
UNIT 15 RESEARCH DESIGN

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15.0 OBJECTIVES

After reading this Unit, you will be able to:

- understand the concept of research design;
- comprehend its need and purpose;
- know its types; and
- apply appropriate design for research to be undertaken by you.

15.1 INTRODUCTION

Research is a systematic effort towards unraveling the mysteries surrounding us. It involves putting in persistent efforts to know the unknown. In doing so, we start from where we are, what is our present state of knowledge? We tend to interpret this present state by studying the work done by others in the field. We have used the word systematic to characterise research. There are reasons for that; there is a specific purpose while carrying out research; the effort required is monumental in view of the fact that a comprehensive study of what has already been known about it has to be understood. It has to be continued further, from conception to observation to analysis to interpretation and finally reporting, which involves considerable intellectual efforts. Robson has characterised research as systematic, skeptic, and ethic. By systematic, he means that we should be clear about what we are doing, why we are doing, and how we are doing. By skepticism he conveys that the researcher should check, cross-check, and verify his/her views before finalizing them. Researcher should not violate ethics while conducting research, whether it is conceptualisation of topic, data collection, analysis or presentation of results. Research is of two types, viz., pure and applied. The trend today is towards applied research. That is not to belittle pure research, as both are complimentary to each other. Pure research is done to improve upon our existing state

of knowledge. Applied research is done to find out new knowledge to be put into application. It is carried out with an aim of developing something better for the benefit of the society.

We have seen that research needs to be organised and systematic. Research Design is a step towards carrying out research in a planned way. In this Unit, we shall study about what is research design and what is its purpose. We shall also discuss the factors affecting research design and the types of research design.

15.2 WHAT IS RESEARCH DESIGN?

Research is an important activity affecting the society as a whole therefore, it involves a lot of decision making. Research design also involves a lot of decision - making. It provides a structure and shape to your research project. After finalising your topic, you decide about how you are going to conduct your study. It involves formulation of strategy for all the stages starting from formulation of hypotheses to the analysis of data. Kerlinger defines research design as a plan, structure, and strategy of investigation so conceived as to obtain answers to research questions or problems. The plan is the complete scheme or programme of research. It includes an outline of what the investigator will do from writing the hypotheses and their operational implications to the final analysis of data. Thyer has defined research design as a blueprint or detailed plan for a research study - starting from operationalising variables so that they can be measured, to selecting a sample of interest to study, collecting data to be used as a basis for testing hypotheses, and finally analysing the results. Thus, we can conclude that research design provides us a base on which we conduct our research.

15.3 NEED AND PURPOSE

Research is a systematic endeavour towards quest for new knowledge. The word systematic is important and needs clarification. Studying informally and casually may also yield new knowledge but that is not research. In research, organised efforts are put right from thinking of a topic to the presentation of results. The magnitude of the study and the efforts involved require systematisation. Research also involves spending public money therefore, it requires proper planning for effectiveness and efficiency. The methods and techniques involved in data collection and analysis may involve subjectivity. Adequate planning needs to be done to minimise this subjectivity. Validity is another important issue for which a proper design is required. Validity ensures that what we are measuring is what we intend to measure.

The purpose of a research design is to provide information regarding:

- What is the study?
- Why is the study being carried out?
- Where will the study be carried out?
- How will the study be carried out?
- What will be the processes and tasks involved?
- What will be the data?
- How will the data be collected?
- What methods of sampling will be used? and
- How will the analysis be done?

15.4 FUNCTIONS

The functions of a research design are to:

- Provide a plan to undertake systematic study and help to provide procedures to undertake the research work; and
- Ensure objective, valid, and economic undertaking of the study.

Research design enables the researcher to put his study on a sound scientific footing. He is able to decide in advance the what, why, and how of his study. It acts as a guide to conduct the various steps of his/her study in an objective, valid, and economic way.

Self Check Exercise

- 1) Define research design. Discuss its need and purpose.

Note: i) Write your answer in the space given below.

- ii) Check your answer with the answers given at the end of the Unit.

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15.5 TYPES

There are different types of research design. Which one is the best for your study, depends on the purpose and scope of your study. While taking decisions on the research design, a number of factors have to be taken into consideration. These include: Nature of investigation, Data collection methods, Number of contacts made with the subjects, and the Period of reference of your study.

Nature of Investigation:

- Exploratory;
- Descriptive;
- Experimental;
- Semi or Quasi- experimental;
- Non- experimental; and
- Field research.

Data Collection Methods:

- Survey;
- Case studies; and
- Content analysis;

Number of Contacts made with the Subjects:

- Cross-sectional;
- Before- and- after; and

- Longitudinal

- Retrospective;
- Prospective; and
- Retrospective - Prospective.

15.5.1 Based on Nature of Investigation

The nature of investigation can be exploratory, descriptive, causal/experimental, semi or quasi- experimental, non-experimental, and field research. Exploration is an important characteristic of research. Any research begins with it when the researcher dives into the unknown and unsolved terrains. He/She starts with a quest for knowing more through exploration. It is an initial foray into the densities of the unknown. Exploration starts with a vague idea of what is intended to be researched. It forms the basis of research. It is not very systematic to the order of research to be undertaken otherwise. It is a flexible approach to undertaking research where the sampling is generally non-probability and the data collection methods are unstructured. It involves a study and analysis of the literature and discussions with peers and fellow colleagues to know their views on the topic.

Descriptive research is carried out to provide information about a person, thing or process. It describes the characteristics of an individual, group, organisation, or phenomena, conditions, or a situation. The characteristics are described in terms of the dependent variables. Description may be limited to events of past or present but not of the future. In that case it becomes experimental research. Most of the research in social sciences is descriptive in nature. Some examples of descriptive research in LIS are:

- Services, collection, and infrastructure of a particular library
- Status of libraries in a geographical area
- Impact of library services on the performance of students
- Impact of IT on library services
- Attitude of users towards staff in libraries

In descriptive studies data collection is done through structured methods. Samples are selected by random sampling.

The nature of investigation moves systematically from exploratory towards experimental. The degree of investigation goes on increasing as we move ahead. Casual investigation in exploration, to description and finally causal investigation in experimental research. It aims to find cause and effect relations between the dependent and independent variables. Experimental research studies the effect of independent variables on dependent variables. The researcher identifies the two different kinds of variables and the relationship between them. For this, he/she reviews the literature on the subject and also related studies done by others. Discussions with peers and other professionals also help in finding out the relationship. Hypotheses are framed for verifying the relationships. The research is conducted under controlled conditions so that the changes in the dependent variables can be attributed solely to the changes in the independent variables.

Semi - experimental studies are different from experimental studies in that the sampling in experimental studies is random sampling compared to non - random sampling in semi - experimental or quasi-experimental studies.

Non - experimental studies also find out causal relations but they follow the reverse approach. Experimental studies explain the cause - effect relation by identifying the independent variables and later inducing changes in them to find out the resultant effect on the dependent variables. Non- experimental studies ascribe the changes that have

Research Process

taken place in the dependent variables to some independent variables. They do not induce changes in the independent variables to see the effect on dependent variables. This is generally done in the social sciences and the reason for doing so is the population that are human beings compared to physical and chemical entities in sciences. Let us consider an example to clarify the difference. We want to see the effect of use of IT in the classroom on the performance of students. In experimental studies, we would take use of IT in the classroom as the independent variable and the results of students as dependent variable. We would compare the scores of students after introduction of IT to the scores obtained by them earlier and find out the relation. In non-experimental study, we would check the scores of students after IT has been introduced and find out the relation between them by studying the coefficient of correlation. Let us take another example to understand the difference, where we are studying the effect of OPAC on the use of catalogue. We would divide the users randomly into two groups. One group of users is provided the facilities of a traditional catalogue for access to the literature. The other group is provided the facility of an OPAC to access the literature. We would measure the use of catalogue in the two cases and ascribe the difference to OPAC.

Field research is done in the natural surroundings in real life situations. Here the main criterion is doing research in social settings rather than on the techniques of research. Let us discuss some observations on field research:

“Field research is the design, planning and management of scientific investigations in real-life settings” (Fielder)

Kaplan comments that Field research involves direct or indirect observation of behaviour in the circumstances in which it occurs without any significant intervention on the part of the observer. We can conclude that field research is conducted in real life settings without any modifications done to the settings. There is little stress that the techniques applied are scientific. Importance is given to the fact that the observer collects data while being on the site along with those observed. He is trained to be part of the observed group and objective in recording the observations. Such research is carried out particularly in subjects like sociology or social work. Field studies have been divided into field research and field experiments. Field experiments are different from field research in that the former involve studying the effect of varying independent variables on dependent variables in real life natural settings. The difference between experimental research and field experiment is that the former are conducted in laboratory settings whereas the latter are conducted in natural settings. Thus, the control in the observations is not possible in field experiments, which is possible in laboratory experiments.

Self Check Exercise

- 2) Enumerate the different kinds of designs based on the nature of investigation. Describe the descriptive design.

Note: i) Write your answer in the space given below.

- ii) Check your answer with the answers given at the end of the Unit.

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15.5.2 Based on Data Collection Methods

Research Design

Research design based on data collection methods is of the following types: survey, case studies, and content analysis. Survey approach is used on a large population. But instead of studying the whole of population, a sample is studied. The sample is generally large in size. It is generally used in descriptive studies, however it can also be used in experimental studies. The techniques of data collection used are questionnaire and interviews. Questionnaire can be self-administered or mailed. It can be structured or otherwise. In social science research, survey method is generally used.

Case study involves studying few cases in contrast to the large sample in survey. But the level of study in case study is intensive which is not true of survey. Example of a case study can be “Automation in University Libraries of North India: A Case Study of University Libraries of Kurukshetra, Punjab, and Jammu”. The study involves taking a sample and studying that in detail. This would enable the researcher to study automation in detail in these libraries than if the study would have taken all University libraries of North India. But the question is whether we can generalise the results of the study and conclude for the whole of North India.

Content analysis is another type of data collection method where the data is collected from documentary sources. In this method the contents of documents are analysed to arrive at a conclusion. This is a method used and particularly useful in historical research. It enables to study the events in present that have taken place in the past. It is only documents like diaries, autobiographies, archival documents that can act as the source of data. Content analysis can be done quantitatively as well as qualitatively. Quantitative analysis involves counting of words or phrases. Qualitative analysis involves analysing documents to find out the ideas behind words.

Self Check Exercise

- 3) Define survey approach to data collection. Differentiate between survey and case study method.

Note: i) Write your answer in the space given below.
ii) Check your answer with the answers given at the end of the Unit.

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15.5.3 Based on Number of Contacts made with the Subjects

Based on the number of contacts made with the subjects, research studies are: cross-sectional, before- and- after, and, longitudinal. Cross-sectional studies are case studies that involve studying a phenomenon at one point in time. These are also called one-shot studies. Examples of these could be:

- Attitudes of users towards use of IT in libraries
- Status of LIS education in India
- Continuing education for librarians in India

Research Projects are simple to undertake as they involve contact only once with the population. They have a drawback that they are not suitable for measuring change.

Before-and- after study design tries to overcome the disadvantage of cross-sectional studies by taking the observation twice. The observation is done before introducing a change in the independent variable and after introducing a change in the independent variable. Thus, we are able to measure change in the variables over a period of time. Examples of the before and after design are:

- Impact on users of the use of IT in libraries.
- Attitudes of users towards use of IT in libraries before and after automation.

In the above two examples, observations are made twice, before and after introduction of IT in libraries. It enables to measure change, which is not possible in cross- sectional studies.

Longitudinal design tries to overcome the disadvantage of the before-and- after study design. It is able to measure the pattern of change in the dependent variables over a period of time. A number of observations are taken over a population after regular intervals of time, which may vary from a week to even more than a year. In the above two examples, if observations are made over a period of time to know the pattern of impact on users at different stages of automation, the design is called longitudinal design.

15.5.4 Based on Reference Period

Based on the period of reference of study, research design has been divided into: retrospective, prospective, and, retrospective- prospective. Retrospective studies study a phenomenon, event, or situation that has happened in the past. Data is collected on the basis of documentary evidence or the respondents' recall of the situation. Some examples of retrospective studies are:

- Libraries in Ancient India.
- Devastation caused by floods to libraries in the 20th century.
- Employment scenario among LIS Professionals in 1990s.

Prospective studies try to predict situations that have yet to take place. They attempt to foresee the future. The studies are concerned with studying the future of a concept, object, organisation, or even attitudes of people. These are experimental in nature. Examples of some such studies are:

- Libraries of the future: How will they exist.
- Prospects of digital libraries in India.
- Effect of RFID technology on pilferage of books in college libraries.
- Image of IT savvy librarians.

Retrospective- Prospective studies are concerned with the events or phenomena that has happened in the past and predict it for the future. These are like before-after studies with the difference that there is no control group here. The dependent variable is observed before and after variation in independent variable on the same population. Some examples of such studies are:

- Impact of automation on the use of libraries.
- Change in attitude of users towards staff after library orientation.
- Rate of use of helmets by people after heavy fines were imposed by traffic police.
- Effect of advertisement on billboards on the sale of cars in metropolitan cities of India.

The plan of research from the point of operationalisation of hypotheses to the analysis of data is presented as research design. The research design is the blueprint of your nature of investigation, data collection methods to be used, number of contacts to be made with the subjects, and the reference period of study. Broadly your nature of investigation can be either exploratory, or descriptive, or experimental. It depends upon your topic which one you choose. A study can adopt more than one also. For example, any research starts with an exploratory investigation where you tend to explore your topic. It is a stage where you tend to formulate your topic based on the review of literature and discussion with others in the field. The research here does not rigidly follow research methodology. The data collection methods also do not follow strictly probability sampling. As in social sciences, in library science also descriptive methods of research is followed. It describes the situation of an object, phenomenon, or a process or an event in the past or present. If it does in the future it becomes experimental research. If our topic of research is: "Impact of automation on the services of academic libraries in India" it has to be descriptive research. Similarly you have to describe the data collection design. Whether it will be survey, or case study, or content analysis. It will be survey in case of the topic, Impact of automation on the services of academic libraries in India". A mention of the number of contacts to be made with the subjects and period of reference also needs to be made here.

In the research design you should also mention the population under study clearly. Describe the data that you intend to collect in terms of the dependent and independent variables. Then you also need to clarify whether you will collect data from the whole of the population or from only a sample. If it has to be a sample study, you need to specify what methods of sampling would be used. Whether it would be probability sampling or non- probability sampling. Within probability and non- probability sampling also state which type of sampling method would be used. The size of the sample should be mentioned here. Next in the research design, the researcher should mention the techniques and tools of data collection. In the techniques, he/she should mention, whether it would be observation, questioning, or interview. What tools of data collection would be used, questionnaire (mailed or self- administered), interview schedule, etc. The research design should also state when and where will the data collection be done.

Data collection tools are the base on which the results of the study depend upon. If the data is not truly representative of the variables, it has a direct effect on the results. Validity and reliability of the tools are therefore measured before they are used. Let us define these concepts. Validity of a tool refers to the fact that we are measuring what we intend to measure. Smith has defined it "... as the degree to which the researcher has measured what he has set out to measure." The next question is how to measure the validity of an instrument. One is by observation and analysis and the other is statistically. Experts and peers can do observation.

