} = \log \frac{40.17}{3} = \log 13.39 = 1.1268$$

$$K \log \frac{\Sigma SK^2}{K} = 3 \times 1.1268 = 3.3804$$

Difference

$$= K \log \frac{\Sigma SK^2}{K} - \Sigma \log$$

$$= 3.3804 - 3.2884 = 0.092$$

$$\chi^2 \text{ (chi-square)} = 2.3026 \times (N \times 1) \text{ (difference)}$$

where 2.3026 is a constant term

$$= 2.3026 \times 27 \times 0.092$$

$$= 5.7196$$

Correction,

$$C = 1 + \frac{K + 1}{3K(N - 1)}$$

$$= 1 + \frac{3 + 1}{3 \cdot 3 \cdot 27}$$

$$= 1 + 4/243 = 10.16$$

Corrected χ^2 (chi-square)

$$= \frac{\chi^2}{\text{correction}}$$

$$= 5.6296$$

$$df = K - 1 = 3 - 1 = 2$$

The value of χ^2 needed for significance for 2 *df* at 0.05 level is 5.991 (Table E of the Appendix). Since the obtained value of χ^2 , 5.6296 is less than the needed value, the variance within the cells may be treated as homogeneous.

After testing the data for the basic assumptions we may proceed with the computations for the analysis of variance.

$$\text{Correction} = \frac{\Sigma X^2}{N} = \frac{(1319)^2}{84} = 20711.44$$

Total sum of squares (total SS)

$$\begin{aligned}
 &= \Sigma X^2 - \text{Correction} \\
 &= 15^2 + 17^2 + \dots + 16^2 + 8^2 - 20711.44 \\
 &= 1107.56
 \end{aligned}$$

Sum of square between means of treatment 1, 2 and 3 (SS between means)

$$\begin{aligned}
 &= \frac{(\Sigma X_1)^2}{N_1} + \frac{(\Sigma X_2)^2}{N_2} + \frac{(\Sigma X_3)^2}{N_3} - \text{correction} \\
 &= \frac{(419)^2}{28} + \frac{(452)^2}{28} + \frac{(448)^2}{28} - 20711.44 \\
 &= \frac{175561 + 2043304 + 200704}{28} - 20711.44 \\
 &= 20734.61 - 20711.44 \\
 &= 23.17
 \end{aligned}$$

Sum of squares with treatments 1, 2 and 3 (SS within means)

$$\begin{aligned}
 &= \text{total SS} - \text{SS between means} \\
 &= 11.7.56 - 23.17 = 1084.39
 \end{aligned}$$

$$\text{Correction} = \frac{175561 + 2043304 + 200704}{28} \frac{(\Sigma X)^2}{N} = \frac{(1319)^2}{84} = 20711.44$$

Total sum of squares (total SS)

$$\begin{aligned}
 &= \Sigma X^2 - \text{correction} \\
 &= 15^2 + 17^2 + \dots + 16^2 + 8^2 - 20711.44 \\
 &= 1107.56
 \end{aligned}$$

Sum of squares between means of treatment 1, 2 and (SS between means)

$$\begin{aligned}
 &= \frac{(\Sigma X_1)^2}{N_1} + \frac{(\Sigma X_2)^2}{N_2} + \frac{(\Sigma X_3)^2}{N_3} - \text{Correction} \\
 &= \frac{(419)^2}{28} + \frac{(452)^2}{28} + \frac{(448)^2}{28} - 20711.44 \\
 &= \frac{175561 + 204304 + 200704}{28} - 20711.44 \\
 &= 20734.61 - 20711.44 \\
 &= 23.17
 \end{aligned}$$

Sum of squares with treatments 1, 2 and 3 (SS within means)

$$\begin{aligned}
 &= \text{total SS} - \text{SS between means} \\
 &= 1107.56 - 23.17 = 1084.39
 \end{aligned}$$

Calculation of variances from each SS and analysis of the total variance into its component: Each SS becomes a variance when divided by the degrees of freedom (4) allotted to it. There are 84 scores in Table 14.7 and hence there are $(N - 1)$ or 83 *df* in. These 83 *df* are allocated in the following way:

If N is the number of scores in all and K is the number of treatments or groups, we have *df* for total $SS = N - 1 = 84 - 1 = 83$; *df* for within treatments $= N - K = 84 - 3 = 81$; and *df* for between the means of treatments $= K - 1 = 3 - 1 = 2$.

The variance among means of treatments is $23.17/2$ or 11.585; and the variance within means is $1084.39/81$ or 13.387.

Table 14.9 Summary: Analysis of variance

Source of Variation	df	Sum of Squares (SS)	Mean Square (Variance)
Between the means of treatments	2	23.17	11.585
Within treatments	81	1084.39	13.387
Total	83	1107.56	

Using formula

$$F = \frac{11.585}{13.387} = 0.865$$

In the present problem the null hypothesis asserts that three sets of scores are in reality the scores of three random samples drawn from the normally distributed population, and that the means of the treatments 1, 2 and 3 will differ only through the fluctuations of sampling. To test this hypothesis we divided the ‘between means’ variance by the ‘within treatments’ variance and compared the resulting variance ratio, *F*, with the *F*-values in Table D of the Appendix. The *F*-value in our problem is 0.865 and the *df* are 2 for the numerator (*df*₁) and 81 for the denominator (*df*₂). Entering Table D, we read from column 2 and row 81 (interpolate between rows 80 and 90) that an *F* on 3.11 is significant at 0.05 level and *F* of 4.88 is significant at the 0.01 level. Since the obtained *F*-value of 0.865 is less than the table values, we accept the null hypothesis, and therefore, conclude that the means of three groups do not differ significantly.

Analysis of Variance for Factorial Design (Three-way Analysis of Variance)

In many experimental studies, we are concerned with the effect of two or more independent variables, usually called ‘factors’, on dependent variables. The number of ways in which a factor is varied is called the number of levels of the factor. A factor that is varied in two ways is said to have two levels and a factor that is varied in three ways is said to have three levels. With two or more factors each has two or more levels. A treatment in some experiments consists of a combination of one level for each factor. Edwards (1971: 200) says:

When the treatment consists of all possible different combinations of one level from each factor. And we have an equal number of observations for each treatment the experiment is described as a complete factorial experiment with equal replications.

As an illustration let us suppose that the dependent variable is a measure of retention of verbal material. One independent variable (factor) may be the number of times the material is presented: the second independent variable (factor) may be the mode of presentation of the material; and the third independent variable (factor) may be the time of testing. Suppose the first factor (*A*) is varied in two ways: (i) by presenting the material once (*A*₁) and (ii) by presenting the material twice (*A*₂); the second factor (*B*) is varied in three ways: (i) in one case, the subjects read the material themselves (*B*₁ visual mode of presentation); (ii) in the second case, the experimenter reads the material to the subjects (*B*₂ auditory mode of presentation); and (iii) in the third case, first the experimenter reads the material to the subjects and then the subjects are asked to read the material themselves (*B*₃ auditory cum visual mode of presentation); the third factor (*C*) is also varied in three ways: (i) the administration of the test immediately after the experiment (*C*₁ immediate retention); (ii) the administration of the test 2 weeks after the experiment (*C*₂; 2 weeks retention); and (iii) the administration of the test 6 weeks after the experiment (*C*₃ 6 weeks retention).

A given treatment can be obtained by selecting one level from each of the three factors. For example, one treatment will be $A_1B_1C_1$ and will represent a treatment consisting of one presentation, using the visual mode, and an immediate test. The total number of different treatments will be $2 \times 3 \times 3 = 18$, shown in Table 14.10.

Table 14.10 18 treatment combinations of $2 \times 3 \times 3$ factorial experiment

Treatment	Number	Mode	Time
$A_1B_1C_1$	One	Visual	Immediate
$A_1B_1C_2$	One	Visual	2 weeks
$A_1B_1C_3$	One	Auditory	6 weeks
$A_1B_2C_1$	One	Auditory	Immediate
$A_1B_2C_3$	One	Auditory	2 weeks
$A_1B_2C_2$	One	Auditory	6 weeks
$A_1B_3C_1$	One	Visual auditory	Cum immediate
$A_1B_3C_2$	One	Visual auditory	Cum 2 weeks
$A_1B_3C_3$	One	Visual auditory	Cum 6 weeks
$A_2B_1C_1$	Two	Visual	Immediate
$A_2B_1C_3$	Two	Visual	2 weeks
$A_2B_2C_1$	Two	Visual	6 weeks
$A_2B_2C_2$	Two	Auditory	Immediate
$A_2B_2C_3$	Two	Auditory	2 weeks
$A_2B_3C_1$	Two	Visual auditory	Cum 6 weeks

Suppose the researcher randomly assigns 20 subjects to each group for each treatment and obtains data on the dependent variable. The outcomes of this hypothetical experiment are given in Table 14.11.

Assumption of Homogeneity of Variance

This assumption may be tested by applying Bartlett's test of homogeneity to the data given in Table 14.12. Using formulae, we obtain the values for Table 14.11.

Table 14.11 Bartlett's test of homogeneity of variance for data of groups obtained under 18 experimental treatments

Treatment (K)	df (N - 1)	ΣXK^2	SK^2	log SK^2
$A_1B_1C_1$	19	184.95	9.73	0.9981
$A_1B_1C_2$	19	184.95	9.73	0.9981
$A_1B_1C_3$	19	170.80	8.99	0.9583
$A_1B_2C_1$	19	292.00	15.37	1.1866
$A_1B_2C_2$	19	183.20	9.64	0.9841
$A_1B_2C_3$	19	142.95	7.52	0.8762
$A_1B_3C_1$	19	131.20	6.91	0.8762
$A_1B_3C_2$	19	101.20	5.33	0.7267
$A_1B_3C_3$	19	156.80	8.25	0.9165

(Continued)

Table 14.11 (Continued)

Treatment (K)	df (N – 1)	ΣXK^2	SK^2	log SK^2
$A_2B_1C_1$	19	145.75	7.67	0.8848
$A_2B_1C_2$	19	230.55	12.13	1.0838
$A_2B_1C_2$	19	112.95	5.94	0.7738
$A_2B_2C_1$	19	203.20	10.69	1.0289
$A_2B_2C_2$	19	352.55	18.56	1.2685
$A_2B_2C_2$	19	152.95	8.05	0.9058
$A_2B_2C_3$	19	230.95	12.16	1.0847
$A_2B_3C_1$	19	187.00	9.84	0.9930
$A_2B_3C_2$	19	136.20	7.17	0.8554
$A_2B_2C_3$	19	156.00	8.21	0.9143
		$\Sigma SK^2 = 172.16$		$\Sigma \log SK^2 = 17.2645$

Table 14.12 Data of group obtained under different experimental treatments

A ₁																			A ₂	
B ₁				B ₂			B ₃			B ₁			B ₂			B ₃				
C ₁	C ₂	C ₃	C ₁	C ₂	C ₃	C ₁	C ₂	C ₃	C ₁	C ₂	C ₃	C ₁	C ₂	C ₃	C ₁	C ₂	C ₃			
19	18	19	20	22	19	20	15	18	22	19	11	10	23	15	21	17	16			
17	21	16	20	22	198	17	18	22	22	14	15	12	23	15	22	19	14			
14	16	11	263	19	15	22	17	18	14	14	17	13	13	22	24	18	22			
18	16	21	17	18	19	16	18	19	17	15	15	13	15	22	24	20	21			
23	19	13	18	18	23	18	16	15	16	17	25	9	17	21	16	17	14			
17	9	25	20	19	16	19	19	17	20	18	17	14	18	18	20	19	19			
18	18	19	19	21	19	18	17	17	16	14	17	16	9	13	21	18	19			
15	19	20	22	17	18	14	19	14	22	18	21	11	14	12	19	20	18			
21	19	15	22	22	19	20	19	18	18	16	20	9	20	14	18	19	16			
16	14	18	17	17	16	18	11	16	21	15	13	11	18	23	14	22	20			
17	17	22	11	17	17	18	13	20	20	14	17	8	15	19	18	18	14			
14	15	20	20	16	20	18	17	22	19	19	16	12	17	23	20	20	19			
19	20	17	18	14	17	13	14	17	14	14	19	19	16	15	14	19	18			
20	19	19	12	22	18	20	23	18	13	20	12	17	19	15	16	21	21			
19	15	11	18	20	14	17	15	20	17	19	16	23	20	18	15	19	13			
23	23	18	17	19	13	16	13	13	22	21	19	21	17	20	22	22	16			
13	18	19	16	16	19	19	14	20	13	14	18	18	21	17	16	22	20			
18	16	15	18	17	15	14	14	12	16	18	16	14	21	22	16	21	23			
19	16	14	21	13	12	19	16	21	12	17	20	19	15	16	16	24	18			
11	20	10	15	22	16	20	20	18	13	13	20	18	18	19	18	11	19			
ΣX 351	348	340	364	371	344	356	328	355	347	329	344	287	359	359	370	386	360	6298		
ΣX ² 6345	6226	6072	6208	7025	6048	6438	5536	6447	6251	5525	6120	4471	6597	6675	7032	7586	6636	113,838		

Computation: $\log \frac{\Sigma SK^2}{K} = \log \frac{172.16}{18} = \log 9.56 = 0.9805$

$$K \log \frac{\Sigma SK^2}{K} = 18 \times 0.9805 = 17.6490$$

Difference:
Using formula, $= K \log \frac{\Sigma SK^2}{K} - \Sigma \log SK^2$

$$\begin{aligned}\chi^2 \text{ (chi-square)} &= (2.3026) (19) (0.3845) \\ &= (2.3026) (19) (0.3845) \\ &= 16.8216\end{aligned}$$

Using formula,

Correction:
$$\begin{aligned}C &= 1 + \frac{K+1}{3K(N-1)} \\ &= 1 + \frac{18+1}{3 \cdot 18 \cdot 19} \\ &= 1 + \frac{1}{54} = 1.0185\end{aligned}$$

Using formula,

Corrected χ^2 (chi-square)
$$\begin{aligned}&= \frac{\chi^2}{\text{correction (C)}} \\ &= \frac{16.8216}{1.0185} \\ &= 16.52\end{aligned}$$

$$df = K - 1 = 18 - 1 = 17$$

The value of χ^2 needed for significance of 17 df at .05 level is 27.587 since the obtained value 16.52 of χ^2 is less than the needed value, and the variance with the cells may be treated as homogeneous.

After testing the data for the homogeneity of variance, we may proceed with the computations for the analysis of variance.

$$\text{Correction} = \left(\Sigma_N X^2 \right) = \frac{(6298)^2}{360} = 110180.01$$

Total sum of squares (total SS)

$$\begin{aligned}&= \Sigma X^2 - \text{correction} \\ &= [(19)^2 + (17)^2 + (14)^2 + \dots + (23)^2 + (18)^2 + (19)^2] - 110180.01 \\ &= 3657.99\end{aligned}$$

Sum of squares between and within the means. For calculating these values the following table is set up. It shows the sum of 20 scores under each of 18 treatments.

Sum of squares between treatments (SS between means)

$$\begin{aligned}&= \frac{\Sigma X_1^2}{N^1} + \frac{\Sigma X_2^2}{N_2} + \dots + \frac{\Sigma X_{18}^2}{N_{18}} - \text{correction} \\ &= \frac{(351)^2}{20} + \frac{(348)^2}{20} + \dots + \frac{(360)^2}{20} - 110180.01\end{aligned}$$

$$= 110566.80 - 110180.01$$

$$= 386.79$$

Sum of squares within treatments (SS within means)

$$= \text{total SS} - \text{SS between means}$$

$$= 3657.99 - 386.79$$

$$= 3271.20$$

Partitioning the treatment sum of squares. The sum of squares between treatments, which is based upon $(20 - 1)$ or 19 *df* can be divided into different components, i.e., main effects and

From the data given in Table 14.13, we set up the table for the levels of *B* and *C* summed over levels of *A*.

Table 14.13 Two-way table for variables *B* and *C* summed over the levels of *A*

	<i>C</i> ₁	<i>C</i> ₂	<i>C</i> ₃	Σ
<i>B</i> ₁	698	677	684	2059
<i>B</i> ₂	651	730	703	2084
<i>B</i> ₃	726	714	715	2155
Σ	2075	2121	2102	6298

Main Effects for *B* and *C*

Each cell entry in Table 14.13 will be the sum of $2 \times 20 = 40$ observations because the variable *A* has got two levels: *A*₁, and *A*₂. The total of rows 2059, 2084 and 2155 are the sum of three levels of *B*₁*B*₂ and *B*₃, respectively and these sums are based upon column totals 2075, 2121 and 2102, and are the sum of $3 \times 40 = 120$ observations.

Sum of squares B (SS_B)

$$= \frac{1}{120} [(2059)^2 + (2084)^2 + (2155)^2] - \text{correction}$$

$$= 110221.35 - 110180.01$$

$$= 41.34$$

Sum of square for C (SS_C)

$$= \frac{1}{120} [(2075)^2 + (2121)^2 + (2102)^2] - \text{correction}$$

$$= 110188.92 - 110180.01$$

$$= 8.91$$

Double interaction *B* × *C*

The sum of square between the cells of Table 14.14 is based on 40 observations.

Sum of squares between cells (SS_{cells})

$$= \frac{1}{40} [(698)^2 + (677)^2 + \dots + (715)^2] - \text{correction}$$

$$= 110309.90 - 110180.01$$

$$= 129.89$$

The *B* × *C* interaction sums of squares may be obtained by subtracting the sum of squares for *B* and *C* from the sum of squares between the cells.

Sum of squares for *B* × *C*

$$= \text{SS}_{\text{cells}} - \text{SS}_B - \text{SS}_C$$

$$\begin{aligned}
 &= 129.89 - 41.34 - 8.91 \\
 &= 79.64
 \end{aligned}$$

Again from the data of Table 14.12, we set up another two-way table for variables A and B summed over levels of C .

Table 14.14 Two-way table for variables A and B summed over the levels of C

	B_1	B_2	B_3	Σ
A_1	1039	1079	1039	3157
A_2	1020	1005	1116	2141
Σ	2059	2084	2155	6298

Main Effect for A

Each cell entry in Table 14.14 is based upon 60 observations and the sums of 3157 and 3141 are the sums for the levels of A and B , respectively, which are based upon $3 \times 60 = 180$ observations.

Sum of squares for A (SS_A)

$$\begin{aligned}
 &= \frac{1}{180} [(3157)^2 + (3141)^2] - \text{correction} \\
 &= 110180.72 - 110180.01 \\
 &= 0.71
 \end{aligned}$$

Double interaction $A \times B$

The sum of squares for B has already been calculated from Table 14.13 and is equal to 41.34. Now to calculate $A \times B$ interaction sum of squares, we first find out the sum of squares between cells of Table 14.14 (SS_{cells})

Sum of squares between cells (SS_{cells})

$$\begin{aligned}
 &= \frac{1}{60} [(1039)^2 + (1079)^2 + (1039)^2 + (1020)^2 + (1005)^2 + (1116)^2] - \text{correction} \\
 &= 110319.40 - 110180.01 \\
 &= 139.39
 \end{aligned}$$

The $A \times B$ interaction sum of squares may be calculated by subtracting sum of squares for A and B from the sum of squares between the cells.

