**RESEARCH METHODOLOGY AND TECHNICAL WRITING**

**INTRODUCTION TO RESEARCH METHODOLOGY**

**Meaning of research**

* *Research refers to investigation or experimentation aimed at discovery, interpretation of facts, and revision of accepted theories or laws in the light of new facts.*
* It is a scientific and systematic search for pertinent information on a specific topic
* *It is a systematic investigation into and study of materials in order to establish facts and reach new conclusion.*
* It is a systematic method consisting of problem definition, formulation of hypothesis, collection and analysis of data, and reaching certain conclusions either in the form of solution(s) towards the concerned problem or in certain generalizations or theory

**Other definitions of research**

Redman and Mory define research as a “systematized effort to gain new knowledge

* *Burns (1994:4) defines research as a systematic investigation to find answers to a problem.*
* Kerlinger (1986:10) defines scientific research is a systematic, controlled empirical and critical investigation of propositions about the presumed relationships about various phenomena.
* Research has been considered as a systematic, controlled collection analysis and interpretation of data about phenomena to differentiate it from other ways of acquiring knowledge.
* There are many ways through which knowledge can be obtained though they may not qualify to be called scientific research.

**Research methods**

* May be understood as all those methods/techniques that are used for conduction of research*. Methods or techniques*, *thus*, *refer to the methods the researchers use in performing research operations. R*esearch methods can be put into the following three groups:
* In the first group we include those methods which are concerned with the collection of data. These methods will be used where the data already available are not sufficient to arrive at the required solution;
* The second group consists of those statistical techniques which are used for establishing relationships between the data and the unknowns;
* The third group consists of those methods which are used to evaluate the accuracy of the results obtained.

***Research methodology***

* Is a way to systematically solve the research problem? It may be understood as a science of studying how research is done scientifically. It is the study of steps that are generally adopted by a researcher in studying his/her. It is necessary for the researcher to know not only the research methods/techniques but also the methodology. Researchers not only need to know how to develop certain indices or tests, how to calculate the mean, the mode, the median or the standard deviation or chi-square, how to apply particular research techniques, but they also need to know which of these methods or techniques, are relevant and which are not, and what would they mean and indicate and why

**The Nature of Academic Research**

Research can be a way of life; it is the basis for many of the important decisions in our lives. Without it, we are deluged with information, subjected to the claims of advertisers, or influenced by hearsay in making sense of the world around us. This informal, experiential research helps us decipher the information flood we encounter daily.

Formal academic research differs from experiential research and may be more investigative in nature. For example, it may require us to learn about an area where we have little knowledge or inclination to learn. It may be library-oriented or field-oriented, depending on the nature of the research.

***-Academic*** ***research***, like the everyday research we do, is associated with curiosity and intellectual discovery.

-The writing associated with academic research is demanding and challenging, with a methodology and discipline all its own.

-Although many of the concepts and processes of research are generic, academic research is discipline-specific and demands a more rigorous methodology.

**Characteristics of Research**

1: **Objectivity** –quality of the data produced by the procedures which either control for bias or take into account subjectivity

2: **Precision** – language used to convey exact meanings, i.e., study described accurately to enable replication or extension, and correct use of results

3: **Verification** – This implies confirmation of results in subsequent experiments

4: **Explanatory** – since research attempts to explain relationships among phenomena and reduce to simple statements or aims to reduce the complex to the simple, then keep everything simple. That is, give an explanation that predicts

5: **Empiricism** – this means that critical elements in research are evidence/data (obtained from systematic research methods), observations, experience and logical interpretation based on the evidence

6: **Logical reasoning** – This is a thinking process where one proceeds from a general statement to specific conclusion (deduction) or from specific statements to generalization (induction)

7: **Conditional conclusions** – Research results are not absolute truths, so use phrases like “our data tend to indicate” or are suggestive of, etc.

**Importance of Research**

The purpose of research is to discover answers to questions through the application of scientific procedures. The main aim of research is to find out the truth which is hidden and which has not been discovered as yet. Though each research study has its own specific purpose, we may think of research objectives as falling into a number of following broad groupings:

1. **Discovery:** The main purpose of research is to unearth new knowledge. This involves discovery of new facts, their interpretation and practical application.
2. **Prediction:** Research helps people to determine the effect of a particular variable on another. Prediction is the ability to estimate a phenomenon
3. **Controlling:** Control is concerned with the ability to regulate a phenomenon under investigation. Research enables to estimate impact of a variable on another.
4. **Theory Development:** Research helps to formulate concepts, laws, and generalizations about a given phenomenon. It is also conducted in an attempt to confirm or validate existing theories
5. **Explanation:** It involves accurate observation and measurement of a given phenomenon. In order to explain a phenomenon one should be able to describe it, predicts its occurrence and observe factors that cause its occurrence with certainty and accuracy.

***Other objectives of research include:***

* To gain familiarity with a phenomenon or to achieve new insights into it (studies with this object in view are termed as *exploratory* or *formulative* research studies);
* To portray accurately the characteristics of a particular individual, situation or a group (studies with this object in view are known as *descriptive* research studies);
* To determine the frequency with which something occurs or with which it is associated with something else (studies with this object in view are known as *diagnostic* research studies);
* To test a hypothesis of a causal relationship between variables (such studies are known as *hypothesis-testing* research studies).