Validity is of different kinds, viz., Face, Content, Construct, Predictive, and Concurrent Validity. Face validity, as the name implies measures the validity as seen on its face. It is observed and assessed by the observer on the basis of his experience of the subject. Content validity is also measured in the same way when the expert ensures that all the aspects of the subject have been covered in the instrument. Construct validity is an extension of content validity. It analyses the different constructs that contribute to the formation of a concept that the researcher intends to measure. While measuring the construct validity, it is checked whether all the constructs have due representation in the instrument. Let us discuss by taking an example. We are measuring the professional competencies of librarians and construct a scale for that. While ensuring the construct validity, we should check whether all the constructs of competencies, viz., knowledge, skills, and attitudes have been covered in the scale or not. Predictive validity refers to

Research Process which we can predict a measure of the dependent variables. In the above example of Professional competencies of the librarians, we can measure the predictive validity by verifying how far the competencies measured through the instrument match their actual competencies demonstrated through their work. Concurrent validity refers to how far the observations regarding the dependent variables tally at different times.

Reliability is another important characteristic of the instruments that need to be verified before it is used to measure the variables. Reliability is the degree to which we can repeat the results of the observations at different times in the same conditions. The more the degree of correlation between the two results, the more the reliability. The reliability can be increased by making sure that: language used is simple, clear, unambiguous, and precise. There are different methods to increase the reliability, e.g., test- retest. Here we administer the instrument to the subjects again and check the correlation as a ratio of the results. If the ratio of the results of the two observations is unity, it is the ideal situation, i.e., 100% reliability. The less this ratio, the less the reliability. Another method to ensure reliability is to do parallel test where we design two similar instruments and divide the population in two groups and administer one instrument each to the groups. Later we correlate the results of the two to measure the reliability. Split – half technique is another method to increase the reliability of the instrument. Here we divide the questions into two parts. The parts contain questions to cross-check the responses of the subjects on the same issues. Their correlation enables the researcher to measure the reliability of the instrument.

After the data collection methods are discussed, the methods of its presentation and analysis should be described. Here a mention should be made of the types of tables and graphs that you intend to use to present your data. Also explain how you would analyse your data. What statistics do you intend to use? If you plan to do the analysis using some software package like SPSS, MS-Access, or MS-Excel, etc. mention in the design.

Self Check Exercise

- 4) Define content analysis as a method of research design for data collection.
- 5) Enumerate the different kinds of validity. How would you measure content validity of an instrument?

Note: i) Write your answers in the space given below.

- ii) Check your answers with the answers given at the end of the Unit.

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15.6 SUMMARY

In this Unit, we discussed the concept of research design. Research design is the blueprint of your research work. After a discussion of the need and purpose, its functions are discussed. There are different kinds of research designs based on a number of factors. You have to choose one depending upon the purpose of your research work. All these have been explained in the Unit with examples.

15.7 ANSWERS TO SELF CHECK EXERCISES

1) Research design is a plan, structure, and strategy of investigation so conceived as to obtain answers to research questions or problems. It is a blueprint or detailed plan for a research study - starting from operationalising variables so that they can be measured, to selecting a sample of interest to study, collecting data to be used as a basis for testing hypotheses, and finally analyzing the results. Research is a systematic and organised effort towards quest for new knowledge. It involves spending public money and thus accountability towards them. Thus, it needs to have a well thought of research design.

2) The different kinds of designs based on the nature of investigation are:

- Exploratory;
- Descriptive;
- Experimental;
- Semi or Quasi- experimental;
- Non- experimental; and
- Field Research

Descriptive research is carried out to provide information about a person, thing or process. It describes the characteristics of an individual, group, organisation, or phenomena, conditions, or a situation. The characteristics are described in terms of the dependent variables. Description may be limited to events of past or present but not of the future. In that case it becomes experimental research. Most of the research in social sciences is descriptive in nature.

3) Survey approach is one of the approaches of research based on the method of data collection. It is generally done on a large population. But instead of studying the whole of population, a sample is studied. It is used in descriptive studies, however it can also be used in experimental studies. The techniques of data collection used are questionnaire and interviews. It is one of the most used methods in social sciences. It is different from case study in that the size of the population is small in case study method. In case study the level of study done is intensive compared to survey method.

4) In content analysis, documents are analysed to collect data. This is a method used and particularly useful in historical research. It enables to study the events in present that have taken place in the past. It is only documents like diaries, autobiographies, archival documents that can act as the source of data. Content analysis can be done quantitatively as well as qualitatively. Quantitative analysis involves counting of words or phrases. Qualitative analysis involves analysing documents to find out the ideas behind words.

5) Face, Content, Construct, Predictive, and Concurrent Validity. Content validity is measured on the basis of views of experienced people in the subject/area by observation and assessment of the tool.

15.8 KEYWORDS

Descriptive Studies : Research studies that are carried out to describe an object, phenomena, process, or organisation in the present.

Experimental Studies : Research studies that are undertaken to study cause and effect relations between variables are called experimental studies.

Reliability	: The measure of being able to measure the variables with the same accuracy at different times under similar conditions refer to reliability.
Research Design	: The strategy that a researcher adopts to undertake his/her research. It concerns the operationalisation of hypothesis, data collection, and data analysis.
Content Analysis	: It is a method of data collection for studying events that have taken place in the past on the basis of literature.
Validity	: Validity is a measure of the extent of what you are measuring is what you intend to measure.

15.9 REFERENCES AND FURTHER READING

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UNIT 16 RESEARCH PLAN

Structure

- 16.0 Objectives
- 16.1 Introduction
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- 16.4 Functions
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- 16.6 Structure
 - 16.6.1 Title
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- 16.8 Monitoring
- 16.9 Ethics
- 16.10 Summary
- 16.11 Answers to Self Check Exercises
- 16.12 Keywords
- 16.13 References and Further Reading

16.0 OBJECTIVES

After reading this Unit, you will be able to:

- know what is a research plan;
- appreciate its need and purpose;
- understand its functions;
- know its different types and structure;
- comprehend the tools and techniques used in a plan; and
- prepare a research plan.

16.1 INTRODUCTION

We have discussed in Unit 15 on Research Design, the importance of organisation and planning in research. Research design involves formulating a strategy for your research. There are a number of factors involved while taking a decision in this regard. Once you

have formulated a research design, the next step is to prepare a research plan. As with a research design, research plan also gives your research a sound footing. This Unit is devoted to a discussion of the different aspects of research plan in detail.

16.2 DEFINITION

Research plan has been used synonymously with proposal and synopsis. They refer to a blue print of your research. Both are used for documents that describe in detail:

- What are you going to do?
- Why are you going to do?
- How are you going to do?
- In what resources (time, money, infrastructure, etc.) are you going to do?
- What are you not going to do?

A research proposal is thus, a document to your plans and ideas of carrying out your research. You may be wondering, how is it different from research design? Research design is also a strategy of how you are going to conduct your research. But it precedes research plan. Research design is a plan of the technical decisions regarding the what, why, and how of your research. Here we take decisions regarding the nature of investigation, data collection methods to be adopted, and number of contacts to be made with the subjects, and the period of reference with the subjects of study. Research plan can be formulated only when research design has been decided. In fact, research design helps to formulate research plan. It is the document that describes all the decisions that have been taken in the design stage plus the administrative decisions concerned with your research. It presents systematically everything starting with the title of your project to the tentative structure of your thesis.

16.3 NEED AND PURPOSE

As stated earlier, we repeat that research is a systematic endeavour towards quest for new knowledge. There is a role of intuition also in research but a systematic step-by-step approach needs to be followed in research. Studying informally and casually may also yield new knowledge but that is not research. In research, organised efforts need to be put right from thinking of a topic to the presentation of results. Research is a long journey from knowing and understanding the present state of knowledge in a particular field to exploring raw areas where additions and improvements can be done and finally making those improvements. It is a project, which involves investment of considerable resources. And thus, needs planning as a proposal.

The purpose of a research plan is to:

- present for him the proposed plan of action;
- present for the supervisor and other authorities also the plan of action for their approval;

The purpose of a research design is to provide information regarding:

- What is the study?
- Why is the study being carried out?
- Where will the study be carried out?

- How will the study be carried out?
- What will be the processes and tasks involved?
- What will be the data?
- How will the data be collected?
- What methods of sampling will be used?
- How will the analysis be done?

16.4 FUNCTIONS

The functions of a research plan are to:

- give directions on what needs to be done, when and how and in what order;
- provide a route from stating the topic to finalising the results;
- enable to evaluate your progress during research;
- define your topic to limit its scope; and
- prove to your supervisor that you have gone into the fine details of your topic and will be able to conduct research.

Self Check Exercise

1) Define research plan. How is it different from a research design?

Note: i) Write your answer in the space given below.

ii) Check your answer with the answers given at the end of the Unit.

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16.5 TYPES

There are two types of research plans. These are: quantitative and qualitative proposals. Quantitative proposal is given for experimental and descriptive research whereas qualitative proposal is given for descriptive and exploratory research. Though, there is no hard line of demarcation, generally qualitative research doesn't have hypothesis and operationalisation of concepts. Operationalisation of concepts refers to giving operational definitions, finding out the independent and dependent variables, sample selection, and finalising the measuring instruments and their reliability and validity. Instead the qualitative proposal will have research procedures which quantitative research doesn't have.

16.6 STRUCTURE

A research proposal is presented in the following structure:

16.6.1 Title

The title of your study (dissertation or project) is the first part of your plan. We should ensure that the title is self-explanatory. It should convey what we intend to do. There should be no ambiguity. It should be clear, precise, and grammatically correct. It should

not be broad or more specific than what we plan to study in the research. If we wish to study the impact of personality development programmes on the tackling of users by staff, then the topic could be: Handling of users by staff in libraries: Impact of personality development programmes.

16.6.2 Introduction

The introduction provides background information to the topic of your study. It includes a thorough review of what is available related to your area of study. Try to clarify the conceptual area zeroing down towards the topic. Ranjit Kumar enumerates the following list of the aspects to be covered in the introduction:

- An overview of the main area of study;
- A historical perspective (development, growth, etc.) pertinent to the area of study;
- Philosophical or ideological issues related to the topic;
- Trends in terms of prevalence, if appropriate;
- Major theories, if any;
- The main issues, problems and advances in the subject area under study;
- Important theoretical and practical issues relating to the central problem under study; and
- The main findings related to the core issue(s).

Let us clarify with an example. If the topic of study is, “Impact of automation on the services of academic libraries in India”. The introduction should discuss:

- Brief discussion on the concept and history of automation;
- Attempts at automation of libraries in India;
- Trends of automation of academic libraries in India; and
- Impact of automation on libraries and their services.

16.6.3 The Problem

Introduction and the problem could be visualised as occurring together in continuation as background to the study. The difference is that introduction is more general as compared to the problem. The problem starts with where introduction has left the topic. It is continuation of introduction, focusing specifically on the topic. Why have you chosen the topic? Is there any need to conduct such studies? What is the rationale of your topic? What gaps in the existing knowledge does it intend to fill? Ranjit Kumar enumerates the following issues that need to be discussed in the problem:

- Identify the issues that are the basis of your study;
- Specify the various aspects of/perspectives on these issues;
- Identify the main gaps in the existing body of knowledge;
- Raise some of the main research questions that you want to answer through your study;
- Identify what knowledge is available concerning your questions, specifying difference of opinion in the literature regarding these questions if differences exist; and
- Develop a rationale for your study with particular reference to how your study will fill the identified gaps.

Let us discuss what needs to be discussed in the problem if our topic of research is:

“Impact of automation on the services of academic libraries in India”. It should include the following based on a review of literature:

- categorise the different kinds of services and the impact of automation on them;
- discuss the views and theories propounded by experts in this regard;
- present case studies of attempts by professionals towards studying impact of automation on services;
- separate the impact on service providers and users;
- bring to light issues that remain to be studied or point towards a need for more investigation; and
- state the relevance of your study, why is it needed, how is it going to fill the gaps, if anything exists. If such studies have already been conducted, you could justify the need for your study if some aspects have not been studied, or some issues have cropped up from earlier studies, or your study is being conducted in a new environment or conditions, or it is a longitudinal study. You would recall, we have discussed about longitudinal studies in Unit 15 on Research Design. These are studies conducted again on the same population after a gap of time to know the change in dependent variables over a period of time. It helps to provide a pattern of change in the dependent variable.

16.6.4 Scope

After the problem has been stated, it is important to explain its scope also. In the scope one should indicate to what extent one intends to probe the topic. He should clarify the scope as far as the subject content is concerned as well as the geographical area is concerned. There should also be a submission of the scope regarding the coverage of the time period. The scope must give an indication of the limitations of the topic.

Self Check Exercise

2) Describe what would you discuss in the introduction to the plan of your Study.

Note: i) Write your answer in the space given below.

ii) Check your answer with the answers given at the end of the Unit.

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16.6.5 Objectives

After the problem, the plan should state the objectives of your study. This is one of the most important parts of your plan. It helps to know what you intend to do. Anyone interested in your study gets to know the whole picture from just the objectives. You can very well judge the importance of objectives. Therefore, it is important that they are stated in a crisp language so that are clear and unambiguous. Moreover, they should convey what is the intended outcome of your study. Where do you reach to when you

start from here? For that you need to use action verbs like: to know, to find out, to evaluate, to automate, to design, etc. Another thing to be borne in mind while stating objectives is that they should not be broad. One should clearly make out the intentions of one's study that could help him/her or even you while evaluating. It is a pointer to measure how far you have succeeded in your project. Let us discuss the same example again, "Impact of automation on the services of academic libraries in India". The objectives of the study could be stated as to study the impact of automation on:

- Change in the form of services;
- Any new services introduced;
- The service providers;
- The frequency of use of services; and
- Ease of use of services.

Self Check Exercise

3) Taking a hypothetical example, state the objectives of your study.

Note: i) Write your answer in the space given below.

ii) Check your answer with the answers given at the end of the Unit.

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16.6.6 Hypotheses

The next section of your plan should be devoted to hypotheses. Hypothesis is an assumption, presumption, or in simple words guess towards some situation or condition. It is an assumption of relationships between the dependent and independent variables. Hypotheses provide the researcher a line of action along which he/she moves to find out answers to the problem he/she is working on. It is not necessary that every research study has a hypothesis.

Though we have stated that hypotheses formulation involves guess that does not mean there is no base to it. It involves a thorough review of literature to understand the concept and the relationships existing between the various variables existing. It is on the basis of this review and discussion with peers and others in the field that we propose a relationship between the variables. This is tested during the course of study. It is pertinent to recall what we have studied in the earlier units, that hypotheses if proved true later results into theories and finally into laws.

There are two kinds of hypotheses, null and alternative. Hypothesis is stated as null hypothesis, which is a negative statement. We state the relations expected between the variables in a negative way, e.g., if we expect that automation has resulted in increased use of library services. We would frame the null hypothesis as:

HO = There is no increase in use of library services due to their automation. The alternative hypothesis would then be:

H1 = There is increase in use of library services due to library automation

Thus, if null hypothesis is proved to be false, the alternative hypothesis is proved to be true.

16.6.7 Review of Related Literature

After the hypotheses are stated, a brief review of literature is presented. It helps the researcher to know and assimilate what others have already done in the field. It gives him the direction of movement into his research. He comes to know the ripe areas for research. Whenever we plan to research, we have to start from somewhere, which we come to know by literature review. Literature review is conducted at two different stages of research work. This is the first stage when it is a brief review of related literature. It is done again after the proposal is approved and the study is conducted. Later the scope of review of literature is greater covering all aspects and a period of coverage is decided which depends on the subject and topic of study.