Sum of the squares between $A \times B$

$$\begin{aligned}
 &= 139.39 - 0.71 - 41.34 \\
 &= 97.34
 \end{aligned}$$

Double interaction $A \times C$

Again, we set up another two-way table to obtain the sum of squares for $A \times C$ interactions

Table 14.15 Two-way table for variables A and C summed over the levels of B

	C_1	C_2	C_3	Σ
A_1	1071	1047	1039	3157
A_2	1004	1074	1063	3141
Σ	2075	2121	2102	6298

Sum of squares between cells (SS_{cells})

$$= \frac{1}{60} [(1071)^2 + (1047)^2 + (1039)^2 + (1004)^2 + (1074)^2 + (1063)^2] - \text{correction}$$

$$\begin{aligned} &= 110237.20 - 110180.01 \\ &= 57.19 \end{aligned}$$

The sum of squares for the $A \times C$ interaction may be calculated by subtracting the sum of the cells. Sum of squares between $C \times A$

$$\begin{aligned} &= 57.19 - 0.71 - 8.91 \\ &= 47.57. \end{aligned}$$

Triple Interaction $A \times B \times C$

We know that the total of the sum of squares for A , B and C , $A \times B$, $B \times B \times C$, $C \times A$ and $A \times B \times C$ must be equal to the sum of squares between the treatments.

$$\begin{aligned} SS_A + SS_B + SS_C + SS_{A \times B} + SS_{B \times C} + SS_{C \times A} \\ &= 0.71 + 41.34 + 8.91 + 97.34 + 79.64 + 47.57 \\ &= 275.51 \end{aligned}$$

The sum of the squares between $A \times B \times C$ can be obtained by subtracting the sum 275.51 from 386.79, the sum of the squares between the treatments.

$$\begin{aligned} \text{Sum of the squares between } A \times B \times C \\ &= 386.79 - 275.51 \\ &= 111.28 \end{aligned}$$

Degrees of freedom (df). The analysis of variance has resulted in the partitioning of the total sum of squares and degrees of freedom into two parts is associated with differences among 18 treatment means and is based on $K - 1$ or $18 - 1 = 17$ *df*. The other part is associated with the variation with each of the treatment groups and has $(K)(S - 1) = (18)(20 - 1) = 342$ *df*. The sum of squares is based on a comparison of the sum for one and two presentations of the material. This sum of squares has $(2 - 1)$ or 1 *df*. The B sum of squares is based on a comparison of the sums for visual, auditory and visual cum auditory modes of presentation. This sum of squares has $3 - 1$ or 2 *df*. The C sum of squares is based on the sums for the immediate, 2 weeks and 6 weeks tests. This sum of squares also has $3 - 1$ or 2 *df*.

A general rule for determining the degrees of freedom for any interaction sum of squares is to multiply the degree of freedom associated with the factors for which the interaction is being computed. In the present problem, the degrees of freedom for the interactions $A \times B$ and $A \times C$ will be $(2 - 1)(3 - 1) = 2$ *df*. Similarly, the degrees of freedom for $B \times C$ will be $(3 - 1)(3 - 1) = 4$ *df*. The degrees of freedom associated with $A \times B \times C$ interaction is the product of the degrees of freedom associated with the factors involved in the Since we have 1 *df* for A , 2 *df* for B and 2 *df* for C , the *df* for $A \times B \times C$ interaction, sum of squares will be $1 \times 2 \times 2 = 4$ *df*.

The summary of the complete analysis of variance is presented in Table 14.16. The values of F that have been entered in Table 14.16 are obtained by dividing each of the mean squares that is to be tested for significance by the error mean square, that is, within treatment mean square. Thus, the value of F for A is based on 1 and 342 *df*. Each value of F for B , C , $A \times B$ and $C \times A$ is based on 2 and 342 *df*. Similarly, each value of for $B \times C$ and $A \times B \times C$ is based on 4 and 342 *df*.

Table 14.16 Summary: Analysis of variance

	Source of Variation	Sum of Squares	df	Mean Squares	F
A	Number	0.71	1	0.71	0.07
B	Mode	41.34	2	20.57	2.16
C	Time	8.91	2	14.555	0.47

Table 14.16 (Continued)

	Source of Variation	Sum of Squares	df	Mean Squares	F
$A \times B$	Number $\times$ mode	97.34	2	48.67	5.09
$B \times C$	Mode $\times$ time	79.64	4	19.91	2.08
$C \times A$	Number $\times$ time	47.57	2	23.785	2.49
$A \times B \times C$	Number $\times$ mode $\times$ time	111.28	4	27.82	2.91
Error	Within treatments	3271.20	342	9.57	
	Total	3657.99	359		

Summary of conclusions—main effects: Entering Table D, we find that the main effects for A , B and C are not significant at .05 level of significance. The nonsignificance of A mean square indicates that the means for A and B , averaged over levels of B and C , do not differ significantly. Similarly, we can interpret the nonsignificance of B and C main effects.

Interaction. The $A \times B$ interaction is significant. Therefore, the A effect, that is, the difference between A and B or between one and two presentations is dependent on the particular mode of presentation employed. The interactions $B \times C$ and $C \times A$ are not significant.

The significant $A \times B \times C$ interactions indicates that: (1) the $A \times B$ interactions for the separate levels of C are not of the same form, (2) the $C \times A$ interactions for the separate levels of B are not of the same form, and (3) the $B \times C$ interactions for the separate levels of A are not of the same form.

Analysis of co-variance. Analysis of co-variance represents an extension of analysis of variance that tests the significance of difference between the means of final experimental data by taking into account the correlation between the dependent variable and one or more co-variants or pertinent control variables, and by adjusting initial mean differences in the groups. It is useful to the experimental psychologists especially in the field of memory and learning, when for various reasons it is not possible or quite difficult to equate experimental groups on some pertinent variables at the start of the experiment.

In an experiment, suppose the dependent variables were the performance of two groups of students on a criterion test: one group was taught through programmed learning (experimental group) and the other through conventional method (control group). The two groups were framed by randomly assigning 70 subjects to each of the groups and the subjects were equated on the pre-test scores on the criterion test. Since intelligence was also considered to be a significant factor related to the scores on the criterion test, the scores on the intelligence test were also taken into account so as to provide a statistical control for testing the significance of the difference between the means of criterion test scores of the two groups at the end of the experiment.

Let scores of the subjects of the experimental and control groups on intelligence test be denoted by X_1 and X_2 and those on the criterion test (post-test) as Y_1 and Y_2 , respectively. The total number of subjects in experimental and control groups is denoted by N_1 and N_2 , respectively. Moreover, the sum of the scores and the sum of squares of the scores on intelligence and criterion tests obtained by the subjects of the two groups are denoted by the following symbols.

ΣX_1 = Sum of the scores on intelligence test obtained by the subjects on the experimental groups.

ΣX_2 = Sum of the scores on intelligence test obtained by the subject of the control group.

ΣX_1^2 = Sum of squares of the scores on intelligence test obtained by the subject of the control group.

ΣX_2^2 = Sum of the squares of the scores on intelligence test obtained by the subject of the control group.

ΣX^2 = Sum of the scores on criterion test obtained by the subjects of the experimental group.

- $\Sigma Y_1 =$ Sum of the scores on criterion test obtained by the subjects of the control group.
- $\Sigma Y_2 =$ Sum of the squares of the scores on criterion test obtained by the subjects of the experimental group.
- $\Sigma Y =$ Sum of the squares of the scores on criterion test obtained by the subjects of the control group.
- $\Sigma Y_1^2 =$ Sum of the products of the scores on intelligence and criterion tests obtained by the subjects of the experimental group.
- $\Sigma Y_2^2 =$ Sum of the products of the scores on intelligence and criterion tests obtained by the subjects of the experimental group.
- $N =$ Total number of subjects in the experimental and control groups.
 $= N_1 + N_2$

The outcomes of the experiment are given in Table 14.17.

Table 14.17 Data of the experimental and control groups obtained under two-experimental treatments

Experimental Group			Control Group		
Subject		Score on Criterion Test (Y1)	Subject	Score on Intelligence Test (X2)	Score on Criterion Test (Y2)
1	50	84	1	37	70
2	35	80	2	47	81
3	28	76	3	46	70
4	43	80	4	58	84
5	47	83	5	39	80
6	41	81	6	42	76
7	29	70	7	52	81
8	46	82	8	30	65
9	29	68	9	44	70
10	28	76	10	32	72
11	43	81	11	50	82
12	46	82	12	49	81
13	35	78	13	52	70
14	38	81	14	57	80
15	39	81	15	40	69
16	49	80	16	24	80
17	41	81	17	43	80
18	46	81	18	38	80
19	43	80	19	46	83
20	45	82	20	40	78
21	59	85	21	54	81
22	46	82	22	52	75

Table 14.17 (Continued)

Subject	Experimental Group		Subject	Control Group	
		Score on Criterion Test (Y1)		Score on Intelligence Test (X2)	Score on Criterion Test (Y2)
23	43	81	23	48	80
24	38	70	24	53	68
25	49	83	25	48	81
26	59	80	26	46	70
27	53	84	27	44	80
28	52	84	28	40	72
29	48	83	29	60	85
30	56	80	30	47	81
31	42	84	31	48	80
32	33	84	32	70	62
33	54	83	33	52	80
34	58	84	34	27	60
35	63	81	35	49	81
36	58	68	36	49	77
37	57	84	37	50	72
38	60	85	38	51	81
39	23	85	39	42	72
40	53	84	40	24	62
41	63	84	41	68	84
42	48	86	42	46	80
43	44	70	43	47	78
44	40	80	44	60	84
45	46	86	45	61	75
46	55	83	46	59	81
47	26	81	47	52	70
48	48	80	48	53	80
49	51	70	49	27	70
50	42	84	50	43	82
51	24	75	51	50	77
52	53	83	52	68	78
53	44	81	53	39	80
54	51	80	54	61	86
55	52	63	55	60	85
56	47	74	56	49	84
57	48	80	57	51	80

(Continued)

Table 14.17 (Continued)

Experimental Group			Control Group		
Subject		Score on Criterion Test (Y1)	Subject	Score on Intelligence Test (X2)	Score on Criterion Test (Y2)
58	50	83	58	63	81
59	47	84	59	19	70
60	56	82	60	51	79
61	39	82	61	48	82
62	46	83	62	38	80
63	62	82	63	40	77
64	37	82	64	49	80
65	46	83	65	28	77
66	53	82	66	50	80
67	39	85	67	56	80
68	46	70	68	59	86
69	49	82	69	52	79
70	31	86	70	50	79

$$M_{x1} = 4.5, M_{x2} = 46.90, G_{Mx} = 46.22, M_{y1} = 80.11, M_{y2}, 77.44$$

Basic Assumptions of Analysis of Co-variance

Analysis of co-variance has certain basic assumptions underlying it. According to Ray (1960: 129–32), Lindquist (1970: 195–96) and Edwards (1971: 332–39) the assumptions are as follows:

- The distribution of the adjusted scores within groups should be normal.
- The method groups should be selected at random from the same population.
- The groups should be homogeneous in variability.
- The effect to each treatment should be constant and additive on the responses of the subjects in the group on which the treatment is imposed.
- There should be a real correlation between the dependent variable and the co-variable or pertinent control variable.
- There should be homogeneity of regressions from group to group.

The basic assumptions underlying the technique of analysis of co-variance for the data Y and Y2 in Table 14.16 are tested as follows:

Assumption of normality: In the light of the findings of Eden and Yates (Johnson 1961), and Norton (Guildford 1965: 300–01) the assumption of normality may not be considered important for the data of the experiment.

Assumption of randomness: The requirement of randomness was amply fulfilled for the data of the experiment. First 70 pairs of subjects were chosen on the basis of subject-to-subject matching on the pre-test criterion scores. Finally, two groups, with 70 subjects in each group, were framed by randomly assigning one member of each pair of each group.

Assumption of homogeneity: The assumption of homogeneity of sample variance may be tested by applying Bartlett's test of homogeneity of variance.

Computation of $\Sigma Y_1, K^2$ and $\Sigma S_1, K^2$:

Using formula,

$$\begin{aligned}\Sigma Y_1, K^2 &= \Sigma Y_1^2 - \frac{(\Sigma Y_1)^2}{N_1} \\ &= 451038 - \frac{(5608)^2}{70} \\ &= 1757.09\end{aligned}$$

Using formula,

$$\begin{aligned}\Sigma S_1, K^2 &= \frac{\Sigma Y_1 K^2}{N_1 - 1} \\ &= \frac{1757.09}{70 - 1} = 25.47\end{aligned}$$

Computation of $\Sigma Y_2, K^2$ and $\Sigma S_2, K^2$:

Using formula,

$$\begin{aligned}\Sigma Y_2, K^2 &= \Sigma Y_2^2 - \frac{(\Sigma Y_2)^2}{N^2} \\ &= 422299 - \frac{(5421)^2}{70} \\ &= 2481.27\end{aligned}$$

Using formula,

$$\begin{aligned}\Sigma S_2, K^2 &= \frac{\Sigma Y_2 K^2}{N_2 - 1} \\ &= \frac{2481.27}{70 - 1} \\ &= 35.96\end{aligned}$$

Computation of $K \log \frac{\Sigma SK^2}{2}$:

$$\begin{aligned}K \log \frac{\Sigma SK^2}{2} &= K \log \frac{\Sigma S_1 K^2 + \Sigma S_2 K^2}{2} \\ &= 2 \log \frac{25.47 + 35.96}{2} \\ &= 2 \log 30.715 \\ &= 2.9744\end{aligned}$$

Computation of $\Sigma, \log \Sigma SK^2$

$$\begin{aligned}\Sigma, \log \Sigma SK^2 &= \log \Sigma S_1 K^2 + \log \Sigma S_2 K^2 \\ &= \log 25.47 + \log 35.96 \\ &= 2.9618\end{aligned}$$

Computation of difference D :

$$\begin{aligned}D &= K \log \frac{\Sigma SK^2}{2} - \log \Sigma SK^2 \\ &= 2.9744 \times 2.9618 = 0.0126\end{aligned}$$

Computation of chi-square χ^2 :

Using formula,

$$\begin{aligned}\chi^2 &= (2.3026) (N - 1) (D) \\ &= (2.3026) (70 - 1) (0.0126)\end{aligned}$$

Computation of correction C:

Using formula,

$$\begin{aligned}C &= 1 + \frac{K + 1}{3K \left(\frac{N_1 + N_2}{2} - 1 \right)} \\ &= 1 + \frac{2 + 1}{3 \times 2 \times \left(\frac{70 + 70}{2} - 1 \right)} \\ &= 1.007\end{aligned}$$

Computation of corrected chi-square:

Using formula,

Corrected:

$$\begin{aligned}\chi^2 &= \frac{\chi^2}{\text{correction (C)}} \\ &= \frac{2.002}{1.007} = 1.988 \\ df &= K - 1 = 2 \times 1 = 1\end{aligned}$$

The value of χ^2 needed for significance for 1 df at 0.05 level is 3.841. Since the obtained value 1.988 of χ^2 is less than the needed value, the variance within the treatments may be treated as homogeneous.

Assumption of additivity: The assumption that the effect of treatment is constant and additive on the responses of the subjects in the group on which the treatment was imposed is tested by the test of additivity in the manner described by Ray (1960: 57–58). This test employs a variance ration calculated in terms of F -value described as follows:

Sum of squares for the experimental group

$$\begin{aligned}&= \Sigma Y_1^2 - \frac{(\Sigma Y_1)^2}{N_1} \\ &= 451038 - \frac{(5608)^2}{70} = 1757.09\end{aligned}$$

Variance for the control group

$$\begin{aligned}&= \frac{1757.09}{N_1 - 1} = \frac{1757.09}{70 - 1} \\ &= \frac{1757.09}{69}\end{aligned}$$

Sum of squares for the control group

$$\begin{aligned}&= \Sigma Y_2^2 - \frac{(\Sigma Y_2)^2}{N_2} \\ &= 422299 - \frac{(5412)^2}{70} \\ &= 2481.27\end{aligned}$$

Variance for the control group

$$= \frac{2481.27}{N_2 - 1} = \frac{2481.27}{70 - 1} = \frac{2481.27}{69}$$

Variance ratio

$$F = \frac{1757.09}{69} \bigg| \frac{02481.27}{69} = 0.71$$

Since the value of F needed for significance for 69/69 df at 0.05 level of confidence is greater than the obtained value of 0.71, the assumption of additivity is found to hold good for the data Y_1 and Y_2 in Table 14.16.

Assumption of correlation: The assumption that there should be a real correlation between the dependent variable and the pertinent control variable is tested by using the test of significance of regression in the manner described by Ray (1960: 129). This test also employs the computation of variance ratios in terms of F -value. In the present problem, the scores on the intelligence test are the pertinent control variable and those on the criterion test (post-test) are the dependent variable.

The details computational steps are described as follows:

The predicted sum of square based on the within-sample sums of squares and products

$$\begin{aligned} P_w &= \frac{\left[\Sigma X_1 Y_1 - \frac{(\Sigma X_1)(\Sigma Y_1)}{N_1} + \Sigma X_2 Y_2 - \frac{(\Sigma X_2)(\Sigma Y_2)}{N_2} \right]}{\left[\Sigma X_1^2 - \frac{(\Sigma X_1)^2}{N_1} + \Sigma X_2^2 - \frac{(\Sigma X_2)^2}{N_2} \right]} \\ &= \frac{(2563.66 - 1916.10)^2}{(6297.37 + 7386.30)} \\ &= \frac{(4479.76)^2}{13683.68} = 1466.58 \end{aligned}$$

The predicted variance

$$\begin{aligned} V_{pw} &= \frac{P_w}{C - 1} \quad (C \text{ is the number of group}) \\ &= \frac{1466.58}{2 - 1} = 1466.58 \\ E_w &= \left[\Sigma X_1^2 - \frac{(\Sigma Y_1)^2}{N_1} + \Sigma X_2^2 - \frac{(\Sigma Y_2)^2}{N_2} \right] \\ &\quad - \frac{\left[\Sigma X_1 Y_1 - \frac{(\Sigma X_1)(\Sigma Y_1)}{N_1} + \Sigma X_2 Y_2 - \frac{(\Sigma X_2)(\Sigma Y_2)}{N_2} \right]^2}{\left[\Sigma X_1^2 - \frac{(\Sigma X_1)^2}{N_1} + \Sigma X_2^2 - \frac{(\Sigma X_2)^2}{N_2} \right]} \end{aligned}$$

Within-sample sum of square of error of estimate

$$\begin{aligned} &= 1757.09 + 2481.27 - \frac{(2563.66 + 1916.10)^2}{6297.37 + 7386.30} \\ &= 4238.36 - \frac{(4479.76)^2}{13683.67} \\ &= 2771.78 \end{aligned}$$

The error variance

$$V_{ew} = \frac{E_w}{(N - C - 1)} (N = N_1 + N_2)$$

$$\frac{2771.78}{(140 - 2 - 1)} = 20.23$$

The variance ration

$$F = \frac{V_{pw}}{V_{ew}} = \frac{1466.58}{20.23} = 72.496$$

Since the obtained value 72.495 of F exceeds the value given in Table D of the Appendix for 1/137 df at 0.05 level of confidence, the assumption of real correlation between the dependent variable and the pertinent control variable is justified and that the use of intelligence scores as a pertinent control variable was worthwhile in partially eliminating error from the data.