**TYPES OF RESEARCH**

The basic types of research are as follows:

1. **Descriptive Research: *Descriptive research* includes surveys and fact-finding enquiries of different kinds. The major purpose of descriptive research is description of the state of affairs as it exists at present. The main characteristic of this type of research is that the researcher has no control over the variables; he can only report what has happened or what is happening.** Most *ex post facto research* projects are used for descriptive studies in which the researcher seeks to measure such items as, for example, frequency of shopping, preferences of people, or similar data. *Ex post facto studies* also include attempts by researchers to discover causes even when they cannot control the variables. The methods of research utilized in descriptive research are survey methods of all kinds, including comparative and correlational methods.
2. **Applied/Action Research:Applied researchaims at finding a solution for an immediate problem facing a society or an industrial/business organization, whereas. Thus, the central aim of applied research is to discover a solution for some pressing practical problem.Applied research is directed towards practical applications of knowledge and when successful, results in directives for development of blueprints.**

In applied research, the primary aim of the investigator is to generate knowledge which is of immediate practical utility.

Applied research may investigate ways to improve agricultural production, cure a specific disease, curb population growth, etc.

1. **Fundamental/Basic /Pure Research**: **Basic research is directed towards an increase in knowledge. There is no direct benefit of the findings since the study is conducted to satisfy the curiosity of researcher that is, need to establish why things happen. Basic research is the source of most theories, principles, and ideas.** The research basically stimulates new ways of thinking and motivates man to expand boundaries of knowledge. However basic research in long run forms the basis of applied research.
2. **Exploratory Research:** It is a study conducted into a problem where there is no earlier studies to refer to. The main focus is to gain insights and familiarity for later investigations. It is also a preliminary research conducted to increase understanding of a concept, to clarify the exact nature of the problem to be solved or to identify important variables to be studied.
3. **Experimental Research:** This type of research is guided by hypothesis showing expected relationship between variables. Such research is conducted in laboratory where conditions are manipulated to strengthen conclusion. Experimental research is time consuming and requires a lot of resources.

**Approaches to Research**

* ***Qualitative approach****: This* research is concerned with subjective assessment of attitudes, opinions and behavior. Research in such a situation is a function of researcher’s insights and impressions. Such an approach to research generates results either in non-quantitative form or in the form which are not subjected to rigorous quantitative analysis. Generally, the techniques of focus group interviews, projective techniques and depth interviews are used.
* **Quantitative approach:** It involves the generation of data in quantitative form/numbers which can be subjected to rigorous quantitative analysis in a formal and rigid fashion. This approach can be further sub-classified into *inferential*, *experimental* and *simulation approaches* to research. The purpose of *inferential approach* to research is to form a data base from which to infer characteristics or relationships of population. This usually means survey research where a sample of population is studied (questioned or observed) to determine its characteristics, and it is then inferred that the population has the same characteristics. *Experimental approach* is characterized by much greater control over the research environment and in this case some variables are manipulated to observe their effect on other variables. *Simulation approach* involves the construction of an artificial environment within which relevant information and data can be generated. This permits an observation of the dynamic behavior of a system (or its sub-system) under controlled conditions. The term ‘simulation’ in the context of business and social sciences applications refers to “the operation of a numerical model that represents the structure of a dynamic process. Given the values of initial conditions, parameters and exogenous variables, a simulation is run to represent the behavior of the process over time.”5 Simulation approach can also be useful in building models for understanding future conditions.

**Qualities of a good research:**

* *Good research is systematic:* It means that research is structured with specified steps to be taken in a specified sequence in accordance with the well-defined set of rules. Systematic characteristic of the research does not rule out creative thinking but it certainly does reject the use of guessing and intuition in arriving at conclusions.
* *Good research is logical:* This implies that research is guided by the rules of logical reasoning and the logical process of induction and deduction are of great value in carrying out research. Induction is the process of reasoning from a part to the whole whereas deduction is the process of reasoning from some premise to a conclusion which follows from that very premise. In fact, logical reasoning makes research more meaningful in the context of decision making.
* *Good research is empirical:* It implies that research is related basically to one or more aspects of a real situation and deals with concrete data that provides a basis for external validity to research results.
* *Good research is replicable:* This characteristic allows research results to be verified by replicating the study and thereby building a sound basis for decisions.

Researchers face the following problems in their work:

* There is *insufficient interaction* between the university research departments on one side and business establishments, government departments and research institutions on the other side. A great deal of primary data of non-confidential nature remains untouched/untreated by the researchers for want of proper contacts. *Efforts should be made to develop satisfactory liaison among all concerned for better and realistic researches*. There is need for developing some mechanisms of a university—industry interaction programme so that academics can get ideas from practitioners on what needs to be researched and practitioners can apply the research done by the academics.
* Most of the business units do not have the confidence that the material supplied by them to researchers will not be misused and as such they are often reluctant in supplying the needed information to researchers. The concept of secrecy seems to be sacrosanct to business organisations in the country so much so that it proves an impermeable barrier to researchers. Thus, *there is the need for generating the confidence that the information/data obtained from a business unit will not be misused*.
* *Research studies overlapping one another are undertaken quite often for want of adequate information*. This results in duplication and fritters away resources. This problem can be solved by proper compilation and revision, at regular intervals, of a list of subjects on which and the places where the research is going on. Due attention should be given toward identification of research problems in various disciplines of applied science which are of immediate concern to the industries.
* *There does not exist a code of conduct for researchers* and inter-university and inter- departmental rivalries are also quite common. Hence, there is need for developing a code of conduct for researchers which, if adhered sincerely, can win over this problem.
* Many researchers also face *the difficulty of adequate and timely secretarial assistance,* including computerial assistance. This causes unnecessary delays in the completion of research studies. All possible efforts be made in this direction so that efficient secretarial assistance is made available to researchers and that too well in time.