Self Check Exercise

4) Define hypothesis. Differentiate between null and alternative hypothesis.

Note: i) Write your answer in the space given below.

ii) Check your answer with the answers given at the end of the Unit.

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16.6.8 Research Design

The plan of research from the point of operationalisation of hypotheses to the analysis of data is presented as research design. The research design is the blueprint of your nature of investigation, data collection methods to be used, number of contacts to be made with the subjects, and the reference period of study. Broadly your nature of investigation can be either exploratory, or descriptive, or experimental. It depends upon your topic which one you choose. A study can adopt more than one also. For example, any research starts with an exploratory investigation where you tend to explore your topic. It is a stage where you tend to formulate your topic based on the review of literature and discussion with others in the field. The research here does not rigidly follow research methodology. The data collection methods also do not follow strictly probability sampling. As in social sciences, in library science also descriptive methods of research are followed. It describes the situation of a n object, phenomenon, or a process or an event in the past or present. If it does in the future it becomes experimental research. If our topic of research is: “Impact of automation on the services of academic libraries in India” it has to be descriptive research. Similarly you have to describe the data collection design, whether it will be survey, or case study, or content analysis. It will be survey in case of the topic, “Impact of automation on the services of academic libraries in India”. A mention of the number of contacts to be made with the subjects and period of reference also needs to be made here.

In the research design you should also mention the population under study clearly. Describe the data that you intend to collect in terms of the dependent and independent variables. Then you also need to clarify whether you will collect data from the whole of the population or from only a sample. If it has to be a sample study, you need to specify what methods of sampling would be used. Whether it would be probability sampling or non- probability sampling. Within probability and non- probability sampling

also state which type of sampling method would be used. The size of the sample should be mentioned here. Next in the research design, the researcher should mention the techniques and tools of data collection. In the techniques, he/she should mention, whether it would be observation, questioning, or interview. What tools of data collection would be used, questionnaire (mailed or self-administered), interview schedule, etc. The research design should also state when and where the data collection will be done.

After the data collection methods are discussed, the methods of its presentation and analysis should be described. Here a mention should be made of the types of tables and graphs that you intend to use to present your data. Also explain how you would analyse your data. What statistics do you intend to use? If you plan to do the analysis using some software package like SPSS, MS-Access, or MS-Excel, etc. mention in the design.

16.6.9 Tentative Chapterisation

The physical structure of the research report is also presented in the research plan as tentative chapterisation. What will be the chapters in your thesis are presented here. Normally, the final report also contains the chapters: Introduction, which comprises the introduction, the problem, scope, objectives, hypothesis, limitations, and operational definitions. The other chapters are review of literature, conceptual structure, research design, data collection, analysis of data, discussion, and conclusion.

16.6.10 Limitations

Every research study has limitations. These could be from the point of view of the contents (coverage of the subject), geographical area, time period of study, etc. The researcher should very earnestly admit the limitations in his/her study. This is no drawback for the study. The limitations vary according to the level of study and that of the researcher. If the limitations are presented, the evaluation of the thesis is done keeping in view of these.

16.6.11 Operational Definitions

The research like any other work has to deal with vocabulary. We know the nature of any language is such that there is a lot of flexibility. The occurrence of synonyms, homonyms, and other such concepts may result in confusion. Thus, in the beginning itself, terms that are to be used are standardised in the form of operational definitions given in the research plan.

16.7 FUNDING

Research involves financial investment. The researcher can get support for this investment from different agencies. In India, these agencies are University Grants Commission, Council of Scientific and Industrial Research, Indian Council of Agricultural Research, Indian Council of Medical Research, Indian Council of Social Science Research, etc. Researchers in library and information science can get their research proposals funded from any of these agencies depending upon their area of study.

Why should an agency fund for your research? It would fund:

- to encourage you to do research;
- research adds to the intellectual wealth of a nation; and
- your research topic lies within the scope of the institution and would be beneficial for it

The research plan in case of a research for funding should also submit a financial estimate. The financial estimate should be presented under different heads, i.e., the purpose for which you are asking for grants. These may be:

- space/rooms;
- equipment;
- books/ journals;
- stationary;
- travel; and
- publishing.

The agency may provide grants for some or even all of these expenses. As far as publishing is concerned this grant is provided after the completion of the project/ theses.

16.8 MONITORING

Monitoring is an important component of research like any other project. Research plan should also indicate your plans to monitor your research work. You need to apply time management and prepare a work plan to be submitted along with your research plan. The work plan should indicate when (month and year) would you:

- start your research;
- review related literature;
- prepare data collection instruments;
- collect data;
- do coding of data;
- do statistical analysis of data;
- prepare draft of your report; and
- finally submit report.

It is not possible to follow the time schedule exactly as specified. It is a plan therefore there may be some fluctuations here and there. It is important while planning to make adjustments for any possible disturbances in the time schedule. Monitoring should be done regularly to avoid any delays in fulfilling the schedule. The researcher should be regular in his/her work and subdivide his plan into short time plans. He/She should translate the plan into tasks to be undertaken everyday. And should evaluate his/her days work to focus the cause of delays and overcome the reasons of delay. In case of academic research for the award of degrees the progress report is to be submitted quarterly or half- yearly approved by the supervisor to be submitted to the authorities. Similarly the progress report has also to be submitted to the funding authorities to prove accountability.

16.9 ETHICS

Researcher should follow a code of ethics in research. We need not overemphasise that it is important in research as in any other activity. Following ethics in work implies doing the work in the right way. Right way implies that it is done in a way acceptable to the society. Ethics has been used interchangeably with morals. Ethics is concerned with what one ought to do.

To analyse and make it convenient to understand Chris Hart divides the ethical issues in research as those concerned with:

- Research;
- Researcher;
- Subjects; and
- Sponsoring Body/ University.

While doing the right things the researcher should understand that the above four are the parties affected which should not suffer through your decisions while doing research. Let us discuss by way of examples the areas where ethics have to be taken into consideration:

State the topic in an unambiguous way. It should not be the topic of some other study. The research should add to the repertoire of knowledge. Acknowledge the works of others that have been used in the research. Plagiarism should not be resorted to. Ask for financial grants only where required for research. In data collection the anonymity of the subjects should be maintained. The privacy of subjects should also be maintained. In case the subjects are animals or plants as in the case of sciences their treatment should be ethical. Tampering of data to achieve results should not be done.

Self Check Exercise

- 5) Discuss the areas where ethical considerations are important in a research plan.

Note: i) Write your answer in the space given below.

- ii) Check your answer with the answers given at the end of the Unit.

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16.10 SUMMARY

In this Unit we have discussed the various aspects of research plan. We introduced the concept and discussed the need for, purpose and functions of research plan. The Unit provides comprehensive details on the structure of a plan. A step-by-step approach has been followed to explain all the parts of a plan. Adequate examples have been given at all the stages to make all the steps clear. Research can be funded through various agencies, which has also been described in the Unit. There is a discussion of the heads under which funds can be applied. Researcher should take care that he/she follows ethics while conducting research. What are these areas has been stated for the help of the researcher. It has been discussed in this Unit so that the researcher gets conscious of ethics since the start of research. The Unit ends with some model plans given as examples.

16.11 ANSWERS TO SELF CHECK EXERCISES

- 1) A research plan is a document to your plans and ideas of carrying out your research. It is the document that describes all the decisions that have been taken in the design stage plus the administrative decisions concerned with your research. It presents systematically everything starting with the title of your project to the tentative

structure of your thesis. Research design is also a strategy of how you are going to conduct your research. But it precedes research plan. Research design is a plan of the technical decisions regarding the what, why, and how of your research. In research plan, we take decisions regarding the nature of investigation, data collection methods to be adopted, and number of contacts to be made with the subjects, and the period of reference with the subjects of study. Research plan can be formulated only when research design has been decided. In fact, research design helps to formulate research plan.

- 2) The introduction to the plan of study provides a contextual background to the study. It discusses the basic theoretical and philosophical issues related to your topic. It also discusses the latest trends in the subject and area of discussion.
- 3) Let us assume that the title of the study is “ Use of textbook collection in college libraries”. The objectives of the study could be stated as to know:
 - a. The adequacy of the text book collection;
 - b. Subjects whose collection needs to be strengthened; and
 - c. Improving upon the collection.
- 4) Hypothesis is an assumption, presumption, or in simple words guess towards some situation or condition. It is an assumption of relationships between the dependent and independent variables. It provides the researcher a line of action along which he moves to find out answers to the problem he is working on. Null hypothesis is stated as a negative relationship between dependent and independent variables. The positive relation between the variables is called the alternative hypothesis.
- 5) In a research plan, ethical considerations demand that one should not take a topic of research that has already been studied. If it has to be studied, it should be done from some different perspective or context. Plagiarism should not be resorted to and work of others should be acknowledged. Research grants should be asked for only if genuinely required.

16.12 KEYWORDS

Hypothesis	: Assumption regarding the relations between the variables in a study.
Problem	: A description of the problem you shall study in your research work.
Research Design	: The strategy that a researcher adopts to undertake his research. It concerns the operationalisation of hypothesis, data collection, and data analysis.
Research Plan	: The blue print of your research that states everything from the title to the limitations of your study. It also includes the financial estimates of your project and the work plan.
Work Plan	: The plan of your research in terms of the tasks to be done along with the time at which they will be done.

16.13 REFERENCES AND FURTHER READING

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UNIT 17 STATISTICAL INFERENCE

Structure

- 17.0 Objectives
- 17.1 Introduction
- 17.2 Concept of Statistical Inference
- 17.3 Statistical Estimation
- 17.4 Concept of Hypothesis Testing
- 17.5 Critical Regions and Types of Errors
- 17.6 Testing of Hypothesis for a Single Sample
- 17.7 Test for Difference between Two Samples
- 17.8 Contingency Table
- 17.9 Summary
- 17.10 Answers to Self Check Exercises
- 17.11 Keywords
- 17.12 References and Further Reading

17.0 OBJECTIVES

After going through this Unit you should be in a position to:

- explain the concept of a hypothesis;
- explain the concept of statistical inference;
- test a hypothesis based on a single sample; and
- test the difference between two samples.

17.1 INTRODUCTION

As mentioned in Unit 6 of this course we undertake a sample survey instead of complete census of population because of certain constraints. These constraints could be availability of money, manpower and time. After collection of data through questionnaire, interview or participatory observation method we follow certain steps such as tabulation, presentation and analysis of data. We have discussed these issues in the earlier Units of this course. As you know, we can present data in the form of tables and graphs. Also data can be put to various statistical analyses. Thus we can find out i) measures of central tendency such as mean, median and mode, ii) measures of dispersion such as variance and standard deviation, and iii) correlation and regression coefficients.

Recall that the objective of our study is to analyse the behaviour of the population or the universe, not the sample. In order to make things feasible we are studying the sample and hence whatever results we have got are based on sample information. Naturally a question arises: Are the sample results valid for the population? In other words, can we draw inferences on the basis of sample results?

Let us take a concrete example from our daily life. You must have noticed that before election process starts or just before declaration of election results many newspapers and news channels conduct exit polls. The purpose is to predict election results before

the actual results are declared. At that point of time, it is not possible for the surveyors to ask all the voters about their preferences for electoral candidates - the time is too short, resources are scarce, manpower is not available, and a complete census before election defeats the very purpose of election!

The above is an example of statistical inference. The surveyor actually does not know the result, which is the outcome of votes cast by all the voters. Here all the voters taken together comprise the population. The surveyor has collected data from a representative sample of the population, not all the voters. On the basis of the information contained in the sample, (s)he is making forecast about the entire population.

17.2 CONCEPT OF STATISTICAL INFERENCE

As mentioned above, statistical inference deals with the methods of drawing conclusions about the population characteristics on the basis of information contained in a sample drawn from the population. Let us recall the example on reading habits of economics students in Sambalpur University. Suppose a question in the questionnaire is, 'How many hours do you study in a day'? We obtain the answer to this question from the students included in the sample (100 students), calculate arithmetic mean and find that 'average number of hours devoted to study by economics students in Sambalpur University is 9.5 hours'. The problem comes up because of two reasons:

- i) Sample is a part of the population and there is no reason to expect that sample mean is equal to population mean (if it does, it is a rare coincidence!). In that case, what is the population mean?
- ii) A number of samples can be drawn from the same population. Suppose we send two researchers to Sambalpur University on different days and ask them to administer the same questionnaire (on reading habits) on samples of 100 students each. Obviously both researchers would come out with different results (say 9.25 hours and 10.5 hours) as the sampling units are different. Which result do we take to be correct? Can we say that the difference between the studies is negligible?

Remember that population mean is not known to us. We know the sample mean only. We have posed two types of questions above. First, what would be the value of the population mean? The answer lies in making an informed guess about the population mean. This aspect of statistical inference is called 'estimation'. The second question pertains to certain assertion made about the population mean. Suppose someone claims that the average number of hours devoted to study by economics students in Sambalpur University is 10 hours. On the basis of the sample information can we say that the population mean is not equal to 10 hours? This aspect of statistical inference is called hypothesis testing.

Thus statistical inference has two important aspects: statistical estimation and hypothesis testing (see Fig. 17.1). Estimation could be of two types: point estimation and interval estimation. In point estimation we estimate the value of population parameter as a single point. On the other hand, in the case of interval estimation we estimate lower and upper bounds around sample mean within which population mean is likely to remain.

Hypothesis as you know is an assertion or claim made about the population. It can be in the form of a null hypothesis and its counterpart, alternative hypothesis. We will explain these concepts along with examples below.

Fig. 17.1: Statistical Inference

17.3 STATISTICAL ESTIMATION

As mentioned earlier, we do not know the parameter value and want to guess it by using sample statistic. Obviously the best guess will be the value of the sample statistic. For example, if we do not know the population mean the best guess would be the sample mean. Here, in this case, we use a single value or point as 'estimate' of the parameter and this procedure is called 'point estimation'.

Interval Estimation

The point estimate may not be realistic in the sense that the parameter value may not exactly be equal to it. An alternative procedure is to give an interval, which would hold the parameter with certain probability. Here we specify a lower limit and an upper limit within which the parameter value is likely to remain. We call the interval as 'confidence interval'. Here a question may be shaping up in your mind, 'How do we find out the confidence interval'? In order to estimate the confidence interval we have to specify the 'confidence coefficient'. If the confidence coefficient is 95 percent, we get a 95 percent confidence interval. If repeated samples are drawn from a population, a 95 percent confidence interval implies that in 95 out of 100 cases the population mean will remain within the confidence interval. Similarly, in the case of a 99 percent confidence coefficient, if repeated samples are drawn, the population mean will remain within the confidence interval in 99 out of 100 cases.

When we are estimating a 95 percent confidence interval, we expect population mean to remain within the interval 95 percent times. It implies that in 5 percent cases we are not sure whether population mean will remain within the interval or not. This 5 percent is called the 'level of significance' and is denoted by α (Read as 'alpha'). We will use this concept later in the testing of hypothesis.