Assumption of homogeneity of regressions: The assumption that there should be homogeneity of regressions from group to group is tested by computing the F-ratio for the test of homogeneity of regressions in the following manner as given by Ray (1960: 130–31):

1. The sums of the squares of errors of prediction

$$= \left[\Sigma Y_1^2 - \frac{(\Sigma Y_1)^2}{N_1} \right] - \frac{\left[\Sigma X_1 - \frac{(\Sigma X_1)(\Sigma Y_1)}{N_1} \right]^2}{\left[\Sigma X_1^2 - \frac{(\Sigma X_1)^2}{N_1} \right]}$$

$$+ \left[\Sigma Y_2^2 - \frac{(\Sigma Y_2)^2}{N_2} \right] - \frac{\left[\Sigma X_2 - \frac{(\Sigma X_2)(\Sigma Y_2)}{N_2} \right]^2}{\left[\Sigma X_2^2 - \frac{(\Sigma X_2)^2}{N_2} \right]}$$

$$= 1757.09 - \frac{(2563.66)^2}{6297.37} + 2481.21 - \frac{(1916.10)^2}{7386.30}$$

$$= 713.42 + 1984.21 = 2697.63$$

Within-sample sum of squares of errors of estimate computed earlier in the case of assumption of correlation by using formula

$$E_w = 2771.78$$

The means of homogeneity of regressions

$$= E_w - E_I$$

$$= 2771.78 - 2697.63$$

$$= 74.15$$

The variance ratio

$$F = \frac{E_w - E_I}{C - 1} \bigg| \frac{E_I}{N - 2C}$$

$$= \frac{74.15}{2 - 1} \bigg| \frac{2697.63}{140 - 2 \times 2}$$

$$= 3.74$$

Since the value of F needed for significance for 1/136 df at .05 level of confidence is greater than the obtained value 3.74, the assumption that two sample regressions are homogeneous is taken to be justified.

Analysis of Co-variance of Data of Experimental and Control Groups

After testing the data for assumptions described above, we may proceed further with the analysis of co-variance to test the significance of the difference between the means of the criterion test scores of the experimental and control groups. The computational steps are as follows:

The first adjustment based on the sums of squares and products of deviations from the total means.

$$\begin{aligned}
 E_t &= \left[\Sigma Y^2 - \frac{(\Sigma Y)^2}{N} \right] - \frac{\left[\Sigma XY - \frac{(\Sigma X)(\Sigma Y)}{N} \right]^2}{\left[\Sigma X^2 - \frac{(\Sigma X)^2}{N} \right]} \\
 &= 4488.14 - \frac{(4352.86)^2}{137448} \\
 &= 4488.14 - 1378.18 \\
 &= 3109.96
 \end{aligned}$$

The second adjustment based on the within-sample sums of squares and products of deviations from the sample means.

$$\begin{aligned}
 E_w &= \left[\Sigma Y_1^2 - \frac{(\Sigma Y_1)^2}{N_1} + \Sigma Y_2^2 - \frac{(\Sigma Y_2)^2}{N_2} \right] \\
 &= \frac{\left[\Sigma X_1 Y_1 \frac{\Sigma X_1 (\Sigma Y_1)}{N_1} - \Sigma X_2 Y_2 \frac{(\Sigma X_2)(\Sigma Y_2)}{N_2} \right]}{\left(\Sigma X_1^2 - \frac{(\Sigma X_1)^2}{N_1} + \Sigma X_2^2 - \frac{(\Sigma X_2)^2}{N_2} \right)} \\
 &= 1757.09 + 2481.27 - \frac{(2563.66 + 1916.10)^2}{6297.37 + 7386.30} \\
 &= 4238.36 - \frac{(4479.76)^2}{1368.67} \\
 &= 2771.79
 \end{aligned}$$

The discrepancy sum of squares

$$\begin{aligned}
 D &= E_t - E_w \\
 &= 3109.96 - 2771.78 = 338.18
 \end{aligned}$$

The discrepancy variance, a measure of appeasement effects

$$\begin{aligned}
 V_d &= \frac{D}{C - 1} \\
 &= \frac{338.18}{2 - 1} = 338.18
 \end{aligned}$$

The error variance
Using formula

$$V_{ew} = \frac{E_w}{(N - C - 1)}$$

$$= \frac{2771.78}{140 - 2 - 1} = 20.23$$

F-value for testing the significance of the difference between means

$$F = \frac{V_d}{V_{ew}}$$

$$= \frac{338.18}{20.23} = 16.72$$

Degree of freedom (df)

- (i) For between samples or treatments (D) = C - 1 = 2 - 1 = 1
- (ii) For between samples or error (E_w) = N - C - 1 = 140 - 2 - 1 = 137
- (iii) For total means (E_t) = N - 2 = 140 - 2 = 138

Components of Variability	Sum of Squares (SS)	df	Variance (V)	F
Between samples or treatments (D)	338.18	1	338.18	16.72
With samples or error (E _w)	2771.78	137	20.23	
Total (E _t)	3109.96	138		

The adjusted mean of the criterion test scores of the experimental group

$$My_1x_1 = My_1 - b (Mx_1 - GMx)$$

The adjusted mean of the criterion score of the control group

$$My_2x_2 = My_2 - b (Mx_2 - GMx)$$

where My₁ and My₂ are the means of the scores on criterion test obtained by the subjects of the experimental and control groups, respectively.

Mx₁ and Mx₂ are the means of scores on the intelligence test obtained by the subjects of experimental and control groups, respectively.

GMx is the grand mean of the scores on the intelligence test obtained by the subjects of the two groups.

The regression co-efficient (b) is given by:

$$b = \frac{\left[\Sigma XY - \frac{(\Sigma X)(\Sigma Y)}{N} \right]}{\Sigma X^2 - \frac{(\Sigma X)^2}{N}}$$

$$= \frac{[514129 - (6471)(11029)/140]}{(6471)^2}$$

$$= 312847 - 140 = 0.317$$

Using two formulae

$$My_1x_1 = 80.11 - 0.317 (45.54 - 46.22)$$

$$= 80.33$$

$$\begin{aligned} My_2x_2 &= 77.44 - 0.317 (46.90 - 46.22) \\ &= 77.22 \end{aligned}$$

Table 14.18 Means of intelligence and criterion test score of experimental and control groups

Group	Number of the Subject in Group	M_y	M_x	Adjusted Mean
Experimental	70	80.11	45.54	80.33
Control	70	77.44	46.90	77.22
			$GM_x = 46.22$	

Summary of conclusions: From Table D, it may be found that the criterion value of F for 1 and 137 df at .01 level of confidence is approximately 6.83. It is evident from Table 14.18 that the obtained value of F is 16.72, which is significantly greater than the needed value of significance. Since the obtained F -value exceeds 6.83 the mean criterion score of the experimental group differs significantly from that of the control group. Furthermore, it is evident from Table 14.18 that the adjusted mean of the scores on the criterion test of the experimental group (80.33) is significantly higher than that of the control group (77.22). Significance of Pearson's coefficient of correlation.

The mathematical basis for the standard error of a Pearson coefficient of correlation is rather complicated because of the difficulty in its nature of sampling distribution. The sampling distribution of r is not normal except when the population r is near zero and the size of the sample is large ($N = 30$ or greater). When r is high (0.80 or more) and N is small, the sampling distribution of r is skewed. This is true also when r is low (0.20 or less).

A mathematically more sound method for making the interference regarding Pearson's, especially when its magnitude is very high or very low, is to convert r into r coefficient, Fisher's Z coefficient and find the standard error (S) of Z . The sampling distribution of Z coefficient is normal regardless of the size of r of the size of the sample N and the size of the population r . Furthermore, the SE of Z depends only upon the size of the sample N , and is independent of the size of r .

The formula for standard Z (σ_z) is

$$SE_z = \sigma_z = \frac{1}{\sqrt{N-3}}$$

By way of illustration, consider an r between the scores on an intelligence test and on an achievement test in arithmetic obtained from a standard random sample error of 84 Z in male students of eighth grade. Using formula the standard error of Z is

$$\sigma_z = \frac{1}{\sqrt{84-3}} = \frac{1}{9} = 0.111$$

For an r of 0.78 Table F of the Appendix gives a corresponding Z of 1.05 since the sampling distribution of Z is normal, and the confidence interval at 0.95 level for the population of true Z is $Z \pm 6\sigma_z \times 1.96 = 1.05 \pm 0.111 \times 1.96$ or 0.83 and 1.26. The corresponding r 's, from Table F of the Appendix, are 0.68 and 0.85, which give a well-estimated interval within which we expect the population r with 0.95 confidence, that is the chances are 95 in 100 that population r lies between 0.68 and 0.85. If we want a higher degree of confidence we can take the 0.99 level of confidence, for which the limits are $Z \pm \sigma_z \times 2.58$ or a corresponding from Table F are 0.64 and 0.87, that is, the chances are 99 in 100 that population r lies between 0.64 and 0.87.

Significance of Multiple Correlation Coefficient R

The significance of the multiple correlation coefficient R is tested by computing F -value given by the formula.

$$F = \frac{R^2/g}{(1 - R^2) N - g - 1}$$

where

R is the multiple correlation coefficient, G is the number of independent variables and N is the number of observations.

The interpretation of an obtained F is made with the use of Table D of the Appendix for $df_1 = g$ and $df_2 = Ng - 1$. If the obtained F is significant at a particular level of confidence, R is also significant.

Significance of the Difference Between Pearson's Coefficients of Correlation

The exact method of determining the standard error of the difference between two r 's is first to convert the r 's into Fisher's Z coefficients and then to determine the significance of the difference between the two Z 's.

When we have two correlations between the same two variables, Z_1 and Z_2 , computed from two totally different and unmatched samples, the standard error of a difference between two corresponding independent Z 's is computed by the formula

$$SE_{DZ} = \sigma_{Z_1 - Z_2} = \sqrt{\frac{1}{N_1 - 2} + \frac{1}{N_2 - 3}}$$

where

N_1 and N_2 are the sizes of the two samples.

The significance of the difference between two Z 's is tested with the help of the formula

$$Z = \frac{-Z_1 - Z_2}{SE_{DZ}}$$

Illustrating the use of the formula, let us consider the correlations of 0.70 and 0.62 computed between intelligence and academic achievement on the basis of the data obtained from two groups of seventh-grade students ($N_1 = 103$ and $N_2 = 124$) from two different schools. To test the significance of difference between the two r 's, first convert them into Z coefficients. The corresponding Z 's from F are 0.87 and 0.73. Using formula the SE_{DZ} is

$$\begin{aligned} \sigma_{z_1 - z_2} &= \sqrt{\frac{1}{1 - 3 - 3} + \frac{1}{124 - 3}} \\ &= 0.135 \\ &= \frac{0.87 - 0.73}{0.135} \\ &= 1.036 \end{aligned}$$

The obtained Z value is less than 1.96 and hence is not significant at 0.05 level. This indicates that the correlation between general intelligence and academic achievement does not really differ in the two groups drawn from two different schools.

Non-parametric Tests

Non-parametric tests are either counted or ranked. These tests, sometimes known as distinction-free tests, do not rest upon the more stringent assumption of normally distributed populations. Non-parametric tests, because they are based upon counted or ranked data rather than on measured values, are less precise, have less power than parametric tests and are not likely to reject a null hypothesis when it is false.

Parameters are population measures. The statistics F and t discussed earlier have certain assumptions. They assume by normal distribution and homogenous population. From these statistics, the parameters can be estimated. But often, especially in experimental studies, we may have to deal with small samples, i.e., 10, 12, 15 or so. In such cases, we cannot expect representativeness of the population in the sample. So we use statistics that are known as non-parametric. From these statistics, parameters cannot be inferred, and there is no assumption about the distributions rather than parameters. Since they do not have any assumptions about the distribution of the population, they are also known as distribution-free statistics. These statistics can also be used to test the hypotheses, often in experimental conditions when the sample size is very small.

Many non-parametric statistics have been developed by the statisticians. We have already discussed two of them, though we have not referred to them as non-parametric at that time. They are rank correlation coefficient (ρ) and chi-square statistics. Here, we shall discuss about four more nonparametric tests, i.e., the median test, the Mann–Whitney U test, the Wilcoxon matched pairs test and Kolmogorov–Smirnov test.

Median Test

Median test is one of the earliest non-parametric tests. It is used to find out the differences between two uncorrelated groups (e.g., boys and girls). The groups may not have equal number of cases. Suppose we want to find out whether in an immediate memory test there is difference between boys and girls. These are say 12 boys and 10 girls involved in the study. Their immediate memory scores are as follows.

Boys	15	12	13	10	8	16	17	11	12	10	8	9
Girls	16	10	15	10	4	7	10	12	4	13	–	–

We consider both boys and girls as belonging to one group and find out the common median. What is the common median for all these 22 measured? You arrange them in ascending order and find out the

$11.5\text{th} = -\frac{11}{60}\left(\frac{21+1}{2}\right)$ measure. It is 11.5 (11.5th measure is 11.5 in this case. It may not be the same in other cases.

Common median is 11.5. Now find out how many scores are there above and below the mean in the two groups, separately. How many boys have got above 11.5 and how many got below 11.5? How many girls are above 11.5 and how many are below 11.5. Present the results in a contingency table (2×2) as follows:

	Above	Below
Boys	6 (A)	6 (B)
Girls	5 (C)	5 (D)

We now work out the ‘chi- square’ for this 2×2 contingency table. This is given by the formula:

$$\begin{aligned}\chi^2 &= \frac{N \left(|AD - BC| \frac{N}{2} \right)^2}{(A + B) \times (C + D) \times (C + A) \times (B + D)} \\ &= \frac{22 (130 - 301 - 11)^2}{12 \times 10 \times 11 \times 11} \\ &= \frac{22 \times (-11)^2}{12 \times 10 \times 11 \times 11} \\ &= \frac{22 \cdot 11 \cdot 11}{12 \cdot 10 \cdot 11 \cdot 11} \\ &= \frac{22}{120} = \frac{11}{60} = 0.18 \\ &= -\frac{11}{60} \\ &= 0.18\end{aligned}$$

The table value of chi-square for 1 *df* at 5% level is 3.84. The calculated value is less than the table value. So we accept the null hypothesis and decide that the two groups do not differ.

Who is more authoritarian? Headmaster or headmistress? A District Educational Officer wants to find out this. The officer administers an authoritarian scale to 15 headmasters and 10 headmistresses. Their scores are as follows. Find out whether headmasters and headmistresses differ in their authoritarianism.

Headmasters: 60, 65, 67, 69, 70, 72, 7, 75, 76, 80, 81, 84, 84, 86, 86

Headmistresses: 75, 70, 68, 87, 69, 90, 65, 72, 64, 73

Find out the common median. The common median is 72. Do you get this? How many headmasters are above this? You man ignore the headmasters whose scores are exactly the same as the median. How many are below 72? How many headmistresses have got the scores above 72 and how many below 72?

Prepare the 2×2 contingency table

	Above Median	Below Median
Headmasters		
Headmistresses		

Now calculate χ^2 (chi-square). The calculated value of chi-square is less than the table value. So, we decide that the headmasters and headmistresses do not differ in their authoritarianism.

Mann–Whitney U Test

Mann–Whitney *U* test is one of the most powerful of all nonparametric tests and is a useful alternative to parametric *t*-test. It can be used for small samples not exceeding eight in number and also for samples up to 20.

Using this test, it is possible to find out whether two independent samples differ in the measures of a variable. A researcher in a laboratory experiment wants to find out whether boys and girls differ in

their reaction time. The reaction times are measured (in seconds) for four girls and six boys, which are as follows:

Boys: 3, 2, 5, 4, 1.5, 2, 3, 5

Girls: 4, 5, 5.5, 4.5

To use Mann-Whitney U test, the researcher first arranges the reaction times of both boys and girls combined together and ranks them as follows.

1.5	2	2.5	3	3.5	4	4	4.5	5	5.5
B	B	B	B	B	BG		G	G	G

Then find the value of U . The value of U is the number of times that a score in the larger group (boys) is preceded by a score in the smaller group (girls). In the above example no score in the large group is preceded by a score in the small group. Therefore, $U = 0$.

The researcher then refers to the table for ' U ' test and finds out the probability of getting various values of U for the given numbers in the large and small groups. The table gives the probability of getting a zero value for U , when n_2 (number in the large group) is 6 and n_1 (number in the small group) is 4 as .005. This is much less than .05 (5 per cent probability). The probability of getting a zero value for U under the present conditions due to chance is only 5 in 1000. So the researcher rejects the null hypothesis and concludes that the two groups differ in the reaction time.

Tables for U statistics are available only in selected statistics books that deal with non-parametric statistics, Siegel's *Non-parametric Statistics* (1956) published by McGraw-Hill Book Company is a classic in the field of non-parametrics.

Wilcoxon Matched Pairs Test

This test is used when there are matched pairs in the sample. Often in experimental studies, the researchers select the sample for experimental and control groups in matched pairs. For every student in the experimental group there will be a corresponding student in the control group who are matched for the previous knowledge (value) of the dependent variable. The experiment is then conducted, that is, treatment is given to the experimental group and after the experiment is over final measurements of the dependent variable are made in both groups.

Suppose the final measures of the two groups are as follows:

Table 14.19 Experimental and control group

Matched Pair	Experimental Group	Control Group	d	Rank in d
1	52	48	4	5.5
2	60	57	3	3
3	48	50	-2	-2
4	50	46	4	5.5
5	47	42	5	8.5
6	47	42	5	8.5
7	58	54	4	5.5
8	57	58	-1	-1
9	62	67	-5	8.5
10	51	44	7	10

After listing the mean of the pairs of students, the difference in the marks between the pairs with the signs are noted. The differences are then ranked assigning rank 1 to the lowest difference. The signs are returned for the ranks also. While assigning the ranks, only the absolute differences are considered and not the signs. That is, if a difference of 3 is assigned a rank of 2, then the difference of 4 will get the next rank, that is, 3. While assigning the ranks we ignore the signs (+ 94 -). After assigning ranks, we put them + or -. Now some ranks will have + sign and some will have - sign. Then, we select the ranks having less frequent signs. If, for example, there are six ranks with + and with - sign, we select the ranks with - sign. Then, we add the ranks with less frequent sign (i.e., the ranks with - signs in our example). The sum of these ranks is given by the symbol T .