**TOPIC TWO: RESEARCH PROBLEM AND OBJECTIVES**

**Research Problem**

A research problem, in general, refers to some difficulty which a researcher experiences in the context of either a theoretical or practical situation and wants to obtain a solution for the same

* A research problem is an intellectual stimulus calling for a response in the form of scientific inquiry [Nachmias & Nachmias, 1996]
* Research problems could either be (i) those relating states of nature, or (ii) determine relationships between variables hence decide /choose area of interest for inquiry
* Formulate a general topic (in a broad general way) and then reduce this to more specific research problem (These two steps require thorough understanding of the problem and breaking into manageable components) (Discuss with colleagues and supervisor(s))
* Scour available literature for familiarity with the chosen problem (There are two types of literature: (1) conceptual one that develops concepts and theories, (2) empirical literature comprising previous studies in the chosen area of focus

**Characteristics of Research Problems**

Research problems need to be

* **Empirically grounded**
* **Clearly and specifically stated** (Have action verb(s), variables, scope)

(e.g. “Using Fuzzy K-Modes to Analyze Patterns of System Calls for Intrusion

Detection” – see Holz et al, ITiCSE '06, June 26-28, 2006, Bologna, Italy.)

Lack of clarity and specificity could lead to ambiguous findings and misinterpretations.

* **Logical**
* **Justifiable**
* When a research problem is formulated serious thought should be given to: Unit (level) of analysis (the basic part of the phenomenon to be studied, i.e., what is it to be studied/fathomed?) as it influences research design and data collection since these must be congruent with it. Units of analysis have unique attributes, so it’s not advisable to shift from one to the other, as generalizations derived from individuals as units of analysis may be different from those based on groups. The distortion arising from generalizing from a complex unit of analysis to a simpler one or from a higher level to a lower one is known as ecological fallacy. The converse of ecological fallacy is called individualistic fallacy.

Remember research starts when the researcher identifies a research topic, or problem and then follows methodical steps to investigate/solve the problem.

In trying to identify a research problem ask such questions as: What? Why? How? Note that some research problems may focus on selection of the best courses of action.

The sources of research ideas are many: e.g., society/community/state; Literature (published works so look carefully in introduction, conclusions or recommendations). Thus a prospective researcher must be observant.

**Choosing a research topic**

* Identifying a research problem is made easier if you stick to your area of study/specialization.
* Shy a way from topics that have been extensively studied (difficult to throw new light).
* Eschew controversial areas unless you are experienced.
* Try to identify unresolved problems (have long term plans in your choice of research topic. That which makes you an authority is preferable).
* Avoid too narrow or vague a problem, and choose research topic bearing in mind the resources available at your disposal, time inclusive
* Defining a research problem can be seen to follow sequentially the following pattern:

1. General statement of the problem ➔
2. Understanding the nature of the problem, e.g. through discussion with those knowledgeable ➔
3. Survey available literature ➔
4. Refine or rephrase the research problem (more specific formulation e.g., having objectives that are Specific, Measurable, Achievable, Realistic and Time bound (SMART)

**Factors considered in selecting research problem**

* Interest
* Resources
* Measurement of concepts
* Level of expertise
* Relevance
* Availability of data
* Ethical issues

**Ways of identifying research problem**

* Conducting literature review
* Discussion with experts
* Replication
* Previous research studies
* Media
* Personal experience

**Categories of Topics that Computer Science Researchers Address**

* These fall the following major categories:
  + Problem-solving concepts (e.g., algorithms, AI, Mathematics/computational science)
  + Computer concepts (e.g., Computer/hardware principles/architecture, Inter-computer communication, Operating systems, etc)
  + Systems/software concepts (e.g., System architecture/engineering; Programming languages; Methods/techniques; Tools (including compilers, debuggers); Human–computer interaction; System security)
  + Data/information concepts (e.g., Data/file structures; Data base/warehouse/mart organization; Information retrieval; Data analysis; Data security)
  + Problem-domain-specific concepts (Computer graphics/pattern analysis; Information systems; Scientific/engineering (including bio-informatics))
  + Systems/software management concepts (Project/product management (including risk management))
  + Organizational concepts (Technology transfer (including innovation, acceptance, adoption, diffusion); Management of ‘‘computing’’ function)

**Example of Research Topics:**

* **A framework to support study group formation using Online Social media- the case of twitter**
* **Application of Multi-agent Technology to Information Systems: An Agent-based Design Architecture for Decision Support Systems (*haolan Zhang)***
* **A Model-Driven Approach to Accessing Managerial Information: The Development of a Repository-Based Executive Information System (Minder Chen)**

**Questions that a good research problem should answer:**

* How clearly and concisely is the problem stated?
* Is it sufficiently delimited to be open to investigations? Does it have sufficient practical or theoretical value to warrant the study?
* Is it stated in a way that it expresses the relationship between two or more variables? (exception is descriptive research)
* Does it have a rationale? If the problem been studied before and if so should be studied again and would the study lead to additional knowledge?
* Will the findings lead to further hypotheses, thereby increasing the probability of adding to existing knowledge?