Statistical Background

Let us recapitulate some basic concepts from sampling theory. As mentioned earlier, we can draw many samples from a population. Suppose we could draw all possible samples from a population and calculated sample means () from all the samples. We can arrange these sample means in the form of a relative frequency distribution (see Unit 7 for calculation of relative frequency), which is called 'sampling distribution'. If the sample size is large ($n \geq 30$) then the sampling distribution will follow normal distribution, which looks like a bell-shaped curve when plotted on a graph paper. The sampling distribution has mean equal to population mean () and standard deviation

equal to $\frac{\bar{x} - \mu}{\frac{\sigma}{\sqrt{n}}}$ where σ is the standard deviation of the population from which the sample is drawn. Remember that the standard deviation of the sampling distribution is called the 'standard error'.

When we subtract the population mean from the sample mean divide it by the population standard deviation we obtain the standard normal variable z , which is equal to $\frac{\bar{x} - \mu}{\frac{\sigma}{\sqrt{n}}}$. The z variable has the properties that i) it is normally distributed (implies, it looks like a bell-shaped curve), ii) total area under the curve is =1, and iii) arithmetic mean of z is = 0. We plot the z variable in Fig. 17.2.



Fig. 17.2: Standard Normal Curve

Estimation of Interval

Remember that z is defined in such a manner that $z = \frac{\bar{x} - \mu}{\frac{\sigma}{\sqrt{n}}}$. Therefore, when sample mean ($\bar{x}$) is equal to population mean (μ), we find that $z = 0$. When $\bar{x}$ is greater than μ , we obtain a positive value for z . Similarly, when $\bar{x}$ is smaller than μ we obtain a negative value for z . Thus, as the value of z increases, the difference between sample mean ($\bar{x}$) and population mean (μ) increases.

In Fig. 17.2 we have shown that when $z=1.96$, the area covered under the curve is 95 percent. Therefore, if we add and subtract 1.96 $\frac{\sigma}{\sqrt{n}}$ from sample mean ($\bar{x}$) we obtain a 95 percent confidence interval. In symbols, lower limit and upper limit of the interval

are $\bar{x} - 1.96 \frac{\sigma}{\sqrt{n}}$, $\bar{x} + 1.96 \frac{\sigma}{\sqrt{n}}$.

Similarly we obtain the 99 percent confidence interval as

since 99 percent area under the standard normal curve is covered when $z = 2.58$.

Confidence coefficient could take any value. We can ask for a confidence level of say 81 per cent or 97 per cent depending upon how precise our conclusions should be. However, conventionally two confidence levels are frequently used, namely, 95 per cent and 99 per cent.

Self Check Exercise

- 1) Define the following concepts:
 - a) confidence coefficient
 - b) confidence interval
 - c) level of significance
 - d) sampling distribution
 - e) standard error
- 2) A sample of 50 employees was asked to provide the distance commuted by them to reach office. If sample mean was found to be 4.5 km. Find 95 percent confidence interval for the population. Assume that population is normally distributed with a variance of 0.36.
- 3) For a sample of 25 students in school the mean height was found to be 95 cm. with a standard deviation of 4 cm. Find the 99 percent confidence interval.

Note: i) Write your answers in the space given below.

ii) Check your answers with the answers given at the end of the Unit.

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17.4 CONCEPT OF HYPOTHESIS TESTING

A hypothesis is a tentative statement about a characteristic of a population. It could be an assertion or a claim also. For example, official records for recent years show that female literacy in Orissa is 51 per cent. Since a statement or a claim about the rate of female literacy is being made, it could be considered as a hypothesis.

In hypothesis testing there are four important components: i) null hypothesis, ii) alternative hypothesis, iii) test statistic, and iv) interpretation of results. We discuss each of these below.

Usually statistical hypotheses are denoted by the alphabet H. There are two types of hypothesis: null hypothesis and alternative hypothesis. A null hypothesis is the statement that we consider to be true about the population and put to test by using a test statistic.

Usually we denote null hypothesis by H_0 . In the example on female literacy in Orissa our null hypothesis is

$$H_0 : \quad 0.51 \quad \dots(17.1)$$

where θ is the parameter, in this case female literacy in Orissa.

There is a possibility that the null hypothesis that we intend to test is not true and female literacy is not equal to 51 per cent. Thus there is a need for an alternative hypothesis, which holds true in case the null hypothesis is not true. We denote alternative hypothesis by the symbol H_A and formulate it as

$$H_A : \quad 0.51 \quad \dots(17.2)$$

We have to keep in mind that null hypothesis and alternative hypothesis cannot be true simultaneously. Secondly, there cannot be a third possibility except for H_0 and H_A about the statement we make. For example, in the case of female literacy in Orissa, there are two possibilities - literacy rate is 51 per cent or it is not 51 per cent; a third possibility is not there.

In most cases we find a difference between sample mean ($\bar{x}$) and population mean (μ). Is the difference because of sampling fluctuation or is there a genuine difference between the sample and the population? In order to answer this question we need a test statistic to test the difference between the two. The result that we obtain by using the test statistic needs to be interpreted and a decision needs to be taken regarding the acceptance or rejection of the null hypothesis.

Let us go back to the standard normal curve given at Fig. 17.1. We mentioned that as the value of z increases, the difference between sample mean ($\bar{x}$) and population mean (μ) increases. Moreover, higher the difference between $\bar{x}$ and μ , higher is the absolute value of z . Thus z -value measures the discrepancy between $\bar{x}$ and μ , and therefore can be used as a test statistic for hypothesis testing. Note that we are concerned with the difference between $\bar{x}$ and μ . Therefore, negative or positive sign of z does not matter much.

Our task is to find out a critical value of z beyond which the difference between $\bar{x}$ and μ is significant. Hence, we take the absolute value of z (denoted by $|z|$) and if it is less than the critical value we should not reject the null hypothesis. If the absolute value of z exceeds the critical value we should reject the null hypothesis and accept the alternative hypothesis.

Therefore, in the case of large samples z can be considered as a test statistic for hypothesis testing such that

$$z = \frac{|\bar{x} - \mu|}{\sigma/\sqrt{n}} \quad \dots(17.3)$$

The above procedure is often called z -test. By applying sample values in the formula given at (17.3) above we obtain the observed value of z . We compare it with the critical value of z (to be discussed below).

When the sample size is small, the sampling distribution does not follow normal distribution. Hence, we cannot apply z -test. In the case of small samples, however, we apply t -test, which again is bell-shaped, but has a larger variance compared to normal distribution. The test statistic for t -test is given by

$$t = \frac{|\bar{x} - \mu|}{s/\sqrt{n}} \quad \dots(17.4)$$

A problem here is that the critical value of t depends upon the 'degree of freedom', defined as $(n - 1)$ where n is the sample size. For example, when sample size is 20, degree of freedom is $20 - 1 = 19$. Thus the critical value of t varies according to two factors: i) degrees of freedom, and ii) requisite level of significance.

Fig. 17.3: Testing of Hypothesis

In Fig. 17.3 we present the type of test to be applied in different situations. Some of the factors that guides us in deciding on the test statistic to be used are: i) whether population is normal or not, ii) whether sample size is small or large, and iii) whether population variance () is known to us or not. You may wonder that since population mean is not known to us (our objective is to estimate it from the sample), how do we know population variance! However, we begin with the simpler case of known variance and later on consider the more realistic case of unknown population variance.

17.5 CRITICAL REGIONS AND TYPES OF ERRORS

In Section 17.3 we had mentioned that when $z = 1.96$, we have 5 percent level of significance (and 95 percent confidence level). An implication of the above is that in 95 out of 100 samples the parameter remains within the confidence interval. Therefore, in 5 out of 100 samples, the parameter will not remain within the confidence interval. The area on the extreme left and extreme right of the standard normal curve (see Fig. 17.2 above) belong to this 5 percent. This region of the curve is called the 'critical region' and the value of z beyond which the critical region starts is called 'critical value'.

The critical values for z depend upon the level of significance. In Table 17.1 these critical values for certain specified levels of significance () are given for the tests to be conducted under the assumption of normal distribution.

Table 17.1: Critical Values for z-statistic

Significance Level ()	0.10	0.05	0.01
Critical value of z	1.65	1.96	2.58

Type I and Type II Errors

In hypothesis testing we reject or do not reject a hypothesis with certain level of confidence. As mentioned above, a confidence level of 95 percent implies that in 95

out of 100 samples the parameter remains within the acceptance region and in 5 per cent cases parameter remains in the rejection region. Thus in 5 per cent cases the sample is drawn from the population but sample mean is too far away from the population mean. In such cases the sample belongs to the population but our test procedure rejects it. Obviously we commit an error such that H_0 is true but gets rejected. This is called 'Type I error'. Similarly there could be situations when the H_0 is not true, but on the basis of sample information we do not reject it. Such an error in decision-making is termed 'Type II error' (see Table 17.2).

Note that 'Type I error' specifies how much error we are in a position to tolerate. Type I error is equal to the level of significance, and is denoted by α . Thus $\alpha = 0.05$ implies that we can tolerate 5 percent error in our decision-making. Remember that confidence level is equal to $(1 - \alpha)$.

Table 17.2: Type of Errors

	H_0 True	H_0 Not true
Reject H_0	Type I Error	Correct decision
Do not reject H_0	Correct decision	Type II Error

In the case of small samples we have to use t-test and thus critical values need to be decided on the basis of t-distribution. Application of t-test is a bit complex as we have to look for the i) degrees of freedom, and ii) the level of significance.

We will work out some examples based on z-test and t-test in the next Section.

As mentioned earlier the convention is to apply 5% or 1% level of significance. For these two levels of significance we present the critical values of t-distribution for different degrees of freedom in Table 17.3 at the end of this unit.

Self Check Exercise

- 4) Distinguish between the following:
 - a) Null hypothesis and Alternative hypothesis
 - b) Confidence level and Level of significance
 - c) Type I and Type II errors
- 5) Suppose a sample of 100 students has mean age of 12.5 years. Show through a diagram the critical region at 5 per cent level of significance to test hypothesis that the sample is equal to the population mean. Assume that population mean and standard deviation are 10 years and 2 years respectively.

Note: i) Write your answers in the space given below.
 ii) Check your answers with the answers given at the end of the Unit.

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17.6 TESTING OF HYPOTHESIS FOR A SINGLE SAMPLE

We have so far explained the concepts of null and alternative hypotheses. Also we have learnt that in the case of large samples we apply z-test and in the case of small samples we apply t-test. In many situations we are asked to judge whether a sample is significantly different from a given population. For example, let us assume that we surveyed a sample of 400 households of Raigarh district of Chhatisgarh state and calculated the per capita income of these households. Subsequently, our task is to test the hypothesis that per capita income calculated from the sample is not different from the per capita income of the district.

In the above example we can have two different situations: i) population (in this case all the households of the district) variance is known, ii) population variance is not known to us. We explain the steps to be followed in each case below.

17.6.1 Population Variance is Known

The steps you should follow are:

- 1) Specify the null hypothesis.
- 2) Find out whether it requires one-tail or two-tail test. Accordingly identify your critical region. This will help in specification of alternative hypothesis.
- 3) Apply sample values to z-statistic.
- 4) Find out from z-table the critical value according to level of significance.
- 5) If you obtain a value lower than the tabulated value do not reject the null hypothesis.
- 6) If you obtain a value greater than the tabulated value reject the null hypothesis and accept the alternative hypothesis

Example 1

Let us consider the case that we know the per capita income of Raigarh district of Chhatisgarh as well as its variance. Suppose the data available in official records show that per capita income of Raigarh district is Rs. 10,000 and standard deviation of per capita income is Rs. 1,500. However, we did a sample survey of 400 households and found that their per capita income is Rs. 10,500. Do we accept the data provided in official records?

In this case = Rs. 10,000
 = Rs. 1,500
 = Rs. 10,500
 n = 400

The sample size is large and variance of the population is known. As given in Fig.17.3 we apply z-test.

Our null hypothesis in this case is

$$H_0 : \bar{x}$$

The null hypothesis suggests that sample mean is equal to population mean. In other words, per capita income obtained from the sample is the same as the data provided in official records.

Our alternative hypothesis is

$$H_A: \bar{x}$$

By substituting values in the above we obtain

$$z = \frac{10500 - 10000}{1500/\sqrt{400}} = \frac{500}{500/20}$$

In the above case since $z = 6.67$, the sample lies in the critical region and we reject the hypothesis. Thus the per capita income obtained from the sample is significantly different from the per capita income provided in official records.

Example 2

Suppose the voltage generated by certain brand of battery is normally distributed. A random sample of 100 such batteries was tested and found to have a mean voltage of 1.4 volts. At 0.01 level of significance, does this indicate that these batteries have a general average voltage that is different from 1.5 volts? Assume that population standard deviation is 0.21 volts.

$$\text{Here, } H_0: \mu = 1.5$$

Since average voltage of the sample can be different from average voltage of the population if it is either less than or more than 1.5 volts, our rejection region is on both sides of the normal curve. Thus it is a case of two-tail test and alternative hypothesis is

Since the population standard deviation σ is known, the test statistic is

$$z = \frac{|\bar{x} - \mu|}{\frac{\sigma}{\sqrt{n}}} = \frac{|1.4 - 1.5|}{\frac{0.21}{\sqrt{100}}} = 4.8$$

From the Table 17.2 we find that the critical value at 1 per cent level significance is 2.58. Since the actual value of z is greater than 2.58 we reject the null hypothesis at 1% level and accept the alternative hypothesis that the average life of batteries is different from 1.5 volts.

17.6.2 Population Variance not Known

The assumption that population standard deviation (σ) is known to us is unrealistic, as we do not know the population mean itself. When σ is unknown we have to estimate it by sample standard deviation (s). In such situations there are two possibilities depending upon the sample size. If the sample size is large ($n \geq 30$) we apply z -statistic, that is,

$$z = \frac{|\bar{x} - \mu|}{s/\sqrt{n}} \quad \dots(17.5)$$

In case the sample size is small ($n < 30$) we apply t -statistic with $n - 1$ degrees of freedom. The test statistic is

$$t = \frac{|\bar{x} - \mu|}{s/\sqrt{n}} \quad \dots(17.6)$$

The steps you should follow are:

- 1) Specify the null hypothesis and alternative hypothesis.
- 2) Check whether sample size is large ($n \geq 30$) or small ($n < 30$).
- 3) In case $n \geq 30$, apply z-test (17.5).
- 4) Find out from z-table the critical value according to level of significance ().
- 5) In case , apply t-test (17.6).
- 6) Find out from t-table the critical value for $n - 1$ degrees of freedom and level of significance ().
- 7) If you obtain a value lower than the tabulated value do not reject the null hypothesis.
- 8) If you obtain a value greater than the tabulated value reject the null hypothesis and accept the alternative hypothesis

Example 3

A tablet is supposed to contain on an average 10 mg. of aspirin. A random sample of 100 tablets show a mean aspirin content of 10.2 mg. with a standard deviation of 1.4 mg. Can you conclude at the 0.05 level of significance that the mean aspirin content is indeed 10 mg.?

Here, the null hypothesis is

The rejection region is on both sides of 10 mg. Thus it requires a two-tail test and

Also, the sample mean is $\bar{x} = 10.2$ and the sample size $n = 100$. Since population standard deviation is not known we estimate it by sample standard deviation s and our test statistic is . By applying relevant values from the sample we obtain

$$z = \frac{\frac{|\bar{x} - \mu|}{s}}{\frac{1}{\sqrt{n}}} = \frac{\frac{|10.2 - 10|}{1.4}}{\frac{1}{\sqrt{100}}} = 1.43$$

At 5 per cent level of significance the critical value of z is 1.96. since the z value that we have obtained is less than 1.96, we do not reject the null hypothesis. Therefore the mean level of aspirin is 10 mg.