In the example given above there are three ranks with - sign and seven ranks with + sign. So, we add the ranks having - sign (i.e., -2, -1, -8.5). The sum of these ranks (without the sign) is 11.5. So $T = 11.5$.

We compare this value with the table value for Wilcoxon matched pairs T at 14 selected levels of significance for the given number of pairs. If the calculated value is more than the table value, we accept the null hypothesis and conclude that the two groups do not differ.

If the two groups do not differ, then the sum of the positive differences (and also the sum of the positive ranks) will be equal to the sum of the negative differences (i.e., sum of the negative ranks). If the sum of the positive ranks differs very much from the sum of the negative ranks or vice versa, the groups will differ. This is possible only when the sum of the positive ranks or negative ranks (which is small in number) is very small. So, when T is small, we do accept the null hypothesis and conclude that the groups differ. If T is larger than the table value, we accept the null hypothesis and conclude that the groups do not differ.

The following are the observations in a matched pair experiment. Find out whether the groups differ or not.

The tables value at 5 per cent level for 8 pairs ($N = 8$) is 4. The calculated T value is more than the table value. Therefore, the groups do not/do differ. Which answer did you choose, do not or do. Do not is the correct answer.

Table 14.20 Experimental and control group of t value

Pair	Score		d	Rank of d
	Gr ₁	Gr ₂		
1	1	8	2	5
2	12	13	-1	-1.5
3	14	16	-2	-5
4	8	10	-2	-5
5	7	5	2	5
6	5	4	1	1.5
7	9	7	2	5
8	13	10	3	8
			$T = 11.5$	

Kolmogorov–Smirnov Test

Kolmogorov–Smirnov (KS) test is also an alternative test to the t -test. This is applicable to find out the significance of difference between two independent samples drawn from the same population.

The two groups are measured on an independent variable (say achievement in a subject) and the scores are arranged in a frequency distribution. The frequency distribution for the two groups will have the same class intervals. The cumulative frequencies are then entered in the frequency table. The largest differences in the proportions of cumulative frequencies is then selected for comparison with the D that is expected at 5 per cent level (i.e., the chance D at 5 per cent level). The chance D value at 5 per cent is calculated using the formula.

$$D\ 5\% = 1.36 \sqrt{\frac{N_1 + N_2}{N_1 N_2}}$$

where N_1 and N_2 are the number of cases in each group. The maximum value of D calculated from the frequency table is compared with the chance value of D and if it is more than the chance value, it is concluded that the groups differ. Shall we have an example?

The frequency distribution of four boys and 30 girls are given in Table 14.21.

Table 14.21 Frequency distribution of boys and girls

CI	Boys	GDs	CfD	CfG	Proportion		Difference
					B	G	
46–50	5	3	40	30	1.000	1.000	0
41–45	6	5	35	27	0.875	0.900	0.025
36–40	10	8	–9	22	0.725	0.733	0.008
31–35	7	4	19	14	0.475	0.466	0.009
26–30	5	3	12	10	0.500	0.333	0.033
21–25	4	5	7	7	0.175	0.233	0.058
16–20	3	2	3	2	0.05	0.067	0.088

The chance D at 5 per cent level

$$\begin{aligned}
 D\ 5\% &= 1.36 \sqrt{\frac{N_1 + N_2}{N_1 N_2}} \\
 &= 1.36 \sqrt{\frac{40 + 30}{40 \cdot 30}} \\
 &= 1.36 \sqrt{\frac{70}{1200}} \\
 &= 1.36 \times 0.24 \\
 &= 0.328
 \end{aligned}$$

The maximum D value from the frequency table is 0.056 and the chance value is 0.326. Chance value is more than the calculated value. So null hypothesis is accepted. The two groups (boys and girls) do not differ.

The chance value at 1 per cent level can be calculated using the formula.

$$D\ 1\% = 1.63 \cdot \sqrt{\frac{n_1 + N_2}{n_2 + N_1}}$$

Correlational Analysis

Two variables are said to be correlated when they change together. We discussed about different methods of calculating the correlation between two variables in an earlier lesson when we dealt with hypothesis testing. There you remember the product moment correlation (r), rank correlation (ρ), point biserial correlation (r_{pb}), biserial correlation (r_b), correlation (r_b) and phi co-efficient (ϕ). All these correlations deal with colouration between two variables. We collect data about two variables from the same set of cases and analyse the data collected from the two variables (bivariate) together. Hence, the analysis is known as bivariate analysis.

If we analyse the data collected from one variable, it is univariate (one variable) analysis. So far, we have been discussing about univariate and bivariate analyses only. When we have more than two variables to deal with simultaneously, we analyse the data collected from more than two variables together. This method of analysis is known as multivariate analyses of various types in this and the next two packages. In this package the multivariate correlational analyses are considered.

Regression

When two variables are correlated, then it will be possible to predict the measure of a variable for a given measure of another variable, without actually measuring it. If, for example, height and weight are correlated, then it would be possible to predict (calculate) what would be the weight of a person who is 162 cm tall.

If the correlation is perfect (that is, if the correlation co-efficient calculated is 1), then the predication will be correct. There will be no error in our prediction. If the correlation is zero (that is, if there is no relationship between the two variables, for example, between height and achievements), then the prediction is not possible. Any such prediction, if at all made, will be of no use. Between these two limits, predictions are possible with varying levels of accuracy.

If the correlation is perfect, as, for example, between time and distance when speed is constant, the graph drawn for the measurements of the two variables will be a straight line as shown in Figure 14.6.

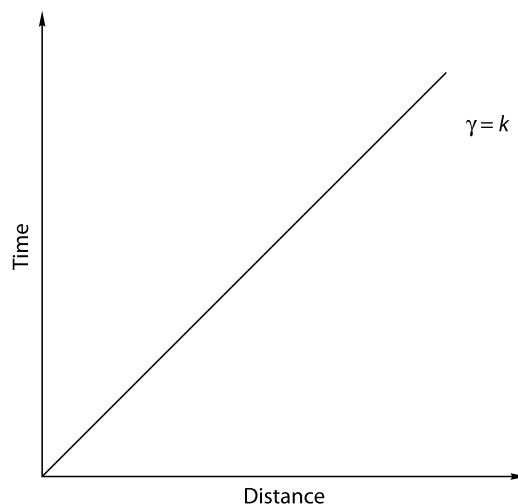


Figure 14.6 Time and distance of correlation graph

From this graph, we can find out the distance covered for any given hours of journey, or the hours required for the journey to cover the given distance and our predictions (findings) will be exact. But when the correlation is not perfect, the points representing various pairs of measures will not lie on a straight line, but for predictions we require a straight line. Unless a straight line is there, we will not know where exactly the given measure in one variable will cut (meet) the measures in the other variable.

If the correlation co-efficient is 0.7, the graph for the various pairs of measures may look like the one given in Figure 14.6. Suppose we want to predict the height of a person whose weight is 170 kg is marked on the x -axis of the graph. If you erect a perpendicular on x -axis, you do not know where will it meet any measure of height. If there is a straight line joining the point plotted on the graph, then the perpendicular will cut the straight line and the point of intersection will indicate the measure in height (Figure 14.7).

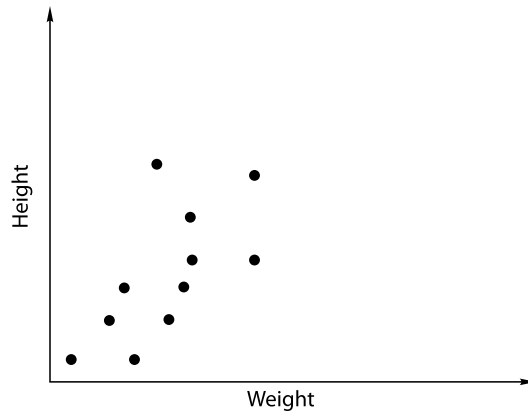


Figure 14.7 Weight and height of correlation graph

As the points do not lie on a straight line and are scattered, we have to think of one line that will represent all the lines that could be drawn, joining two points on the graph (Figure 14.8). As we can draw a straight line joining any two points, we can draw a number of straight lines on the graph. Which straight line should be considered for prediction?

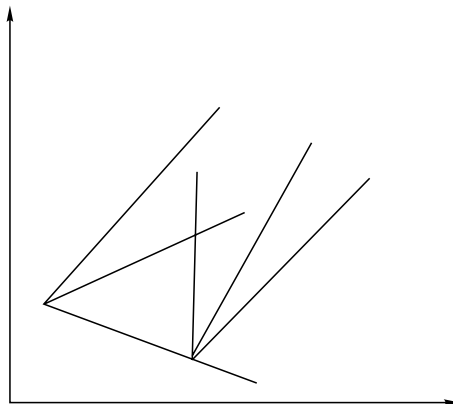


Figure 14.8 Joining two points on the graph

Therefore, we have to select a line that is the most representative of all the possible lines, and a prediction on which will give the least error. If the correlation is not perfect, then predictions will not be correct, or they will have some error. If the correlation is high, the prediction error will be less and the correlation is low, the prediction error will be high.

How do we select this line for prediction? The prediction's line is selected on the principle of least square. This line is known as least square and will have least-squared distance from all the possible points on the graph. The sum of the squared distances of the points will be the least for this line. Other lines will have more squared distances than this line and the predictions based on other lines than the least-squared distance line will have more errors. Predictions based on the line of least square (least-squared distance line) will also have error, but this error will be the least error (Figure 14.9).

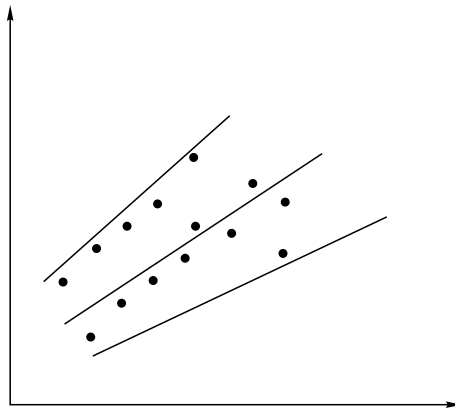


Figure 14.9 Least-squared distance line graph

Of the three lines which do you think will have the least-squared distances? The middle one, of course, can be the line of least square.

Well, if we want to predict, when variables are not perfectly correlated, we take recourse to line of least square. This line of least square is also known as regression line.

If the correlation is perfect, then the prediction will be exact. If the correlation is zero, then the prediction will be futile, but if we want to make a prediction when the correlation is zero, then that prediction will be only the mean of the variable to be predicted. If the correlation is between 1 and 0, then the predicted values will vary from the correct, exact value to the mean of the variable. They tendency of the predicted value to move towards the mean of variable as correlation moves from 1 to 0 is known as regression.

It is interesting to note that Sir Francis Galton, who first gave us this concept of regression called 'filial regression', studied the correlation between the heights of parents and the heights of children. Regression is the tendency to move towards the mean. Prediction from correlation is based on this concept of moving from exact value to the mean value, that is regression. The lines at least square on which predictions are made for various levels of colouration are known as regression lines.

For all straight lines, we know, there are algebraic equations. The equations for regression lines are know as regression equations and predictions are made using these equations.

When there are only two variables and if they are correlated, then we consider one variable as a criterion variable, value of which we want to predict for a given value of the other variable that we consider as predictor variable. Predictor variable is the variable from whose value we predict the value of another variable, that is the criterion variable. If from the intelligence level of a student we can say in advance (predict) what would be the student's achievement in a subject, then intelligence is the predictor variable and achievement is the criterion variable. The nature of the variables determines the type of predictions. The predictor variable may be a metric variable (that can be measured using interval or ratio, scale), then we will have various measures of this variable. The predictor variable may be a nonmetric, if so we will not have the measures of the variables as these nonmetric variables are measured using nominal or ordinal scales. Thus, the predictor variable may be in measures or in attributes. Similarly, the criterion variables can also be either in measures or in attributes.

We can then have four types of general predictions:

- (i) From measures of measures (from a metric variable to a metric) as in predicting achievements from intelligence.
- (ii) From measures of attributes (from metric to nonmetric variables) as in predicting a drop out or a stay in from the achievement scores.
- (iii) From attributes of measures: as in predicting from sex, marital status or socio-economic status, and the measures of attitude towards family planning.
- (iv) From attributes of attributes as in the prediction of choice of profession from sex and socio-economic status.

Regression Equation

The simplest form of prediction is the prediction when there is only one predictor variable. This prediction is made from a simple regression equation which has the general form.

$$Y = b \times X + C$$

where C is the value of Y , the criterion variable when the value of X , the predictor variables is zero, b and c are known as regression coefficients; C indicates the slope of the regression lines. It gives us the value (in the raw score formula), the point (value) at which the line cuts the y -axis.

The ratio b tells us how many units of Y increases for every unit increase in X , i.e., if b is 2, then for every unit increase in X , Y increases by two units.

In a regression equation for prediction b becomes $r \frac{S_Y}{S_X} S_Z$, where r is the correlation between the two variables. S_Y is the standard deviation of the criterion variable (whose value is to be predicted) and S_X is the standard deviation of the predictor variable. In the raw score form the regression equation is given as follows

$$Y = r \frac{S_Y}{S_X} (x - \bar{x}) + \bar{y}$$

where Y^1 is the value of the criterion variable to be predicted, r is the correlation between the two variables, X is the value or the predictor variable given, $\bar{x}$ is the mean of the predictor variable and $\bar{y}$ is the mean of the criterion variable.

Criterion variable is also known as dependent variable and the predictor variable as independent variable. Many researchers and authors use the terms dependent and independent variables instead of predictor and criterion variables.

Multiple Regression

In the prediction exercises, only one independent (predictor) is discussed and the dependent (criterion) variables are involved. We may predict the achievements of students from their intelligence scores. We may also predict the score in achievement of students from the teaching efficiency. But, when the prediction is made from both the independent (predictor) variables, the prediction will be better than the one made from any one of the predictor variables (intelligence or teaching efficiency) independently. This is what is being done in multiple regression. It is regression of more than one independent variable and a dependent variable. A linear combination of two independent variables with differential (varying weightages of each) is arrived at and the correlation between this linear combination is considered as 'latent' variable and the dependent variable is worked out and this correlation (called the multiple correlation and given the symbol R) forms the basis for prediction.

This regression is multiple regression, because it is the regression of many (multiple) variables on one dependent variable. It is, in fact, an extension of simple regression in which there is only one independent variable regression on one dependent variable. The assumptions underlying simple regression and regression are the same and the multiple regression equation is also an extension of the equation for simple regression.

The four basic assumptions under multiple regression are as follows:

- (i) The independent (predictor) variable contains no errors; it is perfectly reliable. But the dependent (criterion) variable may contain error, and it may be only partially valid.
- (ii) One component of the variable may be related effectively to the independent variable implying linearity of regression. Another component, known as residual (what remains after) component, may be totally independent of the independent variable (predictor variable).
- (iii) The residual is purely a random error, with a mean of zero (that is, the errors cancel one another).
- (iv) The independent variables are linearly independent for the R to be the maximum). Linear independence implies that any one independent variable cannot perfectly be predicted from the other remaining independent variables. That is, no two independent variables are perfectly correlated.

If the independent variables correlate among themselves, 'multicollinearity' will be present and it will affect prediction. Of course, there cannot be any multicollinearity in a simple regression.

Equation:

The simple regression equation is

$$Y^1 = b \times x + C$$

where b is the multiplying constant or weight for the independent variable and C is a constant, whose function is to ensure that the mean of x^1 values (that is, predicted values) is equal to the mean of Y^1 values (that is, the mean real values of the dependent variable).

The b co-efficient indicates the weight (the influence) of the independent variable. It is decided by the correlation between the independent and the dependent variables.

Multiple regression equation is an extension of the simple regression equation. For two independent variables, the multiple regression equation will have the general form.

$$Y_1 = b_1x_1 + b_2x_2 + C$$

The b coefficients in the equation for multiple regression, however, are determined by the direct (also known as zero order) correlation between the dependent and the independent variables concerned. This is determined by the partial correlation between the dependent variable and the concerned

independent variable when the influences of other independent variables on the dependent variable and the concerned independent variable are partialled out.

Partial Correlation

What is partial correlation?

Let us consider the following example. Intelligence and achievement are correlated. Motivation and achievement are also correlated. So there is a correlation between motivation and intelligence also. These direct (one to one) correlations are zero-order correlations. Correlation helps in predicting measures.

Suppose we measure the three variables mentioned above, i.e., achievement, intelligence and motivation in a group of students and calculate separately the correlation between the three possible pairs, that is between achievement (say A) and intelligences (say I), between achievement and motivation (say M), and between motivation and intelligence (M and I). Now, we have three sets of correlations between A and I , I and M , and M and A . Suppose we predict A and I from M , that is, achievement and intelligence from motivation. As the correlations between motivation and the other two variables are not perfect, our predictions will not be correct, perfect. What is left over is the residual. So, after the prediction of achievement from motivation, there will be some residual component that is not predicted by motivation. Similarly, there will be some residual (what remains after) in intelligence also. Residuals in two variables after their predictions from a third variable is known as partial correlation.

The partial correlation is the simple correlation between the residuals of two variables, after each has been predicted from a third variable. The third variable whose influence is partialled out (taken away) is known as the co-variate. In our example, motivation is treated as the co-variate.

If the two variables, between which the partial correlation is worked out, correlate in opposite directions with the co-variate (that is, the variable whose influence is partialled out) but positively with each other, the partial correlation will usually be stronger than the zero-order correlation between the two variables. Achievement in XII standard and motivation to learn are positively correlated. Performance in X standard is positively correlated with achievement in XII standard. But motivation to learn in XII standard may be negatively correlated with performance in X standard, the low achievers having more motivation and high achievers having become more complacent. Now in this example the co-variate is motivation and performance in X standard if a predictor (independent) variable and the achievement in XII standard is the criterion variable (dependent variable). The dependent and the independent variables correlate in opposite directions with the co-variate, motivation (the X standard performance negatively and the dependent variable, XII standard achievement positively). But the X standard performance and XII standard achievement are positively correlated. So we can expect the partial correlation between X standard performance and XII standard achievement to be stronger than the zero-order correlation between them.

If the independent and dependent variables correlate in the same direction with the co-variate, then the partial correlation will be weaker (smaller in absolute magnitude) than the zero-order correlation between them.