N/B: **A** **HYPOTHESIS**- A hypothesis is a tentative assumption which is made in order to draw out and test its logical and empirical consequences

**ASSIGNMENT 1**

1. Identify your research problem (depending on your area of specialization) and state it in a general way. (Note this problem is the one you will later on refine).
2. Identify three research areas in the following fields in ICT

* Distributed systems
* Artificial Intelligence
* Electronic Commerce
* Mobile computing

**THE RESEARCH PROCESS**

Research process consists of series of actions or steps necessary to effectively carry out research and the desired sequencing of these steps. The chart shown illustrates a research process.



**1. Formulating the research problem:** There are two types of research problems, viz., those which **relate to states of nature** and those which **relate to relationships between variables.**

**At the very *outset the researcher must single out the problem he wants to study*, i**.e., **he must decide the general area of interest or aspect of a subject-matter that he would like to inquire into. Initially the problem may be stated in a broad general way and then the ambiguities, if any, relating to the problem be resolved.** Then, the feasibility of a particular solution has to be considered before a working formulation of the problem can be set up.

The formulation of a general topic into a specific research problem, thus, constitutes the first step in a scientific enquiry. **Essentially two steps are involved in formulating the research problem, viz**., **understanding** the problem thoroughly, and **rephrasing** the same into meaningful terms from an analytical point of view.

**The best way of understanding the problem is to discuss it with one’s own colleagues or with those having some expertise in the matter.** In an academic institution the researcher can seek the help from a guide who is usually an experienced man and has several research problems in mind.

This task of formulating, or defining, a research problem is a step of greatest importance in the entire research process. The problem to be investigated must be defined unambiguously for that will help discriminating relevant data from irrelevant ones. Care must, however, be taken to verify the objectivity and validity of the background facts concerning the problem.

The statement of the objective is of basic importance because it determines the data which are to be collected, the characteristics of the data which are relevant, relations which are to be explored, the choice of techniques to be used in these explorations and the form of the final report. If there are certain pertinent terms, the same should be clearly defined along with the task of formulating the problem. In fact, formulation of the problem often follows a sequential pattern where a number of formulations are set up, each formulation more specific than the preceding one, each one phrased in more analytical terms, and each more realistic in terms of the available data and resources.

**2. Extensive literature survey:** Once the problem is formulated, a brief summary of it should be written down. It is compulsory for a research worker writing a thesis for a degree, masters or Ph.D. to write a synopsis of the topic and submit it to the necessary Committee or the Research Board for approval.

**At this juncture the researcher should undertake extensive literature survey connected with the problem**. For this purpose, the abstracting and indexing journals and published or unpublished bibliographies are the first place to go to. **Academic journals, conference proceedings, government reports, books etc., must be tapped depending on the nature of the problem.** In this process, it should be remembered that one source will lead to another. The earlier studies, if any, which are similar to the study in hand should be carefully studied. A good library will be a great help to the researcher at this stage.

**3. Development of working hypotheses:** After extensive literature survey, researcher should state in clear terms the working hypothesis or hypotheses. **Working hypothesis is tentative assumption made in order to draw out and test its logical or empirical consequences**. As such the manner in which **research hypotheses are developed is particularly important since they provide** the **focal point for research**. They also **affect the manner in which tests must be conducted in the analysis of data and indirectly the quality of data which is required for the analysis. The role of the hypothesis is to guide the researcher by delimiting the area of research and to keep him on the right track. It sharpens his thinking and focuses attention on the more important facets of the problem. It also indicates the type of data required and the type of methods of data analysis to be used.**

In most types of research, the development of working hypothesis plays an important role. **Hypothesis should be very specific and limited to the piece of research in hand because it has to be tested.**

***How does one go about developing working hypotheses?*** The answer is by using the following approach:

**(a) Discussions with colleagues and experts about the problem, its origin and the objectives in seeking a solution;**

**(b) Examination of data and records, if available, concerning the problem for possible trends, peculiarities and other clues;**

**(c) Review of similar studies in the area or of the studies on similar problems; and**

**(d) Exploratory personal investigation which involves original field interviews on a limited scale** with interested parties and individuals with a view to secure greater insight into the practical aspects of the problem.

Thus, working hypotheses arise as a result of a-priori thinking about the subject, examination of the available data and material including related studies and the counsel of experts and interested parties.

Working hypotheses are more useful when stated in precise and clearly defined terms. It may as well be remembered that occasionally we may encounter a problem where we do not need working

**4. Preparing the research design:** The research problem having been formulated in clear cut terms, the researcher will be required to prepare a research design, i.e., **he will have to state the conceptual structure within which research would be conducted.**

The **preparation of such a design facilitates research to be as efficient as possible yielding maximal information**. In other words**, the function of research design is to provide for the collection of relevant evidence with minimal expenditure of effort, time and money**. But how all these can be achieved depends mainly on the research purpose.