Example 4

The population of Haripura district has a mean life expectancy of 60 years. Certain health care measures are undertaken in the district. Subsequently, a random sample of 25 persons shows an average life expectancy of 60.5 years with a standard deviation of 2 years. Can we conclude at the 0.05 level of significance that the average life expectancy in the district has remained the same?

Here, $H_0: \mu = 60$

We have to test for an increase in life expectancy. Thus it is a case of one-tail test and the rejection region will be on the right-hand tail of the standard normal curve.

Hence our alternative hypothesis is

Here population standard deviation σ is not known and we estimate it by the sample standard deviation s . Here the sample size is small hence we have to apply t-statistic given at (17.6).

$$t = \frac{\left| \frac{\bar{x} - \mu_0}{\frac{s}{\sqrt{n}}} \right|}{\frac{2}{\sqrt{25}}} = \frac{|60.5 - 60|}{\frac{2}{\sqrt{25}}} = 1.25$$

Since sample size is 25, degrees of freedom are $25 - 1 = 24$. From the t-table we find that for 24 degrees of freedom, 5 per cent level of significance.

Since t-value obtained above is less than the tabulated value we do not reject the hypothesis. Therefore, we accept the alternative hypothesis that life expectancy has not changed after the health care measures.

Self Check Exercise

- 6) A report claimed that in the 'School Leaving Examination', the average marks scored in Mathematics were 78 with a standard deviation of 16. However, a random sample of 37 students showed an average of 84 marks in Mathematics. In the light of this evidence, can we conclude that the average has remained unchanged? Use 0.05 level of significance.
- 7) A passenger car company claims that average fuel efficiency of cars is 35 kms per litre of petrol. A random sample of 50 cars shows an average of 32 kms per litre with a standard deviation of 1.2 km. Does this evidence falsify the claim of the passenger car company at 0.01 level of significance?
- 8) A random sample of 200 tins of coconut oil gave an average weight of 4.95 kg per tin with a standard deviation of 0.21 kg. Do we accept the hypothesis of net weight of 5 kg per tin at 0.01 level of significance?
- 9) According to a report, the national average annual income of the government employees during a recent year was Rs. 24,632 with a standard deviation of Rs. 1827. A random sample of 49 government employees during the same year showed an average annual income of Rs. 25,415. On the evidence of this sample, at 0.05 level of significance, Can we conclude that the national average annual income of government employees was indeed Rs. 24,632?

Note: i) Write your answers in the space given below.

ii) Check your answers with the answers given at the end of the Unit.

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17.7 TEST FOR DIFFERENCE BETWEEN TWO SAMPLES

Many times we need to test for the difference between two samples. The objective may be to ascertain whether both samples are drawn from the same population or to

check whether a particular characteristic is the same in two populations. For example, we formulate a hypothesis that the production per worker in plant A is the same as the production per worker in plant B. We discuss below the procedure for testing of such a hypothesis.

Here again we deal with two different situations: whether variance of both the populations are known. Another consideration is sample size: large or small.

The null hypothesis is the statement that population means of both the populations are the same. In notations

$$H_0 : \mu_1 = \mu_2 \quad \dots(17.7)$$

The alternative hypothesis is the statement that both the population means are different. In notations

$$H_A : \mu_1 \neq \mu_2 \quad \dots(17.8)$$

Population Variance is known

When standard deviations (positive square root of variance) of both the populations are known we apply z statistic specified as follows:

$$z = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \quad \dots(17.9)$$

In (17.8) above, subscript 1 refers to the first sample and subscript 2 refers to the second sample. By applying relevant data in (17.9) we obtain the actual value of z and compare it with the tabulated value for specified level of significance.

Example 5:

A bank wants to find out the average savings of its customers in Delhi and Kolkata. A sample of 250 accounts in Delhi shows an average savings of Rs. 22500 while a sample of 200 accounts in Kolkata shows an average savings of Rs. 21500. It is known that standard deviation of savings in Delhi is Rs. 150 and that in Kolkata is Rs. 200. Can we conclude at 1 percent level of significance that banking pattern of customers in Delhi and Kolkata is the same?

In this case the null hypothesis is $H_0 : \mu_1 = \mu_2$

and the alternative hypothesis is $H_A : \mu_1 \neq \mu_2$

We are provided with the information that

$$\begin{aligned} \bar{x}_1 &= \text{Rs. } 22500 & \sigma_1 &= \text{Rs. } 150 \\ &= \text{Rs. } 22400 & \sigma_2 &= \text{Rs. } 200 \\ n_1 &= 250 & n_2 &= 200 \end{aligned}$$

Since μ_1 and μ_2 are known we apply z-test.

The test statistic is

By applying the information provided above we obtain

$$z = \frac{\left| \frac{22500}{150^2} - \frac{22400}{200^2} \right|}{\sqrt{\frac{100}{250} - \frac{20}{200}}}$$

We find that at 1 per cent level of significance the critical value obtained from Table 17.1 is 2.58.

Since the actual value is greater than the tabulated value the null hypothesis is rejected and the alternative hypothesis is accepted. Thus the banking pattern of customers in Delhi and Kolkata are different.

Population Variance is not known

When population variance (σ^2) is not known we estimate it by sample variance (s^2). If both samples are large in size ($n > 30$) then we apply z statistic as follows:

$$z = \frac{|\bar{x}_1 - \bar{x}_2 - (\mu_1 - \mu_2)|}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad \dots(17.10)$$

On the other hand, if samples are small in size ($n \leq 30$) then we apply t-statistic as follows:

$$t = \frac{|\bar{x}_1 - \bar{x}_2 - (\mu_1 - \mu_2)|}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad \dots(17.11)$$

$$t = \frac{|\bar{x}_1 - \bar{x}_2 - (\mu_1 - \mu_2)|}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Degrees freedom for t-test = $(n_1 - 1) + (n_2 - 1) = n_1 + n_2 - 2$

Example 6

A mathematics teacher wants to compare the performance of Class X students in two sections. She administers the same set of questions to 25 students in Section A and 20 students in Section B. she finds that Section A students have a mean score of 78 marks with standard deviation of 4 marks while Section B students have a mean score of 75 marks with standard deviation of 5 marks. Is the performance of students in both Sections different at 1 per cent level of significance?

In this case the null hypothesis is $H_0 : \mu_1 = \mu_2$

and the alternative hypothesis is $H_A : \mu_1 \neq \mu_2$

We are provided with the information that

$$\bar{x}_1 = 78$$

$$s_1 = 4$$

$$\bar{x}_2 = 75$$

$$s_2 = 5$$

$$n_1 = 25$$

$$n_2 = 20$$

Since μ_1 and μ_2 are not known and sample sizes are small we apply t-test.

$$t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} = \frac{|78 - 75|}{\sqrt{\frac{4^2}{25} + \frac{5^2}{20}}} = \frac{3}{1.37} = 2.18$$

The degree of freedom in this case is $25+20-2 = 43$.

We can find out from Table 17.3 that at the 1 per cent level of significance the t-value for 43 degrees of freedom is 2.69.

Since the tabulated value of t is less than actual value of t we reject the hypothesis. Therefore, students in Section A and Section B are different with respect to their performance in mathematics.

17.8 CONTINGENCY TABLE

The concepts of confidence interval and the procedures of testing a hypothesis discussed so far relate to numerical. In the case of qualitative data, however, we cannot undertake such tests, as we do not have parameters. In the qualitative data, therefore, we require to develop non-parametric tests.

There are many types of non-parametric tests depending upon our need. However, we confine ourselves to a common procedure, that is, chi-square (pronounced as kai-squared) test for the test of independence between variables. Recall that qualitative data can be arranged in categories (see Unit 6) and presented in the form of a two-way table.

In order to explain the application of chi-square test let us take a concrete example. Suppose we want to test a hypothesis that number of children in a family is independent of the occupation of father. We divide occupation of father into five categories - i) unemployed, ii) unskilled labour, iii) skilled labour, iv) self-employed, and v) professional. Similarly we divide families into five categories according the number of children - i) no child, ii) one child, iii) two children, iv) three children, and v) more than three children. For a sample of 650 families the data obtained is presented in Table 17.3.

Table 17.3: Occupation and Number of Children

Number of Children	Occupation					Total
	Unemployed	Unskilled Labour	Skilled Labour	Self- Employed	Professional	
	(1)	(2)	(3)	(4)	(5)	
0	10	15	10	12	11	58
1	35	25	17	18	25	120
2	22	33	45	40	43	183
3	11	40	48	58	30	187
4	11	33	30	19	9	102
Total	89	146	150	147	118	650

Table 17.3 is called contingency table, because we are trying to find whether the number of children is contingent upon the occupation of the father.

Our purpose is test for possible relationship between the number of children and the occupation of father. Thus the null hypothesis is specified as:

: Number of children and occupation of father are independent against the alternative hypothesis

H_A : Number of children and occupation of father are dependent

Expected Frequency

In Table 17.3 we have presented the observed frequency for each cell in the table. What should be the expected frequency when there is no relationship between the variables under consideration? We will answer this question below.

Expected frequency is calculated under the assumption that there is no relationship between number of children and occupation of father. For each cell in Table 17.2 the expected frequency is obtained by

$$E_{ij} = \frac{(\text{Row } i \text{ total}) (\text{Column } j \text{ total})}{\text{Sample size}} \quad \dots (17.12)$$

Where E_{ij} is expected frequency for row 'i' and column j. For example, for row 2 and column 2 the expected frequency is

$$E_{22} = \frac{\text{row 2 total} \times \text{col. 2 total}}{\text{sample size}}$$

We find out the row and column totals for the data given in Table 17.3 and estimate the expected frequency for each cell. These are given in Table 17.4.

Table 17.4: Calculation of Expected Frequency for Each Cell

Number of Children	Occupation					Total
	Unemployed	Unskilled Labour	Skilled Labour	Self- Employed	Professional	
	c_1	c_2	c_3	c_4	c_5	
0 r_1	7.94	13.03	13.38	13.12	10.53	58.00
1 r_2	16.43	26.95	27.69	27.14	21.78	120.00
2 r_3	25.06	41.10	42.23	41.39	33.22	183.00
3 r_4	25.60	42.00	43.15	42.29	33.95	187.00
4	13.97	22.91	23.54	23.07	18.52	102.00
Total	89.00	146.00	150.00	147.00	118.00	650.00

The next step is to compare the observed frequency with the expected frequency. In order to compare the observed frequency with the expected frequency we construct the chi-square statistic, which is given by

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i} \quad \dots (17.3)$$

where O refers to observed frequency and E refers to expected frequency.

The chi-square statistic has degrees of freedom $(r - 1)(c - 1)$. For example, if there are 3 rows and 4 columns, then degrees of freedom is $(3 - 1)(4 - 1) = 6$.

Let us summarise the steps to be followed in chi-square test. These are:

- 1) specify the null and alternative hypotheses
- 2) calculate the expected frequency for each cell by using (20.5)

- 3) calculate the observed value of χ^2 statistic by using (20.6)
- 4) determine degrees of freedom according to the formula $(r-1)(c-1)$
- 5) check the level of significance (α) required
- 6) Find out the critical value of χ^2 for α and relevant degrees of freedom
- 7) compare the observed value of χ^2 with the critical value of χ^2
- 8) if observed value is less than critical value, then do not reject H_0
- 9) if observed value is greater than critical value, then reject H_0 and accept H_A

For the data given in Table 17.4 let us find out the observed value of χ^2 .

Table 17.5: Calculation of $\frac{(O_i - E_i)^2}{E_i}$ for each Cell

Number of Children	Occupation					Total
	Unemployed	Unskilled Labour	Skilled Labour	Self- Employed	Professional	
	(1)	(2)	(3)	(4)	(5)	
0	0.53	0.30	0.86	0.10	0.02	1.80
1	20.99	0.14	4.13	3.08	0.47	28.81
2	0.37	1.60	0.18	0.05	2.88	5.08
3	8.33	0.10	0.54	5.84	0.46	15.26
4	0.63	4.44	1.77	0.72	4.89	12.46
Total	30.85	6.58	7.48	9.77	8.72	63.41

Since there are 5 rows and 5 columns, the degrees of freedom is 16. The critical values of χ^2 for 5% & 1% level of significance for different degrees of freedom are given in Table 17.7 at the end of the Unit. We find from the table that for 16 d.f. the critical value of χ^2 at 5 per cent level of significance is 26.30. The observed value of χ^2 to be 63.41. Since the observed value is greater than the critical value we reject the null hypothesis and accept the null hypothesis. Therefore, we conclude that the variables 'number of children' and 'occupation of father' are not independent.

Self Check Exercise

- 10) Explain the following concepts.
 - a) expected frequency
 - b) critical value of χ^2
- 11) There are three brands (orange, cola and lemon) of soft drinks produced by a company. A survey of 160 persons in two states (one from north- Punjab and one from south- Tamil Nadu) provides the following information.

	Orange	Cola	Lemon
Punjab 33	26	31	
Tamil Nadu	17	24	29

Test the hypothesis that there is no preference for particular brand of soft drink on both the states ($\alpha = 0.05$).

- Note:** i) Write your answers in the space given below.
 ii) Check your answers with the answers given at the end of the Unit.

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17.9 SUMMARY

Drawing conclusions about a population on the basis of sample information is called statistical inference. Here we have basically two things to do: statistical estimation and hypothesis testing.

An estimate of an unknown parameter could be either a point or an interval. Sample mean is usually taken as a point estimate of population mean. On the other hand, in interval estimation we construct two limits (upper and lower) around the sample mean. We can say with stipulated level of confidence that the population mean, which we do not know, is likely to remain within the confidence interval. In order to construct confidence interval we need to know the population variance or its estimate. When we know population variance, we apply normal distribution to construct the confidence interval. In cases where population variance is not known, we use t distribution for the above purpose. Remember that when sample size is large ($n > 30$) t-distribution approximates normal distribution. Thus for large samples, even if population variance is not known, we can use normal distribution for estimation of confidence interval on the basis of sample mean and sample variance.

Subsequently we discussed the methods of testing a hypothesis and drawing conclusions about the population. Hypothesis is a simple statement (assertion or claim) about the value assumed by the parameter. We test a hypothesis on the basis of sample information available to us. In this Unit we considered two situations: i) description of a single sample, and ii) comparison between two samples.

In the case of qualitative data we cannot have parametric values and hypothesis testing on the basis of z statistic or t-statistic cannot be performed. Chi-square test is applied to such situations. Chi-square test is a non-parametric test, where no assumption about population is required. There are various types of non-parametric tests beside chi-square test. Moreover, chi-square test can be applied to many situations. We learnt about a particular application of chi-square test - contingency table. In contingency table we test the null hypothesis that variables under consideration are independent against the alternative hypothesis that variables are related. We compare expected frequency with observed frequency and construct the chi-square statistic. If the observed value of chi-square exceeds the expected value of chi-square we reject the null hypothesis.