Partialling may not make much difference if both the correlations of dependent and independent variables with the co-variate are small, that is, less than 0.3. So when you select partial correlation, please see that the zero-order correlations are larger than 0.3.

Multiple Correlation

Multiple correlation deals with the relationship between a dependent variable and two or more other independent variables combined with optional weights. Multiple correlation is related to the

intercorrelations between the independent variables and the correlation between each independent variable with the dependent variable. The co-efficient of multiple correlation shows the strength of this relationship. It is a relationship between the dependent variable and the linear combination of the independent variables with their optional weights.

The co-efficient of multiple correlation is given by the symbol R and it also indicates the correlation between the values of dependent variables predicted from the combined association of the independent variables and the actual values of the dependent variable with respect to a particular group. R is interpreted with reference to its squared value as with r . If R in a case is 0.677, the R^2 will be 0.458. This means that nearly 46 per cent of the variance in the dependent variable is explained by the combined variance in all the independent variables. R^2 is then known as co-efficient of multiple determination and r^2 is known as co-efficient of determination.

Multiple correlation increases as the correlation between dependent and independent variables increase and also when the R correlations between the independent variables decrease. When the correlation between independent variables is very high, then also R will become large. Thus, R will become large when the intercorrelations between the independent variables are very low or very high. When intercorrelations between the independent variables are very high, it will lead to the problem of multicollinearity. High intercorrelation between independent variables may be preferred when the correlation between the dependent variable and the independent variables are unequal and one of two such correlation are very low.

Multiple Regression Equation

The general format of a multiple regression equation is as follows:

$$Y^1 = a + b_1x_1 + b_2x_2 + b_3x_3 \dots b_nX_n$$

How do we arrive at this equation? Before that what is the purpose of doing multiple regression analysis?

Multiple regression analysis helps to predict a single dependent variable, which is usually (continuous or metric) from the knowledge of two or more independent (that may be continuous, or discrete, metric or nonmetric, measures or attributed) variables. Our intention is to make the best possible prediction. Of the many independent variables that we may think of which set in their combination will give us the best result, that is, will help us predict with least error?

First, we start with a number of independent variables that correlate with the dependent variable at various levels. Achievement as a dependent variable is correlated with a number of independent variables, e.g., intelligence, socio economic status, motivation, personality, school facilities, teaching efficiency and so on. We want to know which set (or subset) of these independent variables will give us a better prediction of the dependent variable, i.e., achievement. How do we arrive at this 'best combination'?

There are many ways of arriving at the best set of predictor variables with the least square weights. There are three common approaches:

- Standard multiple regression
- Hierarchical multiple regression
- Stepwise multiple regression

In the standard multiple regression approach, all the independent variables are entered simultaneously into the regression equation. Each independent variable is then assessed as if it had entered the regression after all other independent variables had been entered. Then, each independent variable can be evaluated in terms of what adds to the prediction of the dependent variable over and above what the other independent have helped for prediction.

In the hierarchical multiple regression model the independent variables are entered in the regression equation in some order specified by the researcher. The analysis is done in stages.

One or usually a set of predictor variables (independent variables—IVS) that on the basis of some theory is considered to be highly correlated with the dependent (criterion) variable is first entered in the regression model (equation) and the predictability of the set of IVS entered is determined by calculating R . Then, the next set of IVS is added and tested whether the addition has helped to increase the value of R that it has helped to add to the predictability that had been achieved by the entry of the earlier set. The procedure is some what as follows.

We start with a null model, that is $y^1 = a$, then enter a group of independent variables (say set A) that has theoretical support to be high correlates of the dependent variables and calculate R the multiple correlation co-efficient and from that the predictability. Then add another set of subsequent addition if set B variables add significantly to the predictability, If so, retain them in the regression equation, then add another set (set C) and see whether there is any significant addition to the predictability. If so, retain that set. Go on adding new sets and terminate the process when a new set fails to add significantly to prediction.

Hierarchical entry is a successive entry. The groups of predictors (set A, set A + B, set A + B + C) are chosen on the basis of a theory.

Stepwise multiple regression also admits independent variables in stages as in the hierarchical model. The difference between the two approaches is that in hierarchical model, the selection of independent variables is theory driven and in stepwise model the selection of independent variables is data driven. In stepwise model, the order of entry of independent variable is based on statistical criteria. At each step, the variable that adds most to the prediction equation, in terms of increasing R^2 is entered. First, the independent variables that have the highest zero-order correlation with the dependent variable is entered. Next, the predictor (with the highest squared part correlation, controlling the first predictor but not the criterion) producing the largest increment in R^2 is added to the equation. At the third step, the predictor (having the largest squared part correlation with the criterion when the first two predictors are held constant) is entered. This process continues until all the independent variables that can significantly improve are added in the equation.

In stepwise regression, the basic process is often modified to determine whether an independent variable that has been already included can be excluded because its ability to predict has been absorbed by newly entered predictors. For example, with predictor 'A', in the equation if R^2 is 0.4215 and with A, B and C is 0.572 and with only B and C is 0.625, predictor A can be removed from the equation, retaining only B and C, searching for other predictors that may add significant increase to R^2 .

By any one of these approaches, we work out the multiple regression analysis and get the multiple regression equation in the unstandardized score form. In a study, a researcher worked out multiple regression analysis using achievement as the dependent variable and motivation, teaching efficiency and previous performance as independent variables (achievement is Y variable, motivation as X_1 , teaching efficiency as X_2 and previous performance as X_3), and derived the following equation

$$Y = 4.72 + 0.658X_1 + 0.272X_2 + 0.414X_3$$

This is the multiple regression equation. From this, we can predict the achievement score for any student if the scores of motivation, previous performance and teaching efficiency are known. Suppose in the case of Geetha the scores in the three independent variables are as follows: $X_1 = 12$, $X_2 = 14$ and $X_3 = 15$. What would be her achievement score? Substituting these values in the equation, we get

$$\begin{aligned} & -4.72 + 0.658 \times 12 + 0.272 \times 14 + 0.414 \times 15 \\ & = 13.22 \end{aligned}$$

In this case, R is 0.838 and $R^2 = 0.702$. This is the use of multiple regression.

Suppressor Variables

Some independent variables may have insignificant correlation with the dependent variable, yet their inclusion in the regression equation may add significantly to multiple correlation. In regression analysis, the order correlation between the dependent variable and an independent variable is said to be the validity of the independent variable. Independent variables having significant correlation with the dependent variables are said to be valid independent variables.

A suppressor variable is one that has zero validity, but a nonzero beta weight (standardized regression weight). An independent variable having a validity and a nonzero beta weight with the opposite signs is also a suppressor variable. Suppressor variables are known as such (as suppressor variables) because they suppress other independent variables, the irrelevant variance. Suppressor relations arise from multicollinearity, that is, the intercorrelations among independent variables.

We can identify a suppressor variable by a reference to the intercorrelation metric the '*b*' weights for the independent variables in the regression equation. A suppressor variable will have zero correlation with the dependent variable and a nonzero (significantly) weight for the validity and the '*b*' weight with opposite directions.

Non-metric Variables

In general, the regression analysis is made with reference to one dependent metric (continuous) variable and a set of metric-independent variables. Non-metric variables are nonquantitatives. An advantage, however, in multiple regression is that nonmetric variables can also enter as independent variables in the regression equation. We can thus include, sex, socio economic status, methods of teaching, hemisphericity and other nonmetric variables along with metric variables as independent variables in regression analyses.

When non-metric variables are to be included in regression equations, we turn one non-metric variable into several metric or quantitative variables. We take a non-metric variable and find out the number of categories into which the variable is classified as it is being measured. For example, sex has two levels (attributes) of existence, man and woman. The variable sex, a non-metric, nonquantitative variable has two categories. We form $(2 - 1)$, that is, one quantitative variable and assign numerical value to the variable so formed. This conversion of a non-metric variable into metric variables can be done in a number of ways. But the commonly used strategy is dummy coding.

If there are k categories in a non-metric variable, then it is turned into $(k - 1)$ metric variables. The $(k - 1)$ variables so formed are treated as dummy variables. These dummy variables are assigned values 1 and 0, if the particular attribute of characteristic is present or absent.

Sex is a non-metric variable having two categories. It is turned into one $(2 - 1)$ dummy variable, representing (standing for) one category. If that characteristic (say woman) is present, then it is coded as 1. If it is not present, then the numerical value of 0 is assigned.

If the non-metric variable has four categories (say four methods of teaching—lecture, seminar, tutorial and independent learning), then it is turned into three $(4 - 1)$ dummy variables. The first dummy variable defines whether a student is assigned to lecture group or not. If the student is assigned to first group, the score is 1; if the student does not belong to lecture group, then for dummy variable 1, the score will be 0. Thus, a student is measured on all the three dummy variables and if the student belongs to any one variable group then gets a score of 1 for the variables and 0 for all the other dummy variables. Table 14.22 represents the procedure of dummy coding.

Table 14.22 Procedure of dummy coding

Categories:	Dummy Variables		
	X_1	X_2	X_3
Lecture	1	0	0
Tutorial	0	1	0
Seminar	0	0	1
Independent learning	0	0	0

We have been discussing about regression analysis. Simple regression deals with one independent and one dependent variable. Regression is based on correlation and leads to prediction. Regression is the tendency to fall back from perfection to zero, the prediction moves from the exact measure to the means of the measures of the variable whose measures are predicted. Simple regression equation is formed on the principle of least squares. The regression equation is the equation of the line to least square.

When there are two or more independent variables and one dependent variable under consideration, we work out the multiple correlation and multiple regression equation. Multiple regression is the extension of simple regression. In simple regression, there is only one independent variable and the ' b ' weight of this independent variable indicating the extent of influence of this variable on the dependent variable is decided by the zero-order correlation between the dependent and the independent variables.

But in multiple regression, in which there are two or more independent variables are involved, the b weights of the independent variables are decided not by zero-order correlations, but by partial correlations, as these independent variables may be intercorrelated. If the independent variables are really independent to one another and are not at all related to one another, then their b weights will be decided by the respective zero-order correlation with the dependent variable.

Using multiple regression equation we can predict score in the dependent variable of cases for which measures on the independent variable are available.

Multiple regression analysis helps to identify the best set of independent variables that would help us to have the best prediction. Selection of independent variables for manipulation to achieve better results in the dependent variables can be made based on the information supplied by regression analyses.

Choice of independent variables for entry to the regression equation is made generally through three approaches. We have thus three types of regression analyses: the standard approach, the hierarchical approach and the stepwise regression approach.

In multiple regression analysis even nonmetric variables can be included as independent variables.

Canonical Correlation

Multiple regression analysis, we know, is concerned with the relationship between one dependent variable and a set of independent variables as in the equation

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 \dots$$

Instead of having only one dependent variable, we can think of having more than one (that is, a set of dependent variables) and find out the relationship between these two sets of variables? In multiple correlation, we find out the correlation between a dependent variable and a linear combination of a set of variables duly weighted. We consider the liner combination as one variable (of variables) and find out the relationship as one metavariable (of variables), and find out the relationship between the one simple dependent variable and this metavariable representing the combined influence of all the independent variables included in the analysis.

Now let us think of two sets of variables, one set consisting of five personality variables (set X) and another set consisting of achievement in four different subjects (set Y). Now, we have to find out the relationship between the sets of personality variables and achievement variables. In canonical correlation, there is no distinction between the variables (or sets of variables) as dependent or independent. Now, there are two sets of variables (sets X and Y or sets P and A) and we have to find out the relationship between these two.

These two sets may consist of both metric and nonmetric variables. We first find out the linear combination of the variables in the two sets separately with due weightages to the variables. The linear combination (or linear compound) is a metavariable and in canonical analysis it is known as a canonical variate (that is, a canonical variate is a variable as we all know). Instead of a set of variables, now we have a canonical variate (that is, a linear combination of the variables in the sets).

For set P_{c1} (personality variables) we have a canonical variate. Similarly, for set A (achievement) also we have a canonical variate (a linear combination). Now, we find out the correlation between these two variates (two linear combinations or linear compounds). This correlation between the two canonical variates is the canonical correlation and it is given by R_c (the subscript 'c' denote that it is a canonical correlation and is distinct from the multiple correlation, i.e., R).

The square of the canonical correlation is known as canonical root and it gives an estimate of the amount of shared variance between the two canonical variates. The canonical correlation extracted first from the variables is the first canonical correlation and it accounts for the largest possible linear combinations arrived on the principle of least square that explains the maximum possible shared variance is known as the first canonical variates.

The first canonical variate through its association or correlation is measured by the canonical correlation co-efficient, R_c , which accounts for the maximum possible shared variance. After getting R_c (let us assume that R_{c1} is the first canonical correlation extracted) we analyse the variance left over (residuals) and from the linear combination of residuals in the variables in the two sets find out the correlation between these first-order linear residual combination or residuals in the variables. Then find out the canonical correlation in the second set, R_{c2} . Generally, this correlation will be less than the first canonical correlation, but at times it may be equal to R_{c1} , but will never be more than R_{c1} .

We proceed further forming second-order and third-order residual combinations and calculating third and fourth canonical correlations. Theoretically, the possible number of canonical correlations that could be worked out will be as many as the variables in the smaller set. That is, if one set has five variables and the other set has four, then four pairs of canonical variates can be formed and four canonical correlations can be worked out.

Each canonical variable has to be interpreted as a dimension of the set of variables from which the canonical variates (linear combinations) are formed. Canonical correlations show the relationship between the dimensions of the two sets of variables. If, as in our example, there are five personality variables in one set and four achievement variables in the other, then one after the other we can form four dimensions of personality and four dimensions of achievement in pairs (as canonical correlation analysis.)

Canonical correlation analysis is a general form of multivariate analysis and in fact the other multivariate analyses such as multiple regression, discriminant function analysis and multivariate analysis of variance are only special forms or cases of canonical correlation. Canonical correlations share certain characteristics with the principal components and we shall deal with these similarities in a later lesson when we discuss factor analysis.

Canonical correlation aims at finding out the relationship between the two sets of variables. The two sets of variables may contain both metric and nonmetric variables. First, we first form linear

combinations of the two sets of variables and extract canonical variates. Canonical variates are metavariables representing the linear compounds of the variables in a set. Canonical correlation is the correlation between two canonical variates.

We can form as many pairs of canonical variates as the least number of variables in any one of the two sets of variables and work out so many canonical correlations. If in a problem there are six variables in one set and five in the other, then it will be theoretically correlations. Each canonical variate represents a dimension of the set of variables from which the canonical variate is formed. Canonical correlations measure the relationship between the dimensions of the sets of variables selected for analysis.

▲ Chi-square Test χ^2

The chi-square (denoted by the Greek letter χ^2 and pronounced as chi-square) test is one of the simplest and most widely used nonparametric tests in statistical work. The distribution has so many applications in situations that involve the testing of hypothesis concerning discrete, qualitative or nominal data. The chi-square is a descriptive measure of the magnitude of the discrepancies between observed and expected frequencies. The larger the discrepancies, the larger will be the χ^2 . If no discrepancies exist, and the observed and expected frequencies are the same χ^2 will be '0'. The student should also note that χ^2 in this is always a positive number. Negative values cannot occur. Thus, the chi-square test represents a useful method of comparing experimentally obtained results with those to be expected theoretically on some hypothesis. The formula for the computation of chi-square (χ^2) is

$$\chi^2 = \sum \left| \frac{(f_o - f_e)^2}{f_e} \right|$$

where f_o is the frequency of occurrence of observed or experimentally determined facts and f_e is the expected frequency of occurrence on some hypothesis.

The following is the sequence of steps for calculating the chi-square value.

- (i) Calculate the expected frequency of each observed frequency by using the formula.

$f_e = \frac{CT \cdot RT}{GT}$ where f_e is the expected frequency, CT is column total, RT is row total and GT is grand total.

- (ii) Find out the difference between observed and expected frequencies and obtain the square of their difference, i.e., the value of $(f_o - f_e)^2$.
- (iii) Divide the value $(f_o - f_e)^2$ obtained in step (ii) by expected frequency, i.e., f_e .
- (iv) Sum up all such values obtained for all the cells.
- (v) Find out the degrees of freedom by applying the formula $df(R - 1)(C - 1)$, where R is the number of rows and C is the number of columns in the contingency table.
- (vi) With reference to the degrees of freedom, find the table value at 0.05, 0.01 and 0.001 level of significance from the χ^2 table.
- (vii) Verify whether the calculated χ^2 value is greater than or equal to the table value at any one level of significance.
- (viii) If it is so, the research hypothesis (H_R) is accepted and null hypothesis (H_O) is rejected at the level.
- (ix) If it is otherwise (χ^2 is less than table value), H_O is accepted and H_R is rejected.

Levels of Significance

The experimenters and research workers have chosen several arbitrary standards for convenience, which are called levels of significance of which the 0.05 and 0.01 levels are most often used. The confidence with which an experimenter rejects or retains a null hypothesis depends upon the level of significance adopted.

In psychological and educational circles the 5 per cent (0.05) alpha level of significance is used as standard for rejection. A more rigorous test (0.01), alpha level would suggest that as large a difference as that between the experimental and control mean achievement would not likely have resulted from sampling error in more than 1 in 100 replications of the study with alpha equal to 0.001 if there is only one chance in 1000 of being wrong.

Illustration:

The performance of 1000 college students in terms of residential locality is presented in the following table. Is student performance dependent upon residential locality?

Table 14.23 Performance of urban and rural students

Performance							
	Distinction		I	II	III	Fail	CT
Urban	1	2	3	4	5		
	75	125	200	80	20	500	
	(47)	(102.5)	(215)	(105)	(25.5)		
Sub-urban		6	7	8	9	10	
	10	50	150	70	20	300	
	(28.2)	(64.5)	(129)	(63)	(15.3)		
Rural	11	12	13	14	15		
	9	40	80	60	11	200	
	(18.8)	(43)	(86)	(42)	(10.2)		
RT	94	215	430	210	51		1000 GT

Note: The number in the middle of the cell is the observed frequency; the number in parenthesis is the expected frequency and the number in the top left is cell number.

RT is row total, CT is column total and GT is grand Total.

Here the observed (obtained) frequencies are given. What are the expected frequencies? The expected frequencies for each of the 15 cells is computed by the formula

$$f_e = \frac{CT \cdot RT}{GT}$$

Computation of expected frequencies (f_e).