Research purposes may be grouped into four categories, viz., (i) Exploration, (ii) Description,

(iii) Diagnosis, and (iv) Experimentation. A flexible research design which provides opportunity for considering many different aspects of a problem is considered appropriate if the purpose of the research study is that of exploration.

But when the purpose happens to be an accurate description of a situation or of an association between variables, the suitable design will be one that minimizes bias and maximizes the reliability of the data collected and analyzed.

There are several research designs, such as, experimental and non-experimental hypothesis testing. Experimental designs can be either informal designs (such as before-and-after without control,

after-only with control, before-and-after with control) or formal designs (such as completely randomized design, randomized block design, Latin square design, simple and complex factorial designs), out of which the researcher must select one for his own project.

The **preparation** of the research design, appropriate for a particular research problem**, involves usually the consideration of the following:**

**(i) The means of obtaining the information;**

**(ii) The availability and skills of the researcher and his staff (if any);**

**(iii) explanation of the way in which selected means of obtaining information will be organized**

**and the reasoning leading to the selection;**

**(iv)The time available for research; and**

**(v) The cost factor relating to research, i.e., the finance available for the purpose.**

**5. Determining sample design: All the items under consideration in any field of inquiry constitute a ‘universe’ or ‘population’.** A complete enumeration of all the items in the ‘population’ is known as a census inquiry. It can be presumed that in such an inquiry when all the items are covered no element of chance is left and highest accuracy is obtained. But in practice this may not be true. Even the slightest element of bias in such an inquiry will get larger and larger as the number of observations increases. Moreover, there is no way of checking the element of bias or its extent except through a resurvey or use of sample checks. Besides, this type of inquiry involves a great deal of time, money and energy. Not only this, census inquiry is not possible in practice under many circumstances. For instance, blood testing is done only on sample basis. Hence, quite often we select only a few items from the universe for our study purposes. The items so selected constitute what is technically called a sample.

The researcher must decide the way of selecting a sample or what is popularly known as the sample design. In other words, a sample design is a definite plan determined before any data are actually collected for obtaining a sample from a given population. Thus, the plan to select 12 of a city’s 200 drugstores in a certain way constitutes a sample design. Samples can be either probability samples or non-probability samples. With probability samples each element has a known probability of being included in the sample but the non-probability samples do not allow the researcher to determine this probability. Probability samples are those based on simple random sampling, systematic sampling, stratified sampling, cluster/area sampling whereas non-probability samples are those based on convenience sampling, judgement sampling and quota sampling techniques.

A brief mention of the important **sample designs is as follows**:

(i) ***Deliberate sampling****:* Deliberate sampling is also known as purposive or non-probability sampling. This sampling method involves purposive or deliberate selection of particular units of the universe for constituting a sample which represents the universe. When population elements are selected for inclusion in the sample based on the ease of access, it can be called *convenience sampling*. If a researcher wishes to secure data from, say, gasoline buyers, he may select a fixed number of petrol stations and may conduct interviews at these stations. This would be an example of convenience sample of gasoline buyers. At times such a procedure may give very biased results particularly when the population is not homogeneous. On the other hand, in *judgement sampling* the researcher’s judgement is used for selecting items which he considers as representative of the population. For example, a judgement sample of college students might be taken to secure reactions to a new method of teaching. Judgement sampling is used quite frequently in qualitative research where the desire happens to be to develop hypotheses rather than to generalise to larger populations.

(ii) ***Simple random sampling:***This type of sampling is also known as chance sampling or probability sampling where each and every item in the population has an equal chance of inclusion in the sample and each one of the possible samples, in case of finite universe, has the same probability of being selected. For example, if we have to select a sample of 300 items from a universe of 15,000 items, then we can put the names or numbers of all the

15,000 items on slips of paper and conduct a lottery. Using the random number tables is another method of random sampling. To select the sample, each item is assigned a number from 1 to 15,000. Then, 300 five digit random numbers are selected from the table. To do this we select some random starting point and then a systematic pattern is used in proceeding through the table. We might start in the 4th row, second column and proceed down the column to the bottom of the table and then move to the top of the next column to the right.

When a number exceeds the limit of the numbers in the frame, in our case over 15,000, it is simply passed over and the next number selected that does fall within the relevant range.

Since the numbers were placed in the table in a completely random fashion, the resulting sample is random. This procedure gives each item an equal probability of being selected. In case of infinite population, the selection of each item in a random sample is controlled by the same probability and that successive selections are independent of one another.

(iii) ***Systematic sampling:***In some instances the most practical way of sampling is to select every 15th name on a list, every 10th house on one side of a street and so on. Sampling of this type is known as systematic sampling. An element of randomness is usually introduced into this kind of sampling by using random numbers to pick up the unit with which to start.

This procedure is useful when sampling frame is available in the form of a list. In such a design the selection process starts by picking some random point in the list and then every *n*th element is selected until the desired number is secured.

(iv) ***Stratified sampling:***If the population from which a sample is to be drawn does not constitute a homogeneous group, then stratified sampling technique is applied so as to obtain a representative sample. In this technique, the population is stratified into a number of no overlapping subpopulations or strata and sample items are selected from each stratum. If the items selected from each stratum is based on simple random sampling the entire procedure, first stratification and then simple random sampling, is known as *stratified random sampling*.