17.10 ANSWERS TO SELF CHECK EXERCISES

- 1) Go through the text and define these terms.
- 2) Since it is large sample we apply z-statistic. The confidence interval is .
- 3) Since it is small sample and population variance is not given we apply t-statistics with degrees of freedom 24. The tabulated value of t at 99 per cent confidence level is 2.49. The confidence interval is .
- 4) Go through the text and define these terms.
- 5) It is large sample and σ is unknown. In order to show the rejection regions we use the standard normal curve. Accordingly draw the diagram.
- 6) Since it is large sample with known variance, we apply z-statistic. The alternative hypothesis is $H_1: \mu \neq 78$. The observed value of z is 2.28 and critical value of z at 5% level of significance is 1.96. Since the observed value is greater than the critical value we reject the null hypothesis. Therefore, we conclude that the average marks were different from 78.
- 7) It is a large sample with unknown variance. It requires two-tail test. The observed value of z is 17.68 and critical value of z at 1% level of significance is 2.58. Since the observed value is greater than the critical value, the null hypothesis is rejected.
- 8) It is a large sample with unknown variance. We test the null hypothesis with z-statistic. Observed value of z is 3.37. Null hypothesis is rejected.
- 9) Since it is large sample with known standard deviation, we apply z-statistic. Observed value of z is 3.00. Critical value of z at 5% level of significance is 2.58. Null hypothesis is rejected. Therefore, the national average of annual income of government employees was different from Rs. 24632.
- 10) Go through the text and define these terms.
- 11) The expected frequency are

	Orange	Cola	Lemon
Punjab	28.13	28.13	33.75
Tamil Nadu	21.88	21.88	26.25

The observed value of chi-square statistic is 2.98. Degrees of freedom is 2. The critical value of chi-square at 5 per cent level of significance at 2 degrees of freedom is 5.99. Hence null hypothesis is not rejected and soft drink consumption is independent of the region.

17.11 KEYWORDS

Confidence Level

: It gives the percentage (probability) of samples where the population mean would remain within the confidence interval around the sample mean. If α is the significance level the confidence level is $(1 - \alpha)$.

- Contingency Table** : A two-way table to present bivariate data. It is called contingency table because we try to find whether one variable is contingent upon the other variable.
- Degrees of Freedom** : It refers to the number of pieces of independent information that are required to compute some characteristic of a given set of observations.
- Estimation** : It is the method of prediction about parameter values on the basis of sample statistics.
- Expected Frequency** : It is the expected cell frequency under the assumption that both the variables are independent.
- Nominal Variable** : Such a variable takes qualitative values and do not have any ordering relationships among them. For example, gender is a nominal variable taking only the qualitative values, male and female; there is no ordering in 'male' and 'female' status. A nominal variable is also called an attribute.
- Parameter** : It is a measure of some characteristic of the population.
- Population** : It is the entire collection of units of a specified type in a given place and at a particular point of time.
- Random Sampling** : It is a procedure where every member of the population has a definite chance or probability of being selected in the sample. It is also called probability sampling. Random sampling could be of many types: simple random sampling, systematic random sampling and stratified random sampling.
- Sample** : It is a sub-set of the population. It can be drawn from the population in a scientific manner by applying the rules of probability so that personal bias is eliminated. Many samples can be drawn from a population and there are many methods of drawing a sample.
- Sampling Distribution** : It is the relative frequency or probability distribution of the values of a statistic when the number of samples tends to infinity.
- Sampling Error** : In the sampling method, we try to approximate some feature of a given population from a sample drawn from it. Now, since in the sample all the members of the population are not included, howsoever close the approximation is, it is not identical to the required population feature and some error is committed. This error is called the sampling error.
- Significance Level** : There may be certain samples where population mean would not remain within the confidence interval around sample mean. The percentage (probability) of such cases is called significance level. It is usually denoted by α .

When $\alpha = 0.05$ (that is, 5 percent) we can say that in 5 per cent cases we are likely to reach an incorrect decision or commit Type I error. Level of significance could be at any level but it is usually taken at 5 percent or 1 percent level.

Statistic

: It is a function of the values of the units that are included in the sample. The basic purpose of a statistic is to estimate some population parameter.

17.12 REFERENCES AND FURTHER READINGS

Kiess, H.O. (1989). *Statistical Concepts for the Behavioral Sciences*. Boston: Allyn and Bacon.

IGNOU Course Material (2005). *EEC 13: Elementary Statistical Methods and Survey Techniques*. Block 7.

UNIT 18 PRESENTATION OF RESULTS

Structure

- 18.0 Objectives
- 18.1 Introduction
- 18.2 Research Reports and their Types
- 18.3 Importance and Significance of Research Reports
- 18.4 Preparation of a Research Proposal
- 18.5 Research Reports: Plan Outline, Format and Contents
- 18.6 Preparation and Organisation of Research Notes
- 18.7 Drafting of Research Reports
 - 18.7.1 Language and Grammar
- 18.8 Physical Production
 - 18.8.1 Preparation of Manuscripts
 - 18.8.2 Final Phase of Physical Production
- 18.9 Summary
- 18.10 Answers to Self Check Exercises
- 18.11 Keywords
- 18.12 References and Further Reading

18.0 OBJECTIVES

After reading this Unit, you will be able to:

- grasp the value, significance and purpose of presentation of research results;
- comprehend the meaning of research reports and their different types;
- preparation of research notes as a prerequisite for presentation of research reports;
- draft a research report plan comprising the preliminaries, contents etc.;
- write the research report, using appropriate aids and tools;
- present the final product in a standard physical format; and
- get acquainted with the knowledge of printing, publishing, graphics and other related techniques.

18.1 INTRODUCTION

As the old adage succinctly puts, the proof of the pudding is in the eating, not merely in its making, the report of research work, requires to be presented in an appropriate standard qualitative form that alone would bring credibility to the research work, no matter how well the research work is done. Report writing being a very important facet of the research process, needs to be given the fullest attention to every detail. In terms of presentation of contents, the language should be simple, clear, lucid and unambiguous. The physical form of the final document must also conform to accepted quality standards that aids its use and also gets an aesthetic appeal.

This Unit deals with all aspects of report writing and the physical production of a document, which culminates a research work. The most important and an invaluable prerequisite in the preparation of the final document of research, is the research notes. As a researcher commences his work, he studies a number of documents, extracts useful, relevant and significant information from consulted documents, prepares summaries of useful ideas, consults experts and guides at different stages of his work, records his/her own thoughts and ideas as the work progresses, and a number of similar activities go along with the work. These very valuable data serve as a handy tool aiding the final preparation of the research report. These types of notes must also be properly recorded, documented, filed and stored so that the task of writing the report becomes easier. Indeed, this preliminary effort is worth taking, as it would save a good deal of tension, worry and anxiety, as the time for the final submission of the research document approaches. This aspect of work is dealt with some detail in this Unit.

The research work would culminate with the production of an M.Phil thesis, a doctoral dissertation, a research paper or a corporate research project report. Each one of these types of documents has special elements that must get the appropriate treatment. Drafting a report is, in particular, a very highly skilled activity. A number of factors contribute to writing a good research report. These aspects are given specific attention; especially useful to research students and junior research workers.

The physical presentation of the final product is also an important aspect of the work, which contributes substantially, in obtaining a commendable impression of the work done.

All these aspects of work in the final preparation of a research report are examined in detail in this Unit.

18.2 RESEARCH REPORTS AND THEIR TYPES

“Research reports are detailed and accurate accounts of the conduct of disciplined studies accomplished to solve problems or to reveal new knowledge.” (Busha and Harter, 1988). Research reports must be complete, well organised and carefully drafted if their contents are to contribute to fields in which the research efforts are made. This is an essential means of communication to the peers in the field to judge the value of the research work done.

There are a variety of research reports. The audience to whom a research report is addressed has to be kept in view in the preparation of a research report. Some of these types are detailed below.

Research reports of students and research fellows of academic or research institutions are generally submitted to the University or other similar professional research institutions in fulfillment of conditions for the award of a research degree. The first research degree is the Master of Philosophy. If research studies are further pursued by a student, he or she would work towards the award of a degree of Doctor of Philosophy or Doctor of Science. In some universities research students could take up research work leading to Doctoral degrees without qualifying for M.Phil.

Most research complexes, learned societies and professional institutions have responsibilities for specific areas of research and development. Particularly in applied research and development, research efforts are geared to achieve targets in scientific, industrial and economic growth, technological innovations, market research, etc. with an orientation towards social goals. These research efforts are related to the country's development planning and growth targets. The outputs of these organisations appear in

the form of research papers to learned journals, research/technical reports, various forms of promotional literature with reference to technology transfer from research to commercial organisations for exploitation. Marketing of technologies developed by these research institutions have become increasingly necessary to sustain indigenous research.

Research done in research complexes and corporate institutions are usually team work and most of them may also be relay research. The team leader along with his/her colleagues would prepare this report, in most cases, one of them may be entrusted with the task of writing the first draft. This will be refined and edited before final submission.

Sponsored research most often may be done by industries, conducted by universities or specialised research institutions, to obtain results with reference to a new product or process development or solving a problem. These reports are prepared by the project team.

Research funded by governments, industries or by other bodies is also teamwork. Persons with high qualifications and research experience in different disciplines of science, technology and related social sciences like economics; sociology, etc. are involved in these R & D activities. They produce different types of research documents resulting from their research efforts. The team prepares the reports. Such research projects may be entrusted to specific bodies of research.

Research papers may be produced by researchers to announce their preliminary results through publication in research journals. The editorial office of the research journals have their own system of quality control to ensure the quality standards of the research work reported.

For research projects of long duration, interim reports or status/stage reports are also brought out to disseminate preliminary results. This will be followed a consolidated final report when the project is completed.

Self Check Exercise

1) What are research reports? List their types.

Note: i) Write your answer in the space given below.

ii) Check your answer with the answers given at the end of the Unit.

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18.3 IMPORTANCE AND SIGNIFICANCE OF RESEARCH REPORTS

Whatever may be the types of research reports, its importance and significance can never be exaggerated. They are the final product of communication of research done without which the research work done is incomplete.

Research Process

The time and effort required to produce a good outline are worthwhile; the framework can conserve energy and assist writers in preparing reports that present research in a logical manner.

The results of research and their validity are examined through a system of evaluation in the case of academic research reports like M.Phil theses or doctoral dissertations.

If the research work is of commendable value and meritorious, contributing to the pool of knowledge, it would become eligible for the consideration of the award /reward system, at the national or international levels.

Primary publications, which are research papers carried by research journals, specialised research reports, and such others, are stocked in libraries and cognate institutions for the use of the research communities and others.

Secondary sources, like indexes and abstracts, state-of-art reports, etc. disseminate these types of research reports which are available for those who look for specific information on research done. They are cited by other research scholars in their research papers/reports. This system of citation has led to the citation index, introducing a novel method to measure the quality of research conducted.

Individuals, who are involved in high quality research work, enhance their status and positions among the research community and become sooner or later guides and leaders of research in their respective fields of research.

In sum, the pool of knowledge gets burgeoned with new inputs of value to the already existing knowledge. Numerous primary publications are a source of information and knowledge for the research community.

The secondary sources provide access to these primary documents and also make them available for consultation.

Citation indexes providing scope for citation studies gives a new method of evaluating research work of excellence.

Persons of eminence sprout in such conditions and provide leadership to research efforts in different disciplines, heading specialised research complexes.

All these efforts contribute and eventually accrue to the benefits of the community at large in giving them better living.

Self Check Exercise

2) What are the usefulness and significance of research reports?

Note: i) Write your answer in the space given below.

ii) Check your answer with the answers given at the end of the Unit.

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18.4 PREPARATION OF A RESEARCH PROPOSAL

For students, pursuing higher and research studies always require financial support. Universities and research institutes also need adequate financial aids to take up research projects. While seeking funding for research projects, proposals have to be prepared with great attention so that the funding agency gets convinced about the utility of the research efforts and sanction the funds asked for. This section deals with the preparation of research proposals. A research proposal is a request for getting financial and other support for a research project. The proposal is a formally prepared document which is sent to a funding agency, requesting financial and other aids.

Agencies like the University Grants Commission and the Council of Scientific and Industrial Research and such other agencies, have a selection process enlisting fellows for research at junior and senior levels. Students, therefore, do have avenues like these to get selected for doing research in their respective fields.

There are agencies, both at the national and international levels which invite research proposals for funding research projects.

It would, therefore, be worthwhile to get some ideas in the preparation of research proposals for those who seek such financial assistance in their research careers.

Regardless of the environment in which a person functions, proposals may have to be prepared for getting research projects and programs, or obtain contracts for research projects, change a career position and improve professional prospects.

Generally a proposal is a written statement of: 1) intention, 2) willingness 3) qualifications and expertise to accomplish a particular research task within a given time frame. The most important function of a research proposal is to convince the peers to win approval and get financial and other support for tasks that the proposer wishes to make.

Proposals generally have the following components:

Letter of transmittal: A formal proposal is always accompanied by letter which usually identifies and highlights the problem and offers to work on it on mutually agreed conditions.

Title page: This gives a succinct statement of the problem, name of the organisations to whom the proposal is submitted with an identifying number, date of submission and the period during which the work would be accomplished and completed, etc.

Executive Summary: This is a brief summary of the total proposal. Busy executives seldom find time to go through detailed text of a proposal but they are the ones that approve and sanction funding. Hence the executive summary needs to be carefully drafted to get a favourable response, particularly from financial officer who approves the funding. It must be expressly stated as to who are likely to be beneficiaries of the research effort.

Table of contents: Any proposal having more than five to six pages should have a table of contents.

Statement of Request: If the proposal is in response to a request, the statement of request is sometimes given that may include the terms of reference.

Preliminary Section: States the subject of the report, scope, purpose and plan of execution.

Introduction: It should include an elaborate statement of the problem and its background. The scope of the proposal has to be spelled out in a short form but very expressively.

The body including the methodology: Contains the procedure, equipment to be used for study, analysis, results, discussions, conclusions, and recommendations that logically follow from the conclusions, etc. This explains how the work is going to be accomplished and hence is perhaps the most important section of the proposal.

Facilities: The facilities required to execute the task have to be stated unambiguously to avoid any problem at a later stage. These include equipment, machinery, literature support facilities such as books, photocopies of documents, internet services, etc. transport if the research tasks require travel, communication facilities like telephone expenses, fax, etc. and such others.

Personnel: This includes professionals and secretarial staff their quality and number, depending upon the nature of the project.

Duration: It should indicate milestones, phases and completion time of the task.

Cost and Funding: This is the most crucial aspect of the proposal. It includes salaries, capital expenditure, if any, expendable equipment, miscellaneous expenses and overheads. The estimates should be realistic and properly stated showing the approximate costs.

Summary: Busy executives would also read the summary and conclusion to assess the proposal and hence be written with utmost care and attention. The summary should reiterate the beneficiaries of the research results.

Given below are contents to go into a proposal for a library automation project of a medium size library, specialising in a set of new disciplines. The contents should be fleshed to fit into the different components suggested above.

- A vision of the future of the library in terms of users, collection, computerisation of house keeping operations, databases creation and maintenance, new and innovative services, human resources development, — in general to derive all advantages of library automation;
- A short design plan in which all aspects stated above are spelled out, with reference to the library's current status and inputs needed;
- Selection of the automation software, reasons for any particular choice and its application;
- An operational strategy to evolve a pragmatic method and to apply it in a phased manner, identifying milestones and specific targets to fit into achievable time frame;
- Identifying every component of the operational strategy and estimate requirements in terms of quality and quantity;
- Cost factors and approximate estimates for capital and recurring expenditure; and
- A workable management strategy dealing with professional personnel, operational analysis and transitional problems.