Fe for Cell 1 = $\frac{94 \cdot 500}{1000} = 47$

 Cell 2 = $\frac{215 \cdot 500}{1000} = 102.5$

 Cell 3 = $\frac{430 \cdot 500}{1000} = 215$

$$\text{Cell 4} = \frac{210 \cdot 500}{1000} = 105$$

$$\text{Cell 5} = \frac{51 \cdot 500}{1000} = 25.5$$

$$\text{Cell 6} = \frac{94 \cdot 300}{1000} = 28.2$$

$$\text{Cell 7} = \frac{215 \cdot 300}{1000} = 64.5$$

$$\text{Cell 8} = \frac{430 \cdot 300}{1000} = 129$$

$$\text{Cell 9} = \frac{210 \cdot 300}{1000} = 63$$

$$\text{Cell 10} = \frac{51 \cdot 300}{1000} = 15.3$$

$$\text{Cell 11} = \frac{94 \cdot 200}{1000} = 18.8$$

$$\text{Cell 12} = \frac{215 \cdot 200}{1000} = 43$$

$$\text{Cell 13} = \frac{430 \cdot 200}{1000} = 86$$

$$\text{Cell 14} = \frac{210 \cdot 200}{1000} = 42$$

$$\text{Cell 15} = \frac{51 \cdot 200}{1000} = 10.2$$

Now, let us compute the chi-square value of each cell using the formula:

$$\chi^2 = \frac{(f_o - f_e)^2}{f_e}$$

$$\text{Cell 1} = \frac{(75 - 47)^2}{47} = 16.68$$

$$\text{Cell 2} = \frac{(125 - 102)^2}{102.5} = 4.939$$

$$\text{Cell 3} = \frac{(200 - 215)^2}{215} = 1.047$$

$$\text{Cell 4} = \frac{(80 - 105)^2}{105} = 5.952$$

$$\text{Cell 5} = \frac{(10 - 28.2)^2}{28.2} = 1.186$$

$$\text{Cell 6} = \frac{(10 - 28.2)^2}{28.2} = 11.746$$

$$\text{Cell 7} = \frac{(50 - 64.5)^2}{64.5} = 3.259$$

$$\text{Cell 8} = \frac{(150 - 129)^2}{129} = 3.419$$

$$\text{Cell 9} = \frac{(70 - 63)^2}{63} = 0.778$$

$$\text{Cell 10} = \frac{(20 - 15.3)^2}{15.3} = 1.444$$

$$\text{Cell 11} = \frac{(8 - 18.8)^2}{18.8} = 5.109$$

$$\text{Cell 12} = \frac{(40 - 43)^2}{43} = 0.209$$

$$\text{Cell 13} = \frac{(80 - 86)^2}{86} = 0.419$$

$$\text{Cell 14} = \frac{(60 - 42)^2}{42} = 7.714$$

$$\text{Cell 15} = \frac{(11 - 10.2)^2}{10.2} = 0.063$$

$$\Sigma\chi^2 = 63.964$$

The obtained χ^2 value is 63.964. The degree of freedom for the contingency table is calculated by using the formula:

$$df = (R - 1) (C - 1)$$

Here, the number of rows = 3

Number of columns = 5

Therefore, = (3 - 1) (5 - 1)

$$= 2 \times 4$$

$$df = 8$$

The obtained χ^2 value is greater than the table χ^2 value. What is df ? In our example the df is 8. For df 8, the table value of χ^2 is 26.12, which is significant at 0.001 level.

Here, the obtained χ^2 value is greater than the table value of χ^2 . So, we accept the research hypothesis. What is research hypothesis here? The research hypothesis is that the student performance is dependent (related to) on residential locality. Hence, we accept that student performance is dependent (related to) on residential locality.

Evaluate Yourself

- (i) The t -critical value necessary for the rejection of a null hypothesis (at a given level of significance and for a given number of degree of freedom) is higher for a one-tailed test than for a two-tailed test. Do you agree? Give your opinion.
- (ii) Two samples of B.Ed. students took a standardized teaching aptitude test. Using a two-tailed test at the .05 level of significance, determine whether the two groups are random samples from the same population.

Group A	Group B

$N = 35$

$N = 40$

$\bar{X} = 90$

$\bar{X} = 88$

$S = 8$

$S = 9$

- (iii) Calculate the number of degrees of freedom when
- computing the statistical significance of coefficient of correlation
 - determining the significance between two means
 - $a^2 \times 2x^2$ table computation is involved.
 - $a^3 \times 5x^2$ table computation is involved.
- (iv) In a survey to determine graduate students' preference for a soft drink the result was

	Brand A	Brand B	Brand C
Male	25	30	50
Female	45	24	30

Was there any relationship between the brand preference and the gender of the consumers?

- (v) Compute t -value of the coefficient of correlation

$r = +.30$

$N = 15$

Summary

- Statistics is an indispensable tool for the researchers that enables them to make inferences or generalizations about population from their observations of the characteristics of the sample.
- Inferential statistical data analysis leads to judgements about the whole population, to which the sample at hand is presumed to be related.
- Parametric statistical treatment of data is based upon certain assumptions about the nature of distributions and the types of measures used.
- Nonparametric statistical treatment of data makes possible useful inferences without assumptions about the nature of data distributions. Each type makes a significant contribution to the analysis of data relationship.
- Statistical decisions are not made with certainty, but are based upon probability estimates.
- The central limit theorem, sampling, error, variance, the null hypothesis, level of significance, and one-tailed and two-tailed tests have been explained and illustrated.
- Regression is based on correlation and leads to prediction.
- In multiple regression analysis, even nonmetric variables can be included as independent variables.
- Chi-square test is one of the simplest and most widely used nonparametric test in statistical work.

Key Words

- *Non-parametric Tests*: These tests are distribution-free tests and not dependent upon the nature of population and measurement scale.
- *Parameter*: Population characteristic or constant.
- *Statistic*: Sample characteristic of a constant.
- *Sampling*: Distribution of statistic of interest.
- *Standard Errors*: Standard deviation of sampling distribution of statistic.
- *Hypothesis*: Statement or assertion about one or more populations.
- *Test of Significance*: Test to check whether a hypothesis may be rejected.
- *df*: degree of freedom; it is the number of independent variables.
- *t-score*: The normalized standard scores are called *t*-scores.
- *Raw Score*: A mass of score in its original form is called raw score.
- *Standard Scores*: Deviations from the mean expressed in standard deviation (σ) terms are called standard scores.

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Computer is one of the most versatile and ingenious development of the modern technological age. The use of computer for research to analyse complex data had made complicated research designs practical. Performing calculations almost at the speed of light, the computer has become one of the most useful research tools in the physical and behavioural sciences as well as in humanities.

Computer can perform many statistical calculations easily and very quickly. Computation of means, standard deviations, correlation coefficient, *t*-test, analysis of variance (ANOVA), analysis of covariance, multiple regression, factor analysis and various non-parametric analyses are just a few of the programs (software) and sub-programs that are available at computer centres for many purposes including statistical analyses. The canned program includes the Statistical Package for the Social Sciences (SPSS), Statistical Analysis System (SAS), and others. Although the actual programs, input procedures (syntax) and outputs (printouts) differ for those package programs, they are similar in their capabilities and the variety of statistical analyses that can be performed by SPSS. However, which set of programs is used depends on the user's needs and performance.

▲ Data Organization in Computer System

The organization of data for proper input into the computer system is very important. Regardless of the type of computer or program to be used, if data are poorly organized the researchers will have trouble in analysing their meaning.

The data must be coded first. Categorical data, such as a person's sex or occupation, need to be given a number to represent them. For example:

Sex	Occupation
1 = Female	1 = Farmer
2 = Male	2 = Service
	3 = Professional

The researcher may also want to convert interval or ratio data into categories and code them. For example:

IQ Level	Income
1 = 110–129	1 = 50,000 and over
2 = 90–109	2 = 40,000–49,999
3 = 70–89	3 = 30,000–39,999
4 = 50–69	4 = below 30,000

Program	ABS. DATA	Date: 30.06.2010		Punching Instructions	Graphic					Page 3 or 4
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1	0	3	5	2	0	2	4	1	4	1	3	0	4	0	9	0	7	1	1	0	1	1	1	4	7	2	1	1	1	5	0	9	2	0	9	1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														

The next step is to assign each variable to the spaces in which it will always be placed. Most systems call for a maximum of 80 columns per line. Once the researchers know how many spaces each variable will occupy, the variables can be assigned to their column numbers (from 1 to 80). If more than 80 spaces are needed for each subject, then two or more lines will need to be assigned. The first columns will usually be the individual subject identity (ID) number. If less than 100 subjects are included, two spaces starting with 01 will be needed. Sometimes, a researcher may include one or more attributes into the ID number, thereby increasing the number of columns needed. For instance, in the data set used in the ANOVA presented in this chapter, a four-digit ID is used. The first digit represents the student's major, the second represents the student's sex, and the third and fourth digits represent the distinctive ID numbers.

Thus, subject number 2113 was a philosophy major, male, and the 13 subject coded. When a large number of variables are used in a study, separating the variables with spaces will make the data easier to comprehend and use with some programs. In any case, the researchers need to have a list that shows which variables are represented in which column numbers.

Figure 15.1 shows how data might look when coded on to a form. Note how the variables are separated from each other by a space left between them. Table 15.1 demonstrates the list used to determine which column contains different variables.

Survey researchers frequently have a system for coding and recording their data prior to distribution of the questionnaires. For example, the questionnaire may ask for the sex of the respondent, '1' for male or '2' for female. If data are precoded for all questions and the researcher knows into which column each answer will be placed, the data may be inputted to the computer directly from the returned survey forms, thereby saving the time of transferring the data to coding forms.

Table 15.1 Variable list for coded data for the sex of the respondent

Column Number		Column Number	
1–4	ID Number	36–37	Independent
6–7	Expressive Language (EL)		Functioning (ABS1)
9–10	Receptive Language (RL)	39–40	Physical Development
12–13	Object Permanence (OP)		(ABS2)
15–16	Means-End (ME)	42–43	Language (ABS4)
18–19	Vocal Imitation (VI)	45–46	Self-direction (ABS8)
21–22	Gestural Imitation (GI)	48–49	Mental Age (MA)
24–25	Causality	51–53	Chronological Age)
27–28	Spatial Relations		(CA)
30–31	Responsibility (ABS9)		
33–34	Socialization (ABS10)		

Computer Data Analysis

Once the data are coded, they are ready to be stored in the computer. The researchers then must decide on the descriptive and inferential statistics desired and the program(s) that they will use to analyse the data. The selection of appropriate statistics will generally depend on the design of the study, and the specific program(s) to be used will depend upon the researchers' preference. Some researchers prefer one of the canned program packages and almost always use just that one. Others use different statistical programs from different packages.

```

TITLE: 'SAS CORRELATION EXAMPLE';
DATA-INPUT ID;
    EL RL OP ME VI GI CAUS SPA ABS9 ABS10 ABS1 ABS2 ABS4
    ABS8 MA CA;
LABEL EL = EXPRESSIVE LANGUAGE    RL = RECEPTIVE LANGUAGE
      OP = OBJECT PERMANENCE       ME = MEANS-END
      VI = VOCAL IMITATION         GI = GESTURAL IMITATION
      CAUS = CAUSALITY             ABS1 = INDEPENDENT FUNCTIONING
      ABS4 = LANGUAGE              ABS8 = SELF-DIRECTION
      ABS10 = SOCIALIZATION        CA = CHRONOLOGICAL AGE
      MA = MENTAL AGE;

CARDS;
111 31 36 14 13 7 9 7 11 4 24 66 7 15 17 14 80
112 22 26 14 13 9 9 2 11 0 18 56 19 15 17 16 75
113 23 26 14 13 1 9 7 11 3 18 55 23 13 11 20 90
114 17 21 14 13 5 9 6 11 1 5 31 17 5 11 15 40
115 19 24 14 13 2 9 7 11 44 4 35 22 3 11 19 50
116 20 26 14 13 4 9 7 11 1 17 58 24 17 15 21 41
117 17 22 14 13 5 9 6 11 33 13 48 20 9 10 21 57
118 14 25 14 13 7 9 4 10 4 22 64 24 9 14 20 65
119 25 36 14 13 8 9 7 11 3 15 52 24 17 16 21 84
120 22 31 14 13 1 9 7 11 2 16 56 24 11 13 21 92
121 12 22 14 13 6 9 7 11 0 19 64 24 8 10 19 41
122 14 24 14 13 5 9 7 11 1 9 35 19 7 7 17 47
123 14 24 14 13 6 9 6 11 2 16 54 21 14 11 16 48
124 11 18 14 13 6 9 7 11 2 17 56 22 9 9 15 49
125 15 24 8 10 0 8 5 8 0 14 51 17 3 8 14 50
126 15 21 14 13 0 8 4 11 1 4 32 23 7 5 20 60
127 12 18 14 10 0 8 3 9 1 6 37 16 7 11 21 70
128 20 28 14 11 2 9 6 11 0 11 47 24 10 9 20 118
129 14 19 14 10 1 8 7 9 1 14 44 21 7 7 17 31
130 6 11 14 13 0 8 1 11 2 11 47 18 6 10 17 42
131 11 22 14 13 4 8 4 11 1 17 56 19 3 4 16 47
132 12 20 14 13 4 9 7 11 3 15 52 24 11 7 14 64
133 12 18 14 13 0 8 7 11 2 5 32 24 6 8 10 67
134 9 12 14 13 0 7 5 11 0 14 52 24 11 14 18 82
135 24 29 14 13 4 9 7 11 1 14 52 24 17 6 20 91
136 12 17 14 12 1 0 3 11 0 8 41 17 6 8 9 97
137 4 6 7 10 0 4 0 5 0 3 27 22 5 3 17 104
138 22 28 7 13 1 7 7 9 2 3 24 20 7 7 18 59
139 19 21 14 8 0 0 0 5 0 5 33 24 7 4 17 101
140 16 18 14 12 0 5 5 11 2 12 44 24 7 8 16 49
141 14 17 9 5 0 0 7 10 0 11 40 22 7 14 5 79
142 10 9 14 12 1 2 2 7 2 6 37 22 9 8 4 109
143 7 9 8 10 0 8 5 11 0 6 32 19 7 2 12 49
144 8 10 8 8 0 0 5 9 1 4 36 17 3 1 19 60
145 11 15 5 11 2 0 2 11 0 4 32 23 4 4 17 89
146 10 14 3 10 1 0 1 10 0 7 30 16 2 1 16 47
147 11 14 7 5 1 1 0 1 1 1 30 22 6 8 15 81
148 9 14 14 13 1 2 2 9 0 2 29 19 3 9 14 84
149 8 10 5 7 1 5 5 9 2 6 38 21 7 7 12 56
150 9 9 3 10 0 0 2 4 0 14 17 15 5 0 10 99
151 9 11 8 10 0 4 4 6 0 2 30 21 3 5 9 57
152 7 8 3 10 0 0 3 7 0 5 31 17 4 10 6 76
201 30 36 14 13 5 9 7 10 4 17 64 23 19 12 21 50
202 17 19 12 12 6 5 6 9 2 12 37 24 8 5 8 50
203 8 17 9 10 0 2 3 11 0 7 31 16 7 9 9 91

PROC CORR;
VAR OP ME VI GI CAUS MA CA;
WITH EL RL ABS1 ABS4 ABS8 ABS10;

```

Figure 15.2 Control cards for descriptive statistics example using SAS

In the following we introduce two of the more popular statistical systems, presenting the control cards and output for two analyses from each. A large main-frame computer at the University of Illinois at Chicago was used in the first three analyses. For the fourth analysis, the ANOVA example, an IBM personal computer with a hard disk was used.

In each of these analyses, the data may be presented with the control statements or can be retrieved by appropriate statements from another location (e.g., disk of tape). In three of the sample programs, the data are embedded within the control statements. In the second analysis, we provide an example of control statements that retrieve the data from a disk. When data are retrieved in this manner, an additional group of control cards, known as job control language (JCL) cards, are used to inform the computer of the location of the data and other parameters.

Example 1: Descriptive Statistics—SAS: CORR

SAS offers a number of descriptive statistics programs. The one presented here is called CORR because it includes correlations. The control cards are presented in Figure 15.2.

SAS statements are separated from each other by semicolons (;). Thus, TITLE tells the program that the following words in single quotes (') comprise the title of this program, and DATA tells the program to read the data into an SAS data set created by and for this program. The INPUT statement tells the program the names of the variables and where they are. Since the variables in the data set are separated by spaces, we inform the program where they are simply by naming them in the order they appear in the file. When the input statement is used in this way, missing data must be represented by a period (.) rather than a blank space since a blank space cannot represent a missing data point and a space between variables.

The next statement, LABEL, gives longer labels to the previously listed variables. CARDS merely informs the programs that the data are imbedded in the program, rather than in a separate file, and follow this statement. A semicolon follows the last subject's data to inform the program that all the data have been read. PROC CORR tells the SAS system that the procedure known as 'correlation' is to be used. The next two statements request correlation coefficients to be calculated and printed for only certain combinations. The VAR statement lists the variables desired on the top of the printed correlation matrix and the WITH statement lists the variables desired on the side of the correlation matrix.

Figure 15.3 shows the output produced by this program. The number of subjects, mean, standard deviation, sum of the scores, the lowest score and the highest score for each of the variables are presented first. Below that is the correlation matrix—with the significance level below each correlation—for the VAR variables with the WITH variables. If the VAR and WITH statements had not been included, a correlation matrix consisting of all the possible combinations (all 13 variables by all 13 variables) would have resulted.

Example 2: SAS—Chart

Both SPSS-X and SAS systems have very sophisticated graphing options including three-dimensional and, if the printer is capable, colour graphics. The present example demonstrates the chart procedure, a relatively simple one, from SAS.