(v) *Quota sampling:* In stratified sampling the cost of taking random samples from individual strata is often so expensive that interviewers are simply given quota to be filled from different strata, the actual selection of items for sample being left to the interviewer’s

judgement. This is called quota sampling. The size of the quota for each stratum is generally proportionate to the size of that stratum in the population. Quota sampling is thus an important form of non-probability sampling. Quota samples generally happen to be judgement samples rather than random samples.

(vi) ***Cluster sampling and area sampling****:* Cluster sampling involves grouping the population and then selecting the groups or the clusters rather than individual elements for inclusion in the sample. Suppose some departmental store wishes to sample its credit card holders. It has issued its cards to 15,000 customers. The sample size is to be kept say 450. For cluster sampling this list of 15,000 card holders could be formed into 100 clusters of 150 card holders each. Three clusters might then be selected for the sample randomly. The sample size must often be larger than the simple random sample to ensure the same level of accuracy because is cluster sampling procedural potential for order bias and other sources of error is usually accentuated. The clustering approach can, however, make the sampling procedure relatively easier and increase the efficiency of field work, specially in the case of personal interviews.

*Area sampling* is quite close to cluster sampling and is often talked about when the total geographical area of interest happens to be big one. Under area sampling we first divide the total area into a number of smaller non-overlapping areas, generally called geographical clusters, then a number of these smaller areas are randomly selected, and all units in these small areas are included in the sample. Area sampling is especially helpful where we do not have the list of the population concerned. It also makes the field interviewing more efficient since interviewer can do many interviews at each location.

(vii) *Multi-stage sampling:* This is a further development of the idea of cluster sampling. This technique is meant for big inquiries extending to a considerably large geographical area like an entire country. Under multi-stage sampling the first stage may be to select large primary sampling units such as states, then districts, then towns and finally certain families within towns. If the technique of random-sampling is applied at all stages, the sampling procedure is described as multi-stage random sampling.

(viii) ***Sequential sampling:***This is somewhat a complex sample design where the ultimate size of the sample is not fixed in advance but is determined according to mathematical decisions on the basis of information yielded as survey progresses. This design is usually adopted under acceptance sampling plan in the context of statistical quality control.

In practice, several of the methods of sampling described above may well be used in the same study in which case it can be called mixed sampling. It may be pointed out here that normally one should resort to random sampling so that bias can be eliminated and sampling error can be estimated.

But purposive sampling is considered desirable when the universe happens to be small and a known characteristic of it is to be studied intensively. Also, there are conditions under which sample designs other than random sampling may be considered better for reasons like convenience and low costs.

*The sample design to be used must be decided by the researcher taking into consideration the nature of the inquiry and other related factors*.

**6. Collecting the data: In dealing with any real life problem it is often found that data at hand are inadequate, and hence, it becomes necessary to collect data that are appropriate. There are several ways of collecting the appropriate data which differ considerably in context of money costs, time and other resources at the disposal of the researcher.**

Primary data can be collected either through experiment or through survey. If the researcher conducts an experiment, he observes some quantitative measurements, or the data, with the help of which he examines the truth contained in his hypothesis. But in the case of a survey, data can be collected by any one or more of the following ways:

(i) ***By observation:***This method implies the collection of information by way of investigator’s own observation, without interviewing the respondents. The information obtained relates to be what is currently happening and is not complicated by either the past behaviour or future intentions or attitudes of respondents. This method is no doubt an expensive method and the information provided by this method is also very limited. As such this method is not suitable in inquiries where large samples are concerned.

(ii) *Through personal* ***interview:***The investigator follows a rigid procedure and seeks answers to a set of pre-conceived questions through personal interviews. This method of collecting data is usually carried out in a structured way where output depends upon the ability of the interviewer to a large extent.

(iii) *Through telephone interviews:* This method of collecting information involves contacting the respondents on telephone itself. This is not a very widely used method but it plays an important role in industrial surveys in developed regions, particularly, when the survey has to be accomplished in a very limited time.

(iv)*By mailing of* ***questionnaires:***The researcher and the respondents do come in contact with each other if this method of survey is adopted. Questionnaires are mailed to the respondents with a request to return after completing the same. It is the most extensively used method in various economic and business surveys. Before applying this method, usually a Pilot Study for testing the questionnaire is conduced which reveals the weaknesses, if any, of the questionnaire. Questionnaire to be used must be prepared very carefully so that it may prove to be effective in collecting the relevant information.

(v) *Through schedules:* Under this method the enumerators are appointed and given training.

They are provided with schedules containing relevant questions. These enumerators go to respondents with these schedules. Data are collected by filling up the schedules by enumerators on the basis of replies given by respondents. Much depends upon the capability of enumerators so far as this method is concerned. Some occasional field checks on the work of the enumerators may ensure sincere work.

*The researcher should select one of these methods of collecting the data taking into consideration the nature of investigation, objective and scope of the inquiry, financial resources, available time and the desired degree of accuracy.* Though he should pay attention to all thesefactors but much depends upon the ability and experience of the researcher.

**7. Execution of the project:** Execution of the project is a very important step in the research process. If the execution of the project proceeds on correct lines, the data to be collected would be adequate and dependable. **The researcher should see that the project is executed in a systematic manner and in time. If** the survey is to be conducted by means of structured questionnaires, data can be readily machine-processed. In such a situation, questions as well as the possible answers may be coded. If the data are to be collected through interviewers, arrangements should be made for proper selection and training of the interviewers. The training may be given with the help of instruction manuals which explain clearly the job of the interviewers at each step. Occasional field checks should be made to ensure that the interviewers are doing their assigned job sincerely and efficiently.