The drafting of the proposal is a highly skilled activity which not only takes care of every idea in library automation but must indicate effectively data and information to be collected and used.

Self Check Exercise

3) What is a research proposal? State its components.

Note: i) Write your answer in the space given below.

ii) Check your answer with the answers given at the end of the Unit.

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18.5 RESEARCH REPORTS: PLAN OUTLINE, FORMAT AND CONTENTS

Research reports are always precluded by a plan outline, which serves as a guide in the preparation of the final product. An outline is essentially a skeletal framework upon which a report is constructed from systematically collected and organised materials. A complete outline assists the writer in recognising logical relationships between narrative elements of reports. Outlines are also useful for the construction of cohesive paragraphs and sections that are effectively connected.

Most of the research reports outlines are structured more or less on the following format, although alterations of the format may be necessary for every type of report.

Preliminaries

- Title Page with author's name, affiliation and contact address;
- Acknowledgements, if any;
- Conspectus;
- Table of contents;
- Lists of tables, illustrations, etc.;
- Abstract/Synopsis, Executive Summary.

Introduction

- Statement of the problem;
- Explanation of the theoretical or practical context out of which the research problem originated;
- Need and Purpose of the study and research: their rationale;
- Review of the literature;

Description of the Study

- Conceptual Framework of the Study;
- Definitions of terms.
- Explanation of the Assumptions, Hypothesis of the research problem.
- Foot Notes

Collection of Data and Analysis

- Data collection, Explanation of procedures and methods;
- Data Analysis techniques.

Results

- Data tables and figures;
- Statistical presentation;
- Graphics.

Discussions

- Support or Nonsupport of hypothesis;
- Practical and theoretical implications;
- Inferences, Conclusions and Recommendations, if any.

Summary

Glossary

References

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Appendix

Index

Preliminaries

The preliminaries are the formalities in the presentation of a document that precede the main part of the presentation, giving details of information that follow.

The first page of research report is the *title page*. The title should be crisp, concise and expressive and self-explanatory. It may sometimes have a sub-title explaining the main title if need be. The title should not claim more for the study than it actually offers.

Title indexes like Citation Index, and other types of title services, use the titles of documents, which would help users to decide to seek the original document for study or consultation. Therefore titles should be very carefully drafted to give an exact statement of the work done. The drafting of the title should never be done casually.

The details about the author, his/her affiliation and address are information that would enable a person to get in touch with the author, in case there is a need. This has become a common practice, today in practically every type of research reports.

Acknowledgements are the expression of thanks to those who have helped or assisted the author in his research work. This should include the sponsors, agency that might have financial and other supports, those that have assisted in the preparation of manuscripts, those that have provided library and information support facilities, those who have helped in the preparation of the manuscripts and others.

Conspectus of lengthy research reports is a useful aid in giving an overview of the different chapters of a research document, chapter by chapter. Conspectus is however, written for a document which has a number of chapters reporting different dimensions very extensively. It is different from a synopsis or an executive summary which gives a quick overall review of a research document. For documents of smaller sizes, a synopsis is quite sufficient. For research reports, which are sponsored, the practice is to provide an executive summary.

Executive Summary or Synopsis are meant for those who don't have the time to study the full document. Research reports of a sponsored research invariably should have an executive summary for the authorities to get a quick idea of a research report.

Table of contents may be just simple statements of the titles of each chapter or more details of the subsections of each of the chapters. It all depends upon the length of the chapters that are organised to help users to access with ease any section of the chapters.

The lists of tables, figures, illustrations, maps, photographs, etc. again provide instant access to these parts of a research document – lists of tables, illustrations, photographs, maps, etc. give an idea of additional facilities to get a total view of the document.

Introduction

The Statement of the problem taken up for research should be expressed precisely and crisply so that the rest of the write-up follows a similar pattern.

Explanation of the theoretical or practical context, out of which the research problem has originated should be exactly stated.

The need and purpose of the study and research should be expressed properly; the rationale of the study is also provided so that the inquiry can be placed in its proper setting. In addition, the scope and limitations of the study should be stated.

Review of the literature; Literature review is an important aspect of a research study. It may form part of the introduction or can be given in a separate section, depending upon its size and importance. A review of literature provides a background for the study, identifies gaps, highlighting some important work already done. It may sometimes be a state-of-art report, which gives a total picture of the area taken up for research.

Description of the Study

The real meat of the research work done, begins with this section. Not only the contents of this section should be weighty giving full explanation of the research effort but also written with absolute clarity.

Assumptions are carefully and precisely identified in this section and the general research problem is narrowed down and restated in terms of specific hypothesis or research questions. Hypothesis and questions are often discussed in terms of their relationship to objectives of the study. Operational definitions of concepts in the hypothesis or in the research problem are clearly stated to provide their meanings in the context in which they are used. If a study is not designed to test hypotheses, such as descriptive research, the overall research study has to be clearly identified. The theoretical and practical implications of the study should be discussed in this section.

Foot notes constitute information provided with references to any idea or anything that needs support evidences. Such notes are given at the bottom of the page with indicators to correlate the references. Sometimes such notes are consolidated and given at the end of the chapter or at the end of the report. These types of notes may feature throughout the body of the report also.

Data collection and Analysis

This section focuses attention on how the research problem is handled and the sources of the relevant data, including methods used in obtaining them. An exact, detailed description of all steps taken to collect data is stated; for example selection of topical headings, their location in the study, instruments of measurements and special problems pertaining to the design of the study. Adequate descriptions of procedures will facilitate

better understanding of how the study is accomplished. When pertinent, methods used to validate and to pretest instruments are also described. In addition, sometimes, limitations in the study's methodology should be discussed in terms of actual or possible negative effects on the results of inquiry.

Data analysis includes the method of methods of analysis, statistical methods used, and other related methods. These methods should enable the data to be organised systematically for proper and appropriate interpretation.

Results

Data assembled and organised should be presented in tables which can be graphically displayed to give a visual view of the data analysis. This would enable proper interpretation of data analysis to arrive at a conclusion that may permit some generalisation. Conclusions may be formed and the possible application should also be stated.

Discussions

This section should deal with the results obtained with reference to the hypotheses formed at the beginning whether or not the results support them or reject them. This should be appropriately and convincingly argued.

If there are suggestions and recommendations for further study that should complement the research work pursued, these should be precisely and concisely stated.

Summary

Summary at the end of the research report is different from the synopsis or abstracts of research papers, which are usually given at the beginning. Summaries are at the end of a report that gives a short narrative description of the different chapters and the conclusions arrived at.

This will give a quick methodic and systematic overview of the work done.

Glossary

Glossary is a useful aid in getting clear understanding of the technical jargons or other specialised words employed in the report. It may be optional to provide a glossary, depending upon the necessity.

References and Bibliography

References are the most essential part of a research report. This should include references that are actually cited in the report with reference to the pages in which the ideas are discussed or actual quotations.

A separate section may carry bibliographical references, which are additional references to those that there are actually used and cited. This will help users to seek other sources that may contribute to the further study of the research area.

Appendix

Appendices are those items of information that would add further to the information given in main document.

Index

An index to a research report is a must whether or not the document is mimeographed or printed or in other form. An index is a summary of the document in terms of the ideas and thoughts discussed in the document. It brings together all the different aspects of an idea and maps them out in the context in

which they are discussed in the body of the report. It is totally different from the contents even if the contents are presented in detail. If possible the index may be presented in a graphical form to get the different dimensions of the ideas discussed in the document. There are national and international standards that would provide guidelines for preparing a document index. Graphic presentation of indexes is available for some of the international abstracting and indexing services which provide guidelines in the presentation of graphic indexes.

The plan for the different types of research reports will vary, although the general format model suggested above remains more or less the same. For M.Phil research, which usually, is first research degree and the time span is also of a shorter duration, the outline need not go into such details as are required for a doctoral dissertation for a PhD. programme. For other types of research reports, it depends on the institution that undertakes the research, to include its objectives and goals. The research papers should conform to the required format of the host journal in which the paper is to be published. Every report, should, therefore keep the requirements and necessarily should prepare the outline according to the situation and need.

Self Check Exercise

4) What is the function of plan outline of a research report? State its components.

Note: i) Write your answer in the space given below.

ii) Check your answer with the answers given at the end of the Unit.

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18.6 PREPARATION AND ORGANISATION OF RESEARCH NOTES

One of the most important and invaluable activities in research work is note taking and recording the collected information in a standard format for consultation and reference during the course of research. A researcher consults numerous documents, many of them read intensively. Notes of different kinds get generated from this effort, which also is to be systematically recorded and filed. These may include by and large groups like:

- Bibliographical references, both directly related to the topic of research and additional references;
- Subject notes that get formulated as the research work progresses;
- Quotations, Paraphrases, Summaries, Abstracts; and
- Evaluative notes or remarks and such others.

N.B. This type of detailed notes taking would be absolutely necessary for research projects, which takes a few years to complete. For research work of shorter duration,

reference notes may be considerably small and could be easily managed even recorded in slips and properly organised and maintained for easy reference and use.

A word of caution is necessary in taking notes. Notes files should not grow in bulk, lest it would defeat its very purpose. While taking notes, the researcher should carefully weigh every note in terms of its utility and aid in the preparation of the final report.

Bibliographical References

Literature pertaining to the field of research has to be collected through effective search procedures of information storage and retrieval databases. These searches throw number of bibliographical references to be consulted for obtaining all background information and knowledge of the field of research. Many of these references may be of direct relevance to the research study and are to be read thoroughly. There are also references, which may not be directly relevant to the topic of research but may be useful as additional sources of information. These references, therefore, constitute two categories namely those that are directly concerned with the topic of research and those that are of peripheral value. It is out of these information sources notes are prepared.

These references ought to be very carefully and systematically recorded with one hundred percent accuracy for the simple reason that they are constantly referred to during the course of the research study and even later stages. They ought to be legibly written without any overwriting or just scribbled. The general tendency of most research students is take this work in a casual manner, which may create serious problems at later stages of the work when such documents need to be consulted.

The references should be recorded in standard form prescribed for bibliographic citations for books, journal articles, technical and research reports, conference papers and proceedings, and others.

There are style manuals that prescribe standard practice of citations and the format for recording bibliographic references.

The libraries and other institutions from which the reference source has been obtained have also to be recorded with accuracy. The Call Number of the book, or the Journal title from which the reference has been selected and such other details for other kind of documents ought to be recorded accurately. No effort should ever be spared in doing this work.

A suggested format for bibliographical reference is given below:

- Title of the document with the author and whatever other details necessary. Edition statement, if any. Year of publication. Publisher and Place, collation, if necessary.
- Subject heading of the document.
- Name of the Library form where the reference was sought and address, if need be; Call No. of the document.
- Relevant chapter or section to which the document is related.
- Specific indication of its reference value to the researchers work.

This information is to be stored in a 4" X 6" card and filed alphabetically by title or subject, depending upon the researcher's need or choice with an index for other approaches.

Subject Notes

These are notes of ideas or thoughts that occur to a researcher at different stages of research work. These should be recorded as topical outlines or descriptive subject

description and filed according to standard subject headings with reference to the chapter(s) of the research report.

Such thoughts or ideas may arise while travelling, in the toilet, during listening to lectures, at seminar or conference discussions and at such other odd times. These are the most valuable information in the research process that would provide considerable substance to the research work. Such thoughts or ideas keep coming to the minds of active researchers who are so deeply involved in the work and are constantly or intensively thinking of their research work. The important point to be noted here is that they should be recorded immediately lest easily forgotten. Scribbling slips should always be kept at hand in readiness for recording such thoughts which ought not to be ignored as they occur at odd times.

These thoughts may arise at any stage of the research process i.e. while reviewing literature, formulating assumptions and/or hypothesis, selecting research methods, methods of data collection, their assembly in systematic order, analysis, presentation with graphic representation, interpretation, making inferences, conclusions, generalisation and possible applications of results.

Not only are these notes recorded in a systematic format, but they also are to be filed in a manner, easy for consultation. The way in which these notes are recorded or organised may vary from individual to individual, yet a few suggestions are given below for general guidance, especially for students and junior researchers.

These ideas and thoughts may be classified into two or three sets.

- 1) Ideas pertaining to a particular aspect i.e. data to provide evidences to testing hypothesis, or methods of data analysis, interrelations between different types of data and so on.
- 2) Critical comments on any aspect while reading relevant literature to be considered at the stage of discussions or to be rejected.
- 3) Points that have emerged while discussing these ideas with seniors, peers and colleagues or even students.

Suggested format:

- Subject Heading
- Chapter reference
- Topical statement(s); Descriptive subject heading
- Comments
- Document Reference, if any
- Date/Time of occurrence of ideas
- Names of persons consulted
- Any other important reference

The data can be stored in 4" X 6" cards and filed subject wise.

Bibliographical References: Documents that are directly used. Documents that provide additional references.

Information that should be recorded is full bibliographical details. Name of the library/ other institution(s) at which the document was available for consultation with location details, i.e. call no. of the document and other details to identify the document when needed.

Subject heading of the document. Chapter heading(s) of the research report.

These references should be filed alphabetically or subject wise.

Quotations, Paraphrases, Summaries, Evaluative notes are to be recorded systematically and filed with reference to chapters, under subject headings.

Quotations from the writing of outstanding authors/writers, scholars always give weightage to any serious work of any scholarly nature.

These may general ones or pertaining to the field of the researcher. The quotation should be used in an appropriate place.

Paraphrases/Summaries are usually condensed notes from long passages in a document which are written in the language of the researcher for use at an appropriate place in the report.

Evaluative comments pertain to notes that are critically examined with reference to the research aspects which may or may not be used in the final report. Yet, they may be useful to show that every aspect of the research work had been studied.

Some aspects of drafting ideas in an attractive style both in terms of contents and language may also occur to a researcher during the course of research work. It may be a few sentences or a paragraph or even longer passages of writing. Such drafts may form part of this file.

All these notes are recorded in 4" X 8" cards. The notes may be in three distinct files or in a single file with indexes for easy access. They may be profitably arranged subject wise with indexes to have approaches from any other approach as decided by the researcher.

These cards should be kept in a box for easy transportation if necessary to be carried. They should be updated at regularly intervals.

Self Check Exercise

- 5) What are the three kinds of notes taken for research work? State the format of notes for subject files.

Note: i) Write your answer in the space given below.

ii) Check your answer with the answers given at the end of the Unit.

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Foot Notes

Foot notes are citations, comments, explanations, illustrations, etc. that are placed at the end of a page of a research report, with an indication mark in the appropriate place in the body of the report. The information collected in the notes files are used for this purpose.

It is also a practice to collect them at the end of a chapter or at the end of the report along with References and Bibliography. It all depends where the author would like have them.

18.7 DRAFTING OF RESEARCH REPORTS

Drafting a research report is the communicatory stage in research. The preliminary work, as we have emphasised already, are careful outlining and notes-taking which provide the necessary outfits for drafting the final report.

Communication skills, both oral and written are indispensable for library and information professionals. Other professional skills being equal, those that have communication skills get invariably greater preference in job markets. While both writing and oral communications are equally important, we are concerned in this Unit, with writing skills.

Any type of writing is a skill acquired through cultivation. It takes fairly a long time to be a consummate writer. Picking up skills in writing requires a great lot of reading. In fact writing and reading go hand in glove. Writing abilities stabilise only through repeated attempts at writing in the form of general articles and professional papers. Good writing stems from extensive reading of the works of outstanding authors. Extensive reading over a range of topics for breadth of background and intensive reading on selected themes for analytical, evaluative purposes are desirable for research students. (Good and Scates, 1954). Reading should be much wider than reading professional literature. While research reports are not classed as creative writing, yet they are results of creative work and therefore should also reflect the effects of creative writing.