The first six lines of the control cards presented in Figure 15.3 are the JCL cards. These cards inform the computer of the computer time to be allocated and memory required, the type and place of printing desired, that the SAS system will be used, and the name (CANON1.DATA) and location (disk) of the data set to be used. The next two lines include the first three SAS statements and are similar to the SAS statements used in Example 1. The next six lines present a series of 'IF ... THEN' statements. These

SAS CORRELATION EXAMPLE

VARIABLE	N	MEAN	STD DEV	SUM	MINIMUM	MAXIMUM
OP	45	11.60000	3.72583	522.000	3.00000	14.0000
ME	45	11.44444	2.16958	515.000	5.00000	13.0000
VI	45	2.37778	2.69080	107.000	0.00000	9.0000
GI	45	6.00000	3.59292	270.000	0.00000	9.0000
CAUS	45	4.71111	2.32205	212.000	0.00000	7.0000
MA	45	15.46667	4.66418	696.000	4.00000	21.0000
CA	45	68.17778	21.94755	3068.000	31.00000	118.0000
EL	45	14.48889	6.29077	652.000	4.00000	31.0000
RL	45	19.66667	7.70478	885.000	6.00000	36.0000
ABS1	45	42.55556	12.42350	1915.000	17.00000	66.0000
ABS4	45	8.13333	4.34114	366.000	2.00000	19.0000
ABS8	45	8.57778	4.21301	386.000	0.00000	17.0000
ABS10	45	10.51111	6.01748	473.000	1.00000	24.0000

PEARSON CORRELATION COEFFICIENT/PROB > |R| UNDER HO:RHO=0 / N = 45

	OP	ME	VI	GI	CAUS	MA	CA
EL	0.65652	0.38170	0.51784	0.48869	0.52799	0.43898	0.04397
EXPRESSIVE LANGUAGE	0.0016	0.0097	0.0003	0.0007	0.0002	0.0026	0.7743
RL	0.54628	0.48900	0.61572	0.63134	0.59282	0.54136	-0.05985
RECEPTIVE LANGUAGE	0.0001	0.0007	0.0001	0.0001	0.0001	0.0001	0.6961
ABS1	0.59804	0.45439	0.62313	0.63238	0.47839	0.42373	-0.18458
INDEPENDENT FUNCTIONING	0.0001	0.0017	0.0001	0.0001	0.0009	0.0037	0.2248
ABS4	0.49236	0.39896	0.58317	0.53185	0.45032	0.36614	0.10995
LANGUAGE	0.0006	0.0066	0.0001	0.0002	0.0019	0.0134	0.4721
ABS8	0.52037	0.33429	0.49153	0.47595	0.37290	0.20341	0.00550
SELF-DIRECTION	0.0002	0.0248	0.0006	0.0010	0.0116	0.1802	0.9714
ABS10	0.44623	0.44701	0.63768	0.55503	0.46135	0.28849	-0.14336
SOCIALIZATION	0.0021	0.0021	0.0001	0.0001	0.0014	0.0546	0.3475

Figure 15.3 Sample SAS PROC CORR output

statements convert two of the variables to categories. The first four statements deal with chronological age in months (CA). Those children with CAs from 36–59 months are assigned a score of 1; those with CAs from 60 to 83 months are assigned a score of 2; those with CAs from 84 to 107 months are assigned a score of 3; and those with CAs from 108 to 155 months are assigned a score of 4. Because the first digit of the three-digit ID number represents the subject's sex, those children with IDs over 200 are females (F) and those with IDs below 200 are males (M).

The next line (PUT AGE SEX) creates the computer space for the variables of age and sex created in the previous six statements. The PROC FORMAT and VALUE statements assign more meaningful values to the variables 'age'. Thus, those children who are assigned a score of 1 for CAs from 36 to 59 months are 3–4 years old; those with a score of 2 for CAs from 60 to 83 months are 5–6 years old, and so on.

The next two lines request the SAS procedure CHART, a vertical bar graph (VBAR) to be created using the variables age, and the number of children of each sex to be included in the bars of the graph. The next two lines request another graph using the same SAS procedure. This time a pie chart or circular graph in sections should be created using the variables age (Figure 15.4).

```
/*JOBPARM T=(.29), R=900
/*OUTPUT PRT FORMS=8502, DEST=U1
// EXEC SAS
//FT12F001 DD SYSOUT=(A, PRT)
//SAS.IMBCD DD DSN=EDO4001.CANON1.DATA,DISP=SHR
//SAS.SYSIN DD *
DATA; INFILE INBCD;
INPUT ID A B C D E F G H I J K L M N Q CA;
IF CA>35 <60 THEN AGE=1;
IF CA>59 <84 THE AGE=2;
IF CA>83 < 108 THEN AGE=3;
IF CA >107 THEN AGE=4;
IF ID <200 THEN SEX='M';
IF ID> 200 THEN SEX='F';
PUT AGE SEX;
PROC FORMAT;
    VALUE AGE 1='3 TO 4'
              2='5 TO 6'
              3='7 TO 8'
              4='9 TO 11';
PROC CHART; VBAR AGE/DISCRETE SUBGROUP=SEX;
            FORMAT AGE AGE.;
PROC CHART; PIE AGE/DISCRETE;
            FORMAT AGE AGE.;
```

Figure 15.4 Control cards for charting

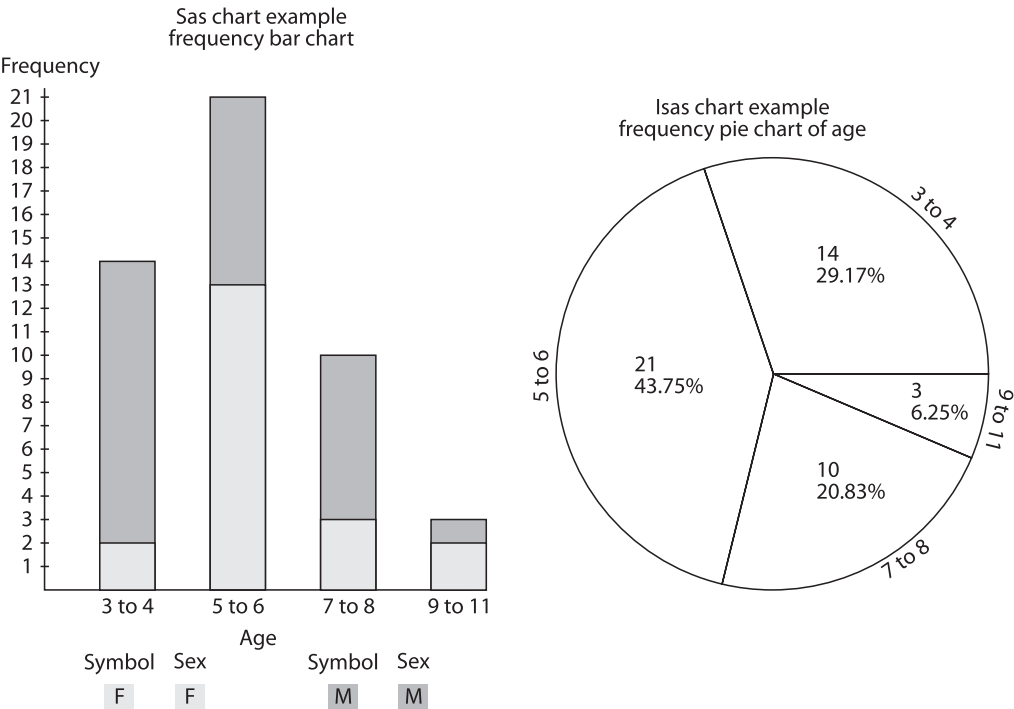


Figure 15.5 Sample SAS PROC CHART output

Figure 15.5 presents both these graphs on what would be two pages of output.

The pie chart gives both the frequency (number of subjects) and the percentage of the total sample in each age range. The bar chart shows the number of males and females and the total number of children in each age group.

Example 3: Multiple Regression—SPSS-X

SPSS, Inc. has published more than ten versions of SPSS for main-frame computers. The version used in this example is called SPSS-X.

The current example uses data collected by the second author. The multiple regression presented uses three Piagetian independent variables (object permanence, means-end and vocal imitation) to predict a receptive language score (presented as an age in months) of 45 profoundly retarded children.

The first SPSS-X control card in Figure 15.6, TITLE, is used to name the program (SPSSX REGRESSION EXAMPLE). The data LIST cards (two lines are used) tell the program that the data are presented in such a way that each variable is always in the same column (FIXED) and gives the short name and column number for each variable (e.g., RL is in columns 9 and 10, OP is in columns 12 and 13). The VARIABLE LABELS card assigns more complete labels to the initially short names. Next comes the REGRESSION command and its options on the next five lines. The first of these lines instructs SPSS-X to do a regression analysis and identifies the descriptive statistics that are desired (those automatically calculated plus significance levels).

The second and third lines present the variables to be used in the regression equation and the regression statistics to be calculated (R requests the multiple correlation and COEF requests the regression coefficients and beta weights). The fourth and fifth lines specify the dependent variable (RL) and request that all other variables—the remaining variables are the independent variables—should be entered simultaneously into the prediction equation. Finally, the program is told to read the data (BEGIN DATA), followed by the data set and two statements, informing the program to stop reading data (END DATA) and that there are no more statements (FINISH).

Figure 15.7 presents two pages of output produced by the above example. The first page shows the descriptive statistics requested. The mean and standard deviation of each variable and a correlation matrix—showing the Pearson r and its significance level for each pair of variables—are presented. The second page of output shows multiple correlation coefficient (multiple R), its square (R square) the adjusted R square (which corrects R for sampling error), and the standard error of estimate for predicting a score using the regression equation. This page also contains a table that shows B , standard error of B , and $Beta$ for each independent variable. The table also presents the constant or intercept and a T and its significance level for the importance of each variable to the prediction of the dependent variable. These t -tests show that only object-permanence and vocal imitation add significantly to the prediction of receptive language.

We could use the information regarding the B weights and the constant in a multiple regression equation to predict a profoundly retarded person's receptive language age given their vocal imitation, object-permanence and means-end scores.

$$Y = a + b_1X_1 + b_2X_2 \dots$$

$$Y(\text{RL}) = 1.411 + 1.287(\text{VI}) + .793(\text{OP}) + .385(\text{ME})$$

The resulting prediction of receptive language would have a standard error of estimate of 5.713.

```

TITLE SPSSX REGRESSION EXAMPLE
DATA LIST                               FIXED
      /RL 9-10 OP 12-13 ME 15-16 VI 18-19
VARIABLE LABELS  RL 'RECEPTIVE LANGUAGE'
                  OP 'OBJECT PERMANENCE'
                  ME 'MEANS-END'
                  VI 'VOCAL IMITATION'
REGRESSION      DESCRIPTIVE=DEFAULTS SIG/
                  VARIABLE=RL OP ME VI/
                  STATISTICS=R COEF/
                  DEPENDENT=RL/
                  ENTER/

BEGIN DATA
111 30 36 14 13 07 09 07 11 03 22 64 06 13 14
112 20 24 14 13 09 09 02 11 00 17 56 20 13 15
113 22 27 14 13 01 09 07 11 03 16 54 24 13 10
114 15 20 14 13 05 09 06 11 00 05 30 16 05 11
115 18 24 14 13 02 09 07 11 02 03 31 22 02 07
116 21 27 14 13 04 09 07 11 02 16 52 23 16 14
117 14 20 14 13 05 09 06 11 00 12 48 20 08 07
118 14 24 14 13 07 09 04 10 02 20 60 22 19 12
119 24 36 14 13 08 09 07 11 02 14 52 23 16 15
120 20 30 14 13 01 09 07 11 03 15 54 24 10 13
121 12 22 14 13 06 09 07 11 03 18 60 22 08 08
122 14 24 14 13 05 09 07 11 01 07 34 19 07 07
123 14 22 14 13 06 09 06 11 00 15 56 20 15 12
124 10 18 14 13 06 09 07 11 01 16 54 19 08 07
125 16 24 08 10 00 08 05 08 02 12 48 15 03 08
126 14 20 14 13 00 08 04 11 01 03 30 22 07 01
127 12 18 14 10 00 08 03 09 00 06 31 14 06 10
128 18 27 14 11 02 09 06 11 00 10 45 23 09 10
129 13 18 14 10 01 08 07 09 01 10 43 21 07 07
130 05 10 14 13 00 08 01 11 00 11 47 18 05 10
131 10 20 14 13 04 08 04 11 00 16 54 19 04 05
132 12 20 14 13 04 09 07 11 01 15 55 24 10 05
133 12 18 14 13 00 08 07 11 00 04 33 23 07 06
134 08 12 14 13 00 07 05 11 03 12 49 23 07 11
135 20 24 14 13 04 09 07 11 01 11 47 21 15 04
136 10 14 14 12 01 00 03 11 00 08 40 19 07 05
137 04 06 07 10 00 04 00 05 01 03 28 21 05 02
138 16 16 07 13 01 07 07 09 00 03 24 20 06 06
139 18 18 14 08 00 00 00 05 00 05 31 20 05 02
140 16 18 14 12 00 05 05 11 01 09 37 23 07 09
141 06 11 09 05 00 00 07 10 00 11 40 22 07 10
142 09 09 14 12 01 02 02 07 02 05 34 22 08 07
143 06 06 08 10 00 08 05 11 00 04 30 19 05 00
144 06 06 08 08 00 00 05 09 00 03 34 15 03 01
145 10 14 05 11 02 00 02 11 00 03 30 21 03 02
146 09 11 03 10 01 00 01 10 00 05 30 18 01 00
147 10 10 07 05 01 01 00 01 00 01 28 19 04 06
148 08 10 14 13 01 02 02 09 00 01 26 19 03 09
149 07 09 05 07 01 05 05 09 00 01 27 18 03 04
150 08 08 03 10 00 00 02 04 00 04 29 15 03 00
151 08 08 08 10 00 04 04 06 00 02 30 21 03 05
152 06 06 03 10 00 00 03 07 00 03 26 15 00 09
201 28 36 14 13 05 09 07 10 04 15 52 18 17 10
202 15 17 12 12 06 05 06 09 02 10 35 21 09 04
203 06 15 09 10 00 02 03 11 00 06 30 18 06 08

END DATA
FINISH

```

Figure 15.6 Control cards for regression example using SPSS-X

```

*****MULTIPLEREGRESSION*****
Listwise Deletion of Missing Data

      Mean   Std Dev   Label
RL      18.067    8.170  RECEPTIVE LANGUAGE
OP      11.600    3.726  OBJECT PERMANENCE
ME      11.444    2.170  MEANS-END
VI       2.378    2.691  VOCAL IMITATION

N of Cases = 45
Correlation, 1-tailed Sig:

      RL      OP      ME      VI
RL      1.000    .610    .542    .634
      .999    .000    .000    .000
OP      .610    1.000    .621    .437
      .000    .999    .000    .001
ME      .542    .621    1.000    .508
      .000    .000    .999    .000
VI      .634    .437    .508    1.000
      .000    .001    .000    .999

*****MULTIPLEREGRESSION*****
Equation Number 1   Dependent Variable   RL   RECEPTIVE LANGUAGE
Descriptive Statistics are printed on Page   2
Beginning Block Number 1. Method: Enter
Variable(s) Entered on Step Number 1..   VI   VOCAL IMITATION
                                   2..   OP   OBJECT PERMANENCE
                                   3..   ME   MEANS-END

Multiple R           .73784
R Square            .54441
Adjusted R Square    .51107
Standard Error       5.71260

F =      16.33089      Signif F = .0000
-----Variables in the Equation-----
Variable           B      SE B      Beta      T      Sig T
VI                1.286557   .377700   .423740    3.406   .0015
OP                .792628   .299906   .361478    2.643   .0116
ME                .384680   .537731   .102156    .715   .4784
(Constant)       1.410578   4.960245          .284   .7776
-End Block Number 1 All requested variable entered.
END OF JOB.

```

Figure 15.7 Sample regression output

Example 4: Analysis of Variance—SPSS-PC+

The data used in this example are identical to the data used in Chapter 11 on the ANOVA, with one important difference. In the current example, ten students in each college major are evenly divided into males and females. Thus, instead of the simple one-way ANOVA presented in Chapter 14, the current example is a two-way ANOVA.

The SPSS-PC+ control statements are quite similar to the SPSS-X statements (see Figure 15.8). TITLE is again used to name the program, in this case SPSSPC ANOVA EXAMPLE. The next two lines (DATA LIST) inform the program that each variable is always presented in the same column (FIXED)

and gives the name and location of each variable (i.e., MAJOR in column 1, SEX in column 2, and ABSTR in columns 6 and 7). VALUE LABELS give names to the categories of each variable. For instance, a subject with a 1 for major and a 1 for sex is a female mathematics major. While in SPSS-X the command to execute a particular statistic (e.g., regression or ANOVA) would appear next, with SPSS-PC+, the data precede this command.

```

TITLE SPSSPC ANOVA EXAMPLE
DATA LIST FIXED
      /MAJOR 1 SEX 2 ABSTR 6-7.
VALUE LABELS  MAJOR 1 'MATHEMATICS'
                2 'PHILOSOPHY'
                3 'CHEMISTRY'
              /SEX 1 'FEMALE'
                2 'MALE'

BEGIN DATA.
1101 18
1102 22
1103 18
1104 23
1105 19
1206 24
1207 20
1208 21
1209 19
1210 25
2111 26
2112 27
2113 18
2114 22
2115 23
2216 19
2217 27
2218 26
2219 24
2220 26
3121 18
3122 14
3123 15
3124 14
3125 19
3226 21
3227 17
3228 17
3229 18
3230 19
END DATA.
ANOVA      ABSTR BY MAJOR (1,3) SEX (1,2)/STATISTICS=3.
FINISH.

```

Figure 15.8 Control cards for analysis of variance example using SPSS-PC+

Thus, the next several lines consist of the BEGIN DATA statement, the data themselves and the END DATA statement. After the data, the ANOVA command, indicating that we want to calculate an ANOVA, is presented. This line also specifies abstract reasoning (ABSTR) as the dependent variable, major as an independent variable with three levels, sex as another independent variable with two levels, and that we wish certain statistics to be produced (statistics = 3)—the means for each category. Finally, FINISH tells the program that there are no further commands.

```

SPSSPC ANOVA EXAMPLE                                30/06/2010
*** CELL MEANS ***

      ABSTR
    BY MAJOR
      SEX

TOTAL POPULATION
  20.63
(   30)
MAJOR
  1      2      3
  20.90  23.80  17.20
(   10)  (   10)  (   10)

SPSSPC ANOVA EXAMPLE                                30/06/2010
SEX
  1      2
  19.73  21.53
(   15)  (   15)
SEX
MAJOR
  1      2
  1  20.00  21.80
    (   5)  (   5)
  2  23.20  24.40
    (   5)  (   5)
  3  16.00  18.40
    (   5)  (   5)

SPSSPC ANOVA EXAMPLE                                30/06/2010
*** ANALYSIS OF VARIANCE ***

      ABSTR
    BY MAJOR
      SEX

Source of Variation    Sum of Squares    DF    Mean Square    F    Signif
of F
Main Effects          243.167          3    81.056    11.180    .000
  MAJOR              218.867          2   109.433    15.094    .000
  SEX                24.300          1    24.300     3.352    .080
2-way Interactions     1.800          2     .900     .124    .884
  MAJOR SEX          1.800          2     .900     .124    .884
Explained              244.967          5   48.993     6.758    .000
Residual              174.000         24     7.250
Total                 418.967         29   14.447

SPSSPC ANOVA EXAMPLE                                30/06/2010
30 Cases were processed.
0 CASES ( .0 PCT) were missing.
SPSSPC ANOVA EXAMPLE                                30/06/2010

```

Figure 15.9 Sample analysis of variance output

Figure 15.9 shows two pages of output from the ANOVA program just described. The first page lists the means (and in parentheses the number of subjects) for the total sample ('population' on the printout), each major, each sex and the six cells of the major by sex table. The second page of output presents the ANOVA table. The sources of variation include the total for the two main effects, each of the two main effects (major and sex), the interaction effect of the two independent variables, the total of the main effects and interaction effect (EXPLAINED), the within-group or error (RESIDUAL) and the total. The sum of squares, degrees of freedom (*df*) and means squared are presented for each of these sources of variation. *F*s and the significance of each *F* are presented for each of the effects.