A careful watch should be kept for unanticipated factors in order to keep the survey as much realistic as possible. This, in other words, means that steps should be taken to ensure that the survey is under statistical control so that the collected information is in accordance with the pre-defined standard of accuracy. If some of the respondents do not cooperate, some suitable methods should be designed to tackle this problem. One method of dealing with the non-response problem is to make a list of the non-respondents and take a small sub-sample of them, and then with the help of experts vigorous efforts can be made for securing response.

**8. Analysis of data:** After the data have been collected, **the researcher turns to the task of analyzing them.** **The analysis of data requires a number of closely related operations such as establishment of categories, the application of these categories to raw data through coding, tabulation and then drawing statistical inferences**. The unwieldy data should necessarily be condensed into a few manageable groups and tables for further analysis. Thus, researcher should **classify** **the raw data** into some **purposeful** and **usable categories**. *Coding* operation is usually done at this stage through which the categories of data are transformed into symbols that may be tabulated and counted. ***Editing***is the procedure that **improves the quality of the data for coding**. With coding the stage is ready for tabulation.

***Tabulation***is a part of the **technical procedure wherein the classified data are put in the form of tables.** The mechanical devices can be made use of at this juncture. A great deal of data, especially in large inquiries, is tabulated by computers. Computers not only save time but also make it possible to study large number of variables affecting a problem simultaneously.

Analysis work after tabulation is generally based on the computation of various percentages, coefficients, etc., by applying various well defined statistical formulae. In the process of analysis, relationships or differences supporting or conflicting with original or new hypotheses should be subjected to tests of significance to determine with what validity data can be said to indicate any conclusion(s).

For instance, if there are two samples of weekly wages, each sample being drawn from factories in different parts of the same city, giving two different mean values, then our problem may be whether the two mean values are significantly different or the difference is just a matter of chance. Through the use of statistical tests we can establish whether such a difference is a real one or is the result of random fluctuations. If the difference happens to be real, the inference will be that the two samples come from different universes and if the difference is due to chance, the conclusion would be that the two samples belong to the same universe. Similarly, the technique of analysis of variance can help us in analyzing whether three or more varieties of seeds grown on certain fields yield significantly different results or not. In brief, the researcher can analyze the collected data with the help of various statistical measures.

**9. Hypothesis-testing:** After **analyzing the data as stated above, the researcher is in a position to test the hypotheses,** if any, he had formulated earlier. Do the facts support the hypotheses or they happen to be contrary? This is the usual question which should be answered while testing hypotheses.

**Various tests, such as Chi square test, *t*-test, *F*-test, have been developed by statisticians for the purpose.** The **hypotheses may be tested through the use of one or more of such tests, depending** upon **the nature and object of research inquiry.** **Hypothesis-testing will result in either accepting the hypothesis or in rejecting it**. If the researcher had no hypotheses to start with, generalizations established on the basis of data may be stated as hypotheses to be tested by subsequent researches in times to come.

**10. Generalizations and interpretation: If a hypothesis is tested and upheld several times, it may be possible for the researcher to arrive at generalization**, i.e., to build a theory. As a matter of fact, the real value of research lies in its ability to arrive at certain generalizations. **If the researcher had no hypothesis to start with, he might seek to explain his findings on the basis of some theory. It is known as interpretation.** The process of interpretation may quite often trigger off new questions which in turn may lead to further researches.

**11. Preparation of the report or the thesis:** Finally, **the researcher has to prepare the report of what has been done by him. Writing** of report must be done with great care keeping in view the following:

1. **The layout of the report should be as follows**: (*i*) the preliminary pages; (*ii*) the main text,

and (*iii*) the end matter.

***In its preliminary pages***the report should carry title and date followed by acknowledgements

and foreword. Then there should be a table of contents followed by a list of tables and list

of graphs and charts, if any, given in the report.

***The main text of the report* should** have the following parts:

(a) *Introduction:* It should contain a clear statement of the objective of the research and an explanation of the methodology adopted in accomplishing the research. The scope of the study along with various limitations should as well be stated in this part.

(b) *Summary of findings:* After introduction there would appear a statement of findings and recommendations in non-technical language. If the findings are extensive, they should be summarized.

(c) *Main report:* The main body of the report should be presented in logical sequence and broken-down into readily identifiable sections.

(d) *Conclusion:* Towards the end of the main text, researcher should again put down the results of his research clearly and precisely. In fact, it is the final summing up.

***At the end of the report*,** appendices should be enlisted in respect of all technical data. Bibliography, i.e., list of books, journals, reports, etc., consulted, should also be given in the end. Index should also be given specially in a published research report.

2. Report should be written in a concise and objective style in simple language avoiding vague expressions such as ‘it seems,’ ‘there may be’, and the like.

3. Charts and illustrations in the main report should be used only if they present the information more clearly and forcibly.

4. Calculated ‘confidence limits’ must be mentioned and the various constraints experienced in conducting research operations may as well be stated.

**REVIEW OF RELATED LITERATURE**

The literature review helps the researcher to develop knowledge that will assist in operationalizing the research.