In writing one should always be very clear as to whom the writing is meant for. In other words who are the potential readers of the writer. Research reports are for those who are peers in the field, research colleagues, students and those that are likely to use the report findings for their possible applications and such others. This important factor should always be kept in mind while drafting a research report.

Self Check Exercise

6) What constitutes good writing? How is it cultivated?

Note: i) Write your answer in the space given below.

ii) Check your answer with the answers given at the end of the Unit.

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18.7.1 Language and Grammar

The hall mark of good writing is its lucidity and ease of understanding of the contents. Keeping this as a fundamental principle, the language employed has to conform to all other attributes of writing like style, diction, semantics and syntactic and rules of grammar.

Style is a natural ability to write in a captivating manner. This requires perfect understanding of the subject written about, a flair for writing, command of the language and a clear vision of those who are likely to read the output. This skill can also be acquired by reading excellent research reports/technical written eminent research scholars some of whom have great writing capabilities.

Diction refers to the choice of words, their arrangement and the force, accuracy and distinctions with which they are used. Need less to say that choice of words and phrases are to be in a form that helps a reader to get a clear idea of the contents of any writing. Apt words and phrases greatly enhance readability. This skill will have to be cultivated through extensive reading and constant writing.

Semantics deals with different meanings of words. English language is full of synonyms and the choice of a word should be selected from among the shades of differences in the meaning of a word which perfectly represents the correct sense, the writer wishes to convey. There are excellent dictionaries which not only provide the meanings of a word but also the meanings of all its synonyms and their usage. In many examples are also given. Roget's thesaurus of synonyms and antonyms of words in dictionary form is a valuable tool that could be very effectively used for good writing. This natural language thesaurus gives for every word its synonyms as nouns, verbs, adjectives and adverbs.

Syntactics deals with the pattern of structure of the word order in a sentence or phrase to convey ideas effectively. While diction pertains choice of appropriate words and phrases, the syntax fixes the chosen words and phrases in a meaningful order in a sentence. This skill again comes through reading and writing.

Grammar provides the basic principles for writing good prose in the form of a set of rules. Although grammar is learnt even at the school stage, correct writing has to be cultivated. Some elementary rules such as sentences must use correct form of verbs tenses. They should agree in number with the subjects of sentences. Pronouns should agree with their antecedents. Prepositions should be used very carefully to connect words. The rules of grammar for sentence formation for simple, compound and complex must be carefully adopted. Although these are very simple rules, quite often not much attention is paid to these aspects, particularly at the student level which invariably hampers readability.

Self Check Exercise

7) What aspects of language would ensure quality writing? Explain Syntactics.

Note: i) Write your answer in the space given below.

ii) Check your answer with the answers given at the end of the Unit.

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Organisation of the Report

Keeping in view all these aspects of language and grammar and the framework for the preparation of research reports, two types of drafting outlines viz. sentence outline or topical outline may help in the presentation of the theme(s) of the research report, pertaining to any section i.e. from Introduction to Interpretation, Discussion and Summary. The sentence outline consists of statements that can be expanded in each

section of the report. The topical outline, on the other hand, is a list of topics and sub-topics that are covered in the report.

Illustrative examples of the two types of outlines for drafting are given below. The examples pertain to using information technology for various library operations and information support services to optimise the use of collections in a library and at providing the best possible information support systems and services, attending maximally to users' information needs with speed and efficiency.

A drafting sentence outline for a library automation project with building up systems and services for optimum use of the collections is as follows:

Drafting sentence outline for a Library Automation Research Project

The hypothesis of this research project may be 'Optimal facilities and best users' systems and services can be provided in a modern library, only with the use of information technology with collection development oriented towards the needs of users. The modern library should renovate at periodical intervals to keep the system and services alive and dynamic to changes.'

Sentence Outlines According to the Fifth Law of Library Science of Ranganathan, "A Library is a Growing Organism." This implies that a library is ever changing due to various environmental developments and advances in technology. Currently libraries are switching to automating their operations with the applications of special software systems, making use netting soft wares and also availing Web and internet services.

I) So a self-renovating library has to respond to changes in all dimensions. If not, the problems likely to arise are:

- Hampered growth in size, the quality of service getting poorer and poorer;
- Undue delay in every service, increasing waiting time for getting any required material;
- Shelf failures becoming numerous, failing to locate even oft used items;
- The library catalogue too often fails to respond to requests;
- Circulation counter getting slower in operation and services;
- Few meetings of reference staff and library leaders;
- Mechanical operations with no human element in each and every service.

II) If this condition is allowed to continue, it results in huge fall in standards and the entire facility becoming obsolete;

- Collection grow without adequate shelving facilities, resulting hampering easy movement of collections;
- Browsing becomes almost impossible, in open access systems;
- Stacking areas encroach on reading areas;
- Less facilities for user service, readers getting very little space;
- Financial allocations get imbalanced, attention given to provision for space for stacks, budgets for collection getting reduced;

III) The only alternative is to choose alternatives that will arrest the unmanageable and undesirable growth and yet maintain high quality of service.

- Automate library operations with a soft ware that provide a highly user oriented services'
- The collection development should totally concentrate on active areas of knowledge and should be highly oriented towards to user needs;
- Acquire alternate forms of materials to print materials;
- Use more and more networking facilities for providing items;
- Adopt a vigorous policy for weeding and wherever possible digitizing technology;
- Use extensively internet facilities for accessing data bases and providing user services;
- Employ professional staff with considerable knowledge in subjects handled by the library with high skills in computer operations, systems and services.

These outlines should be used at the appropriate sections to expand the ideas they carry, justifying the changeover to renovating the library.

Topical Outlines

- A library is a growing Organism;
- Goal to provide high quality service;
- Problems of disjointed growth;
- Collections, Shelf Space, Readers facilities, staff and others.
- Fall in standards; Disproportionate allocations of funds;
- Services and staff;
- Alternatives:
- Library automation
- Collection development –user oriented.
- Services development using network systems;
- Alternative forms to print material;
- Highly professional and computer skilled personnel;
- Use of Internet and Web services.

The sentences outline generally is rather difficult to formulate, unless there is a clear vision of the renovated library. But once they are formed, it helps drafting the sections with greater ease and connecting coordinating and coordinating the ideas logically and convincingly.

The topical outline is easy to draft but requires considerable skill in expanding them. It also requires a high degree of organising skill in fleshing ideas with an excellent vision of a renovated library.

Self Check Exercise

8) What are the aids that help drafting a research draft?

Note: i) Write your answer in the space given below.

ii) Check your answer with the answers given at the end of the Unit.

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18.8 PHYSICAL PRODUCTION

Two aspects need careful attention in the production of the final Copy of the Research Report viz. 1) Preparation of the manuscript and 2) the physical production including printing.

18.8.1 Preparation of Manuscripts

Manuscript here refers to the researcher's final draft of the research report which goes to the typesetter for the final production of the research report. For theses and dissertations which are lengthy, the preparing the final draft should be given careful attention so that the typesetting work does not get into any unnecessary and avoidable problem. If the draft is prepared using Micro Soft Word processor, it can provide a clean and accurate copy of the final draft for typesetting using a Desk Top Publishing Software. In fact, if the researcher has training and experience in using MS Word, it would considerably save time and an assurance of accuracy of the draft. It is highly desirable for a library and information professional to cultivate and acquire expert skills in word processing.

The composition and page layout and related organization of the manuscript for the physical production of the Research Report is a specialist job who may not have any idea of the contents of the Research Report. Hence the researcher has to give clear instructions to the typesetter for every detail e.g. Fonts and sizes of letters, headings and sub-headings, footnotes, their format and fonts, size, words in bold, or in italics or underlined, graphics to be placed at the right places, tables and figures at the appropriate places and similar other instructions. A Style Manual would give the right format for bibliographical citations for every type document, footnotes, graphics and illustrations, tables and figures and to many other details in the preparation of the final copy. Spell Check facilities available in Software should be utilized to correct any error which had come inadvertently or by oversight.

Self Check Exercise

9) State the two steps of physical production.

Note: i) Write your answer in the space given below.

ii) Check your answer with the answers given at the end of the Unit.

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18.8.2 Final Phase of Physical Production

Once the final copy of the manuscript is ready, the physical production of the manuscript is taken up. This involves four operations viz.

- Composing the matter
- Page layout of the composed matter
- Production of the final document
- Binding and final finish
- Publishing aspects, if the report is published.

Composing

Advances in information and communication technology are changing the entire process of writing and publishing scenario. The emergence of personal computers with a number of features of DTP facilities, have virtually enabled an author to become a publisher too. The results of these facilities brought about amazing speed in the processes of composing, layout of pages, printing and binding. All these have also ensured excellence in quality of the final product.

The standard features of most word processing software packages with reference to text formatting and text editing. The former provides for setting left, right, top and bottom margins, line spacing, justification, page size, page numbering, centered and shoulder headings, etc. The latter facilitate deletion of words, blocks of texts or move sentences or blocks to any other place desired or move to another file, types of founts and their sizes, facilities for insertion of tables and figures, graphics, appending text from a floppy file, insertion of new text, global search and replacement of occurrence of one word with another and easy movement backwards and forwards, and the like. Latest versions of MS Word and other similar software packages handle graphic images, spell checks, thesaurus, indexing, calculations, etc. Top range softwares such as Word Perfect offer features close to Desktop publishing in addition to all the features mentioned here.

Page Layout of Composed Matter

Desktop Publishing (DTP) software is user friendly package that enables documents to be produced with a quality approaching that of documents produced by professional printing. An important feature of DTP is that it includes text formatting, page layout, features of word processing, spread sheets (Excel) for tables and some graphics, insertion of graphics and illustrations in the body of text and such others.

Production of the final document

The physical production of the final Research report depends on a clean and errorless manuscript and detailed instructions to the typesetter on every aspect of the production. Print-outs obtained by computer printers, depends very much on their quality. Laser printers are the best choice. Expensive models of laser printers provide for storage for a range of founts and type sizes for Roman scripts and English and other scripts of languages.

Scanners can be very useful to capture data from printed pages, images of various kinds. These have to be inserted in appropriate pages along with the text and well laid out.

If the document has to be printed and a great number of copies are to be produced, modern printing technology offers several alternatives.

Binding and final finish of the physical production should also be given considerable attention for their aesthetic value which always creates a feeling of pleasure in using a well brought out document.

If the report is to be published, the researcher does well to discuss the publisher and act according to the suggestions given by the publisher with reference to the manner of publication and marketing.

Self Check Exercise

10) What are the four operations involved in the final production of a research report?

Note: i) Write your answer in the space given below.

ii) Check your answer with the answers given at the end of the Unit.

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18.9 SUMMARY

This section deals with last major step in the conduct of a research project. Effective reports of completed research should communicate the procedures and results of research studies both to peers, scholars and professionals and students. This requires a clear understanding of the different types reports, their importance and significance. Research projects that need financial support, a research proposal has to be prepared which is outlined. The research Outline is discussed in detail and a model outline is suggested for the different types of research reports. The Note taking is an important aspect of research studies. This is explained in detail and the different categories notes file are given as a guide, particular for students and junior research fellows. The preparation of the manuscript and the production aspects are explained.

18.10 ANSWERS TO SELF CHECK EXERCISES

1) Research reports are detailed and accurate accounts of the conduct of disciplined studies accomplished to solve problems or to reveal new knowledge.

Research reports include 1) Research degrees: M.Phil. P.hd. ,etc. 2) Research reports of projects funded/sponsored by research institutions and industries 3) Research reports which are in the nature of technical reports and 4) Research papers published by research journals.

2) The usefulness and significance of research reports are:

The pool of knowledge gets burgeoned with new inputs of value to the already existing knowledge. Numerous primary publications are a source of information and knowledge for the research community.

The secondary sources provide access to these primary documents and also make them available for consultation.

Citation indexes providing scope for citation studies gives a new method of evaluating research work of excellence.

Persons of eminence sprout in such conditions and provide leadership to research efforts in different disciplines, heading specialized research complexes.

- 3) A research proposal is a formal document with a letter of transmittal sent to a research funding agency, applying for financial and other aids for a research program.

Its components are: Letter of Transmittal, Title page, Executive Summary, Table of contents, Statement of Request, Introduction, Preliminary section, The body and methodology, Facilities, Personnel, Duration, Cost and Funding, Summary.

- 4) An plan outline of a research report is essentially a skeletal framework upon which a report is constructed from systematically collected and organized materials. A complete outline assists the writer in recognizing logical relationships between narrative elements of reports. Outlines are also useful for the construction of cohesive paragraphs and sections that are effectively connected.

The components include: Preliminaries, Introduction, Description of study, Collection of data and analysis, Results, Discussion, Summary, Glossary, References, Appendix, Index.

- 5) Bibliographical references, both directly related to the topic of research and additional references; Subject notes that get formulated as the research work Progresses; Quotations, Paraphrases, Summaries, Abstracts, Evaluative notes or remarks and such others.

The subject notes file may have the following format:

Subject Heading

Chapter reference

Topical statement(s); Descriptive subject heading

Comments

Document Reference, if any

Date/Time of occurrence of ideas

Names of persons consulted

Any other important reference

- 6) Good writing is a communication process, keeping the target audience in mind. It should be lucid, simple, logical and organized to help understanding the contents by those for whom it is written. Good writing stems from extensive reading of the works of outstanding authors. Extensive reading over a range of topics for breadth of background and intensive reading on selected themes for analytical, evaluative purposes are desirable for research students. Reading should be much wider than reading professional literature. While research reports are not classed as creative writing, yet they are results of creative work and therefore should also reflect the effects of creative writing.

- 7) The aspects that contribute to good writing are Style, Diction, Semantics, Syntactics, Rules of Grammar. Syntactics deals with the pattern of structure of the word order

in a sentence or phrase to convey ideas effectively. While diction pertains choice of appropriate words and phrases, the syntax fixes the chosen words and phrases in a meaningful order in a sentence. This skill again comes through reading and writing.

- 8) The aids that help drafting are the two types of drafting outlines viz. sentence outline or topical outline may help in the presentation of the theme(s) of the research report, pertaining to any section i.e. from Introduction to Interpretation, Discussion and Summary. The sentence outline consists of statements that can be expanded in each section of the report. The topical outline, on the other hand, is a list of topics and sub-topics that are covered in the report.
- 9) The two steps involved in the final production of a research report are:
1) Preparation of the Manuscript, and 2) the physical production including printing.
- 10) This involves four operations involved in the final stage of production of a research report are:
 - Composing the matter
 - Page layout of the composed matter
 - Production of the final document
 - Binding and Final finish

18.11 KEYWORDS

Creative Writing : Original writing with a flair for writing, induced by intuition and ability to imagine events dramatically.

Desktop Publishing : Publication using computer software packages to manage or create data to be printed, as well as that used to make up the pages of a final document. Word processors, spreadsheets and database packages are, therefore, an essential part of DTP. As most routine publications can be produced literally on the top of a desk using a computer, it is known as desktop publishing.

Peers : Persons who are equal or above to another in position, abilities, qualification and experience.

Target Readers : Readers for whom a particular writing is meant.

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