Of interest are the F s for the three effects: college major, sex and the major by sex interaction. The F for major was found to be 15.094. Significance levels are carried out to three decimal places. Thus, a significance of 0.000 is less than 0.001—less than one chance in a thousand that the three groups of students with different majors were observed to differ because of sampling error. The F for sex was found to be 3.352. The significance level of 0.080 is not low enough (.05 being the highest acceptable error rate) for us to reject the null hypothesis for the main effect of sex. That is, any observed difference between females and males should be considered due to sampling error. Finally, the F for the interaction of major and sex was found to be 0.124 with a significance level of 0.884. Obviously, the null hypothesis for the interaction of these variables is also not rejected.

The reader may be interested in comparing the results of this 3 by 2 (major by sex) ANOVA with the one-way ANOVA (major) performed in Chapter 14 on the same data. The reader should note that the total sum of squares and the sum of squares for major are identical. However, because this example included an additional main effect and an interaction effect, the residual (within-groups) sum of squares is reduced by the amount explained by these two effects. Similarly, the degrees of freedom of the residual changes from 27 to 24, with sex (1) and the interaction of sex and major (2) taking up these three degrees of freedom. Finally, due to the changes in the residual, the F for major (the only one that could be calculated using a one-way ANOVA) was changed slightly from 14.77 to 15.09. Here, we present the researcher with an introduction to use of computers in the data analysis.

Evaluate Yourself

- (i) What is the need and importance of computer programme for statistical analysis?
- (ii) Clarify SPSS and SAS with examples.

Summary

- In modern and technological era computer programs (Software) have become widely available.
- The steps in using computer to calculate statistical data analyses are: (1) data organizing and coding, (2) storing the data in the computer system, (3) selection of appropriate descriptive and inferential statistics, (4) selection of appropriate programs for the desired statistics, (5) writing of control cards and (6) execution of the computer programs.
- In this chapter, the presented examples are related to a two-way ANOVA, a multiple regression analysis, a descriptive statistics program and along with simple graphs.

Key Words

- *Computer*: It is one of the most powerful electronic digital instruments. It includes four basic function: input, storage, control and output. It can perform many statistical calculations easily and quickly.
- *ANOVA*: Analysis of variance.
- *SPSS*: Statistical package for the social sciences.
- *SAS*: Statistical analysis system.
- *JCL*: Job control language. It is the type of cards used to inform the computer of the location of data and other parameters.

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Additional Readings

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Appendix A

Table A.1 Table of *t*-values

Degrees of freedom	Two-tailed test level of significance		One-tailed test level of significance	
	.05	.01	.05	.01
1	12.706	63.557	6.314	31.821
2	4.303	9.925	2.920	6.965
3	3.182	5.841	2.353	4.541
4	2.776	4.604	2.132	3.747
5	2.571	4.032	2.015	3.365
6	2.447	3.707	1.943	3.143
7	2.365	3.499	1.895	2.998
8	2.306	3.355	1.860	2.896
9	2.262	3.250	1.833	2.821
10	2.228	3.169	1.812	2.764
11	2.201	3.106	1.796	2.718
12	2.179	3.055	1.782	2.681
13	2.160	3.012	1.771	2.650
14	2.145	2.977	1.761	2.624
15	2.131	2.947	1.753	2.602
16	2.120	2.921	1.746	2.583
17	2.110	2.898	1.740	2.567
18	2.101	2.878	1.734	2.552
19	2.093	2.861	1.729	2.539
20	2.086	2.845	1.725	2.528
21	2.080	2.831	1.721	2.518
22	2.074	2.819	1.717	2.508
23	2.069	2.807	1.714	2.500
24	2.064	2.797	1.711	2.492
25	2.060	2.787	1.708	2.485

Table A.1 (Continued)

Degrees of freedom	Two-tailed test level of significance		One-tailed test level of significance	
26	2.056	2.779	1.706	2.479
27	2.052	2.771	1.703	2.473
28	2.048	2.763	1.701	2.467
29	2.045	2.756	1.699	2.462
30	2.042	2.750	1.697	2.457
40	2.021	2.704	1.684	2.423
60	2.000	2.660	1.671	2.390
120	1.980	2.617	1.658	2.358
α	1.960	2.576	1.645	2.326

Appendix B

Table B.1 Critical values for Chi square

Degrees of Freedom	Level of Significance	
	0.5	0.01
1	3.84	6.64
2	5.99	9.21
3	7.82	11.34
4	9.49	13.28
5	11.07	15.09
6	12.59	16.81
7	14.07	18.48
8	15.51	20.09
9	16.92	21.67
10	18.31	23.21
11	19.68	24.72
12	21.03	26.22
13	22.36	27.96
14	23.68	29.14
15	25.00	30.58
16	26.30	32.00
17	27.59	33.41
18	28.87	34.80
19	30.14	36.19
20	31.41	37.57
21	32.67	38.93
22	33.92	40.29
23	35.17	41.64
24	36.42	42.98
25	37.65	44.31
26	38.88	45.65

Table B.1 (Continued)

Degrees of Freedom	Level of Significance	
27	40.11	46.96
28	41.34	48.28
29	42.56	49.59
30	43.77	50.89

Appendix C

Table C.1 Significance levels for the Pearson product-moment coefficient of correlation

Degrees of Freedom	0.05	0.01
(N- 2)		
1	0.997	0.9999
2	0.950	0.990
3	0.878	0.959
4	0.811	0.917
5	0.754	0.874
6	0.207	0.834
7	0.666	0.798
8	0.632	0.765
9	0.602	0.735
10	0.576	0.708
11	0.553	0.684
12	0.512	0.661
13	0.514	0.641
14	0.497	0.623
15	0.482	0.606
16	0.468	0.590
17	0.456	0.575
18	0.444	0.561
19	0.433	0.549
20	0.423	0.537
21	0.413	0.526
22	0.404	0.515
23	0.396	0.505
24	0.388	0.496
25	0.381	0.487

Table C.1 (Continued)

Degrees of Freedom	0.05	0.01
26	0.374	0.479
27	0.367	0.471
28	0.361	0.463
29	0.355	0.456
30	0.349	0.449
35	0.325	0.418
40	0.304	0.393
45	0.288	0.372
50	0.273	0.354
60	0.250	0.325
70	0.232	0.303
80	0.217	0.283
90	0.205	0.267
100	0.195	0.254
125	0.174	0.228
150	0.159	0.208
200	0.138	0.181
300	0.113	0.148
400	0.098	0.128
500	0.088	0.115
1000	0.062	0.081

Source: Gull, J. P. and B. Fruchter. 1978. *Fundamental Statistics in Psychology and Education*. Tokyo: McGraw-Hill Kogakusha Ltd., pp. 531–32.

Appendix D

Table D.1 Coefficient of multiple correlation significant at the 0.05 level (lightface type) and at the 0.01 level (boldface type) for various df (N–m) and numbers of variables (m)

Degrees of Freedom	Number of Variables					
	3	4	5	6	7	9
1	0.999 1.000	0.999 1.000	0.999 1.000	1.000 1.000	1.000 1.000	1.000 1.000
2	0.975 0.995	0.983 0.997	0.987 0.998	0.990 0.998	0.992 0.998	0.994 0.999
3	0.930 0.976	0.950 0.983	0.961 0.987	0.968 0.990	0.973 0.991	0.979 0.993
4	0.881 0.949	0.912 0.962	0.930 0.970	0.942 0.975	0.950 0.979	0.961 0.984
5	0.836 0.917	0.874 0.937	0.898 0.949	0.914 0.957	0.925 0.963	0.941 0.971
6	0.795 0.886	0.839 0.911	0.867 0.927	0.886 0.938	0.900 0.946	0.920 0.957
7	0.758 0.855	0.807 0.885	0.838 0.904	0.860 0.918	0.876 0.928	0.900 0.942
8	0.726 0.827	0.777 0.867	0.811 0.882	0.835 0.898	0.854 0.909	0.880 0.926
9	0.697 0.800	0.750 0.836	0.786 0.861	0.812 0.878	0.832 0.891	0.861 0.911
10	0.671 0.776	0.726 0.814	0.763 0.840	0.790 0.859	0.812 0.874	0.843 0.885
11	0.648 0.753	0.708 0.793	0.741 0.821	0.770 0.841	0.792 0.857	0.826 0.880
12	0.627 0.732	0.683 0.773	0.722 0.802	0.751 0.824	0.774 0.841	0.809 0.866
13	0.608 0.712	0.664 0.755	0.703 0.785	0.733 0.807	0.757 0.825	0.794 0.852
14	0.590 0.694	0.646 0.737	0.686 0.768	0.717 0.782	0.741 0.810	0.779 0.838

Table D.1 (Continued)

Degrees of Freedom	Number of Variables					
	3	4	5	6	7	9
15	0.574 0.677	0.630 0.721	0.670 0.752	0.701 0.776	0.736 0.796	0.765 0.825
16	0.559 0.662	0.615 0.706	0.665 0.783	0.686 0.762	0.712 0.782	0.751 0.813
17	0.545 0.647	0.601 0.691	0.641 0.724	0.673 0.749	0.698 0.769	0.738 0.800
18	0.532 0.633	0.587 0.678	0.628 0.710	0.660 0.736	0.686 0.756	0.726 0.789
19	0.520 0.620	0.575 0.665	0.615 0.698	0.647 0.723	0.674 0.744	0.714 0.778
20	0.509 0.608	0.563 0.652	0.604 0.685	0.636 0.712	0.662 0.733	0.703 0.767
21	0.498 0.596	0.552 0.641	0.592 0.674	0.674 0.700	0.651 0.722	0.693 0.756
22	0.488 0.585	0.542 0.630	0.582 0.663	0.614 0.690	0.640 0.712	0.682 0.746
23	0.476 0.574	0.532 0.619	0.572 0.652	0.604 0.679	0.630 0.701	0.673 0.736
24	0.470 0.565	0.523 0.609	0.562 0.642	0.594 0.669	0.621 0.692	0.663 0.727
25	0.462 0.555	0.514 0.600	0.553 0.633	0.585 0.660	0.612 0.682	0.654 0.718
26	0.454 0.546	0.506 0.590	0.545 0.624	0.576 0.651	0.603 0.673	0.645 0.709
27	0.446 0.538	0.498 0.582	0.536 0.615	0.568 0.642	0.594 0.664	0.637 0.701
28	0.439 0.530	0.490 0.573	0.529 0.606	0.560 0.634	0.586 0.656	0.629 0.692
29	0.432 0.522	0.482 0.565	0.521 0.598	0.552 0.625	0.579 0.648	0.621 0.685
30	0.426 0.514	0.476 0.558	0.514 0.591	0.545 0.618	0.571 0.640	0.614 0.677
35	0.397 0.481	0.445 0.523	0.482 0.556	0.512 0.582	0.538 0.605	0.580 0.642
40	0.373 0.454	0.419 0.494	0.455 0.526	0.484 0.552	0.509 0.575	0.551 0.612
45	0.353 0.430	0.397 0.470	0.432 0.501	0.460 0.527	0.485 0.549	0.526 0.586
50	0.336 0.410	0.379 0.449	0.412 0.479	0.440 0.504	0.464 0.526	0.504 0.562
60	0.308 0.377	0.348 0.414	0.380 0.442	0.406 0.466	0.429 0.488	0.467 0.523

(Continued)

Table D.1 (Continued)

Degrees of Freedom	Number of Variables					
	3	4	5	6	7	9
70	0.286 0.351	0.324 0.380	0.364 0.413	0.379 0.436	0.401 0.456	0.438 0.491
80	0.269 0.330	0.304 0.362	0.332 0.389	0.356 0.411	0.377 0.431	0.413 0.464
90	0.254 0.312	0.288 0.343	0.315 0.368	0.338 0.390	0.358 0.400	0.392 0.441
100	0.241 0.297	0.274 0.327	0.300 0.351	0.307 0.352	0.341 0.390	0.374 0.421
125	0.216 0.266	0.246 0.294	0.269 0.316	0.28 0.324	0.307 0.352	0.338 0.381
150	0.198 0.244	0.225 0.270	0.247 0.290	0.266 0.308	0.28 0.324	0.310 0.351
200	0.172 0.212	0.196 0.234	0.215 0.253	0.231 0.269	0.246 0.283	0.271 0.307
300	0.141 0.174	0.160 0.192	0.176 0.208	0.190 0.221	0.202 0.233	0.223 0.253
400	0.122 0.151	0.139 0.167	0.153 0.180	0.165 0.192	0.176 0.202	0.194 0.220
500	0.19 0.096	0.088 0.106	0.097 0.115	0.105 0.122	0.112 0.129	0.124 0.141
1000	0.077 0.096	0.088 0.106	0.097 0.115	0.105 0.122	0.112 0.129	0.124 0.141

Source: Guilford, J. P. and B. Fruchter. 1978. *Fundamental Statistics in Psychology and Education*. Tokyo: McGraw-Hill Kogakusha Ltd., p. 533.

Appendix E

Table E.1 Critical values of F distribution

DF for Numerator		DF for Number											
	X	1	2	3	4	5	6	7	8	9	10	11	12
1	0.10 0.05	39.9 161	49.5 200	53.6 216	55.8 225	57.2 230	58.2 234	58.9 237	59.4 239	59.9 241	60.2 242	60.5 243	60.7 244
2	0.10 0.05 0.01	8.53 18.5 98.5	9.00 19.0 99.0	9.16 19.2 99.2	9.24 19.2 99.2	9.29 19.3 99.3	9.33 19.3 99.3	9.35 19.4 99.4	9.37 19.4 99.4	9.38 19.4 99.4	9.39 19.4 99.4	9.40 19.4 99.4	9.41 19.4 99.4
3	0.10 0.05 0.01	5.54 10.1 34.1	5.46 9.55 30.8	5.39 9.28 29.5	5.34 9.12 28.7	5.31 9.12 28.7	5.28 8.94 28.2	5.27 8.89 27.7	5.25 8.85 27.5	5.24 8.81 27.3	5.23 8.79 27.2	5.22 8.76 27.1	5.22 8.74 27.1
4	0.10 0.05 0.01	4.54 7.71 21.2	4.32 6.94 18.0	4.19 6.59 16.7	4.11 6.39 16.0	4.05 6.26 15.5	4.01 6.16 15.2	3.98 6.09 15.0	3.95 6.04 14.8	3.95 6.04 14.7	3.92 5.96 14.5	3.91 5.94 14.4	3.90 5.91 14.4
5	0.10 0.05 0.01	4.06 6.61 16.3	3.78 5.79 13.3	3.62 5.41 12.1	3.52 5.19 11.4	3.45 5.05 11.0	3.40 4.95 10.7	3.37 4.88 10.5	3.34 4.82 10.3	3.32 4.77 10.2	3.30 4.74 10.1	3.28 4.71 9.96	3.27 4.68 9.89
6	0.10 0.05 0.01	3.78 5.99 13.7	3.46 5.14 10.9	3.29 4.76 9.78	3.18 4.53 9.15	3.11 4.39 8.75	3.05 4.28 8.26	3.01 4.21 8.26	2.98 4.15 8.10	2.96 4.10 7.96	2.94 4.06 7.87	2.92 4.03 7.79	2.90 4.00 9.89
7	0.10 0.05 0.01	3.59 5.59 12.2	3.26 4.74 9.55	3.07 4.35 8.45	2.96 4.12 7.85	2.88 3.97 7.46	2.83 3.87 7.19	2.78 3.79 6.99	2.75 3.73 6.84	2.72 3.68 6.72	2.70 3.64 6.62	2.68 3.60 6.54	2.67 3.57 6.47
8	0.10 0.05 0.01	3.46 5.32 11.3	3.11 4.46 8.65	2.92 4.07 7.59	2.81 3.84 7.01	2.73 3.69 6.63	2.67 3.58 6.37	2.62 3.50 6.18	2.59 3.44 6.03	2.56 3.39 5.91	2.54 3.35 5.81	2.52 3.31 5.73	2.50 3.28 5.67
9	0.10 0.05 0.01	3.36 5.12 10.6	3.01 4.26 8.02	2.81 3.86 6.99	2.69 3.63 6.42	2.61 3.48 6.06	2.55 3.37 5.80	2.51 3.29 5.61	2.47 3.23 5.47	2.44 3.18 5.35	2.42 3.14 5.26	2.40 3.10 5.18	2.38 3.07 5.11
10	0.10 0.05 0.01	3.29 4.96 10.0	2.92 4.10 7.56	2.73 3.71 6.55	2.61 3.48 5.99	2.52 3.33 5.64	2.46 3.22 5.39	2.41 3.14 5.20	2.38 3.07 5.06	2.35 3.02 4.94	2.23 2.98 4.85	2.30 2.94 4.77	2.28 2.91 4.71

(Continued)

Table E.1 (Continued)

DF for Numerator		DF for Number											
	X	1	2	3	4	5	6	7	8	9	10	11	12
11	0.10	3.23	2.86	2.66	2.54	2.45	2.39	2.34	2.30	2.27	2.25	2.23	2.21
	0.05	4.84	3.98	3.59	3.36	3.20	3.09	30.1	2.95	2.90	2.85	2.82	2.79
	0.01	9.65	7.21	6.22	5.67	5.32	5.07	4.89	4.74	4.63	4.54	4.46	4.40
12	0.10	3.18	2.81	2.61	2.48	2.39	2.33	2.28	2.24	2.21	2.19	2.17	2.15
	0.05	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.72	2.69
	0.01	9.33	6.93	5.95	5.41	5.06	4.82	4.64	4.50	4.39	4.30	4.22	4.16
13	0.10	3.14	2.76	2.56	2.43	2.35	2.28	2.23	2.20	2.16	2.14	2.12	2.10
	0.05	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.63	2.60
	0.01	9.07	6.70	5.74	5.21	4.86	4.62	4.44	4.30	4.19	4.10	4.02	3.96
14	0.10	3.10	2.73	2.52	2.39	2.31	2.24	2.19	2.15	2.12	2.10	2.08	2.05
	0.05	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.57	2.53
	0.01	8.86	6.51	5.56	5.04	4.69	4.46	4.28	4.14	4.03	3.94	3.86	3.80
15	0.10	3.07	2.70	2.49	2.36	2.27	2.21	2.16	2.12	2.09	2.06	2.04	2.02
	0.05	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.51	2.48
	0.01	8.68	6.36	5.42	4.89	4.56	4.32	4.14	4.00	3.89	3.80	3.73	3.67
16	0.10	3.05	2.67	2.46	2.33	2.24	2.18	2.13	2.09	2.05	2.02	2.01	1.99
	0.05	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.46	2.42
	0.01	8.53	6.23	5.29	4.77	4.44	4.20	4.03	3.89	3.78	3.69	3.62	3.55

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