It Concretizes the research problem (i.e., making it more specific and unambiguous) (A very important step in any research process).

Helps in specifying the objectives of the proposed study (which will determine the data to be collected, relations to be examined, choice of techniques to use, and form of final report).

**Characteristics of Literature Review**

1. Comes after formulation of research problem
2. It is a search for studies that are related to the problem
3. The review summarizes and analyzes previous research and shows how the proposed study is related to this literature
4. Length varies, but should be selective and should concentrate on how the present study will contribute to the existing knowledge.
5. It should be long enough to demonstrate that the research has sound understanding of the relationship of what has been done and what will be done

**The Purpose of Literature Review**

1. Define and limit the problem
2. Place the study in a historical perspective
3. Identifies the gaps between the study and previous similar studies
4. Avoid unintentional and unnecessary replication
5. Select promising methods and measures
6. Relate the findings to the previous knowledge and suggest further research
7. Develop research hypotheses

**Organization of Literature Review**

LR is organized by three sections: Introduction, critical review, and summary

1. **Introduction** – states the purpose or scope of the review, e.g., the purpose may be a preliminary review in order to state a problem or develop a proposal, or it may be an exhaustive review to analyze and critique the research-based knowledge of the topic
2. **Criticism** - the review must be organized logically as it relates to the selection and significance of the problem. Studies are classified, compared, and contrasted in the way they contribute or fail to contribute to knowledge, including criticism of designs and methodologies

* Criticism in an LR serves to illuminate, to discuss both strengths and limitations of the knowledge of the problem

1. **Summary** – states the status of knowledge on the topic, identifies gaps in it, and relates the review to the present study. The gaps may be due to methodological difficulties, lack of studies on the problem, or inconclusive results from prior research. Hence it provides the rationale for the specific research statement, question or hypothesis

**N/B:** -LR can be organized in several ways: (a) historically, by dates of publication; (b) by variables or treatments; (c) by research designs and methods; (d) by the most general literature (least related) and ending with the closest related reference; or (e) by a combination of all these.

-LR should be cited and later referenced using various approved methods. This is because most of the content is borrowed from previous work for other scholars/researchers.

**RESEARCH DESIGN**

Research design is a detailed outline of how an investigation will take place. A research design will typically include how data is to be collected, what instruments will be employed, how the instruments will be used and the intended means for analyzing data collected.

***Others refer to KOTHARI***

**CHAPTER 4: QUALITIES OF A GOOD RESEARCH INSTRUMENT**

Research Instruments are measurement tools (for example, questionnaires or scales) designed to obtain data on a topic of interest from research subjects.

Instrument is the generic term that researchers use for a measurement device (survey, test, questionnaire, etc.). To help distinguish between instrument and instrumentation, consider that the instrument is the device and instrumentation is the course of action (the process of developing, testing, and using the device).

Instruments fall into two broad categories**, researcher-completed and subject-completed**, distinguished by those instruments that researchers administer versus those that are completed by participants. Researchers chose which type of instrument, or instruments, to use based on the research question.

**Examples of Research Instruments:**

|  |  |
| --- | --- |
| **Researcher-completed Instruments** | **Subject-completed Instruments** |
| Rating scales | Questionnaires |
| Interview schedules/guides | Self-checklists |
| Tally sheets | Attitude scales |
| Flowcharts | Personality inventories |
| Performance checklists | Achievement/aptitude tests |
| Time-and-motion logs | Projective devices |
| Observation forms | Sociometric devices |

Below are some of the qualities of a good research instrument

**Validity:**

-          It means the degree to which a test or measuring instrument measures what it intends to measure.

***Types of Validity***

         **Content validity** – It means the extent to which the content or topics of the test is truly representative of the content of the course.

         **Concurrent validity** – It is the degree to which the test agrees or correlates with a criterion set up as an acceptable measure.

         **Predictive validity** – It is determined by showing how well predictions made from the test are confirmed by evidence gathered at some subsequent time.

         **Construct validity** – It is the extent to which the test measures a theoretical construct or trait.

**Reliability**

It means the extent to which a research instrument is dependable, consistent and stable. This can be ascertained by carrying out a number of tests. Some of the methods of testing are shown below.

***Methods in Testing the Reliability of a Good Research Instrument***

         **Test-retest method** – In this method, the same instrument is administered twice to the same group of subjects and the correlation coefficient is determined.

         **Parallel-forms method** – Parallel or equivalent forms of a test may be administered of the group of subjects, and the paired observations correlated.

         **Split-half method** – The test in this method may be administered twice, but the test items are divided into two values.

         **Internal-consistency method** – This method is used with psychological test which consist of dichotomously scored items.

**Usability**

It means the degree to which the research instrument be satisfactorily used by teachers, researchers, supervisors and school managers without expenditures of time, money and effect.

***Factors to Determine Usability***

1.      Base of administration. To facilitate the administration of a research instrument, instruction should be complete and precise.

2.      Base of scoring. It depends on the following aspects:

         Construction of a test in the objective type.

         Answer keys are adequately prepared.

         Scoring directions are fully understood

3.  Ease of interpretation and application. Results of test are easy to interpret and

apply if tables are provided.

4.  Low cost. It is more practical if the test is low cost material-wise.

5.  Proper mechanical make-up. A good research instrument should be printed

clearly in an appropriate size for the grade or year level for which the instrument is intended.