**CHAPTER ONE**

**INTRODUCTION TO SCIENTIFIC RESEARCH**

The term Research is related to seek out the information and knowledge on a particular topic or subject. In other words, research is an art of systematic process of collecting and analyzing information to increase our understanding of a phenomenon under study.

1. The systematic investigation into and study of materials, sources, etc, in order to establish facts and reach new conclusions.
2. An endeavor to discover new or collate old facts etc by the scientific study of a subject or by a course of critical investigation. *[Oxford Concise Dictionary]*

The word *research* is composed of two syllables, *re* and *search*. The dictionary defines the former as a prefix meaning again, anew or over again and the latter as a verb meaning to examine closely and carefully, to test and try, or to proble. Together they form a noun describing a careful, systematic, patient study and investigation in some field of knowledge, undertaken to establish facts or principles.



*[Grinnel, 1993]*

Research and experimental development (R&D) comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.

*[OECD Definition]*

In the world of business, research and development is the phase in a product's life that might be considered the product's 'conception‘:

* ***Research* phase**: basic science must exist to support the product's viability, and if the science is lacking, it must be discovered.
* ***Development phase***: if the science exists, then turning it into a useful product.

To qualify as research the process must have the following characteristics:

* **Controlled** – in exploring causality in relation to two variables, the study must be set in a way to minimize the effects of other factors affecting the relationship.
* **Rigorous** – be scrupulous in ensuring that the procedures followed to find answers to questions are relevant, appropriate and justified.
* **Systematic** – the procedures adopted to undertake an investigation follow a certain logical sequence. Different steps cannot be taken in a hazardous way.
* **Valid and verifiable** – whatever is concluded on the basis of the findings must be correct and can be verified by the researcher and others.
* **Empirical** – any conclusions drawn are based upon hard evidence gathered from information collected from real-life experiences or observations.
* **Critical** – critical scrutiny of the procedures used and the methods employed. *[Kumar 2005]*

Research is a pedagogic action the term should be used in a technical sense. According to Clifford Woody research comprises defining and redefining problems, formulating hypothesis or suggested solutions; collecting, organizing and evaluating data; making deductions and reaching conclusions; and at last carefully testing the conclusions to determine whether they fit the formulating hypothesis.

**Objectives of Research**

The major aim of any type of research is to find out the reality and facts which is unknown and which has not been exposed. Although each research activity has its own particular reason, the objectives of research can be grouped into the following categories:

1. To achieve skillfulness with a trend or to get novel opinions into it (studies with this objective can be termed as exploratory or formulative);
2. To find out the characteristics of a particular individual, situation or a grouping (research with this objective can be termed as descriptive research);
3. To establish the relationship with which something occur or with which it is associated with something else (research with this objective are known as diagnostic research);
4. To test a hypothesis of a reasonable liaison between different variables (this type of research can be grouped into hypothesis-testing research).

**MOTIVATION IN RESEARCH**

What makes people to undertake research? This is a question of fundamental importance. The possible motives for doing research may be either one or more of the following:

1. Desire to get a research degree along with its consequential benefits;

2. Desire to face the challenge in solving the unsolved problems, i.e., concern over practical problems initiates research;

3. Desire to get intellectual joy of doing some creative work;

4. Desire to be of service to society;

5. Desire to get respectability

However, this is not an exhaustive list of factors motivating people to undertake research studies.

Many more factors such as directives of government, employment conditions, curiosity about new things, desire to understand causal relationships, social thinking and awakening, and the like may as well motivate (or at times compel) people to perform research operations.

**TYPES OF RESEARCH**

The basic types of research are as follows:

1. **Descriptive vs. Analytical**

Descriptive research consists of survey and fact-finding investigation of different kinds. The main purpose of descriptive research is explanation of the set of circumstances as it is present as such. The term Ex post facto research has been used to elaborate this type of research in different areas or subjects of research. The main feature of this method is that the scientist does not have direct control over the variables; he can only report what is happening or what has happened. For example, why peoples of the south side are suffering from lung cancer as compared to north-side neighbors and investigation revealed that south side persons have wood burning stoves and fire places, the researcher could hypothesize the reason that the wood smoke is a factor of lung cancer. The techniques used in descriptive research are can be of all kinds like survey methods, comparative and correlational methods etc. On the other hand, in analytical research, the researcher could be use the facts, information, data which is already available, and analyze these sources to make a hypothesis to evaluation of the material.

1. **Applied vs. Fundamental**

Applied research refers to finding a solution for specific, practical problem facing by an individual, society or an industrial or business organization, for example how to abolish hate crime, what are the ways to market a product, what is causing increased poverty etc. whereas fundamental research is mainly concerned with overview and with the formulation of a theory. This is pure and basic type of research, for example an investigation looking for whether stress levels influence how often students engage in academic cheating or how caffeine consumption impacts the brain. Thus, the main aim of applied research is to find out a solution for some critical practical problem, whereas basic research is handling towards finding information that has a wide sense of applications to the already existing organized body of scientific knowledge.

1. **Quantitative vs. Qualitative**

In natural sciences and social sciences, quantitative research is based on the aspect of quantity or extent. It is related to object that can be expressed in terms of quantity or something that can be counted. Such type of research involves systematic experimental analysis of observable phenomenon via statistical, mathematical or computational techniques in numerical form such as statistics, percentages, etc. whereas qualitative research is concerned with qualitative phenomenon, i.e., relating to quality or variety. Such type of research is typically descriptive and harder to analyze than quantitative data. Qualitative research involves looking in-depth at non-numerical data. It is more naturalistic or anthropological.

1. **Conceptual vs. Empirical**

Conceptual research is that related to some abstract idea(s) or theory. It focuses on the concept and theory that explain the concerned theory being studied. It is generally used by logicians, philosophers and theorist to develop new concepts or to again understand the existing ones. On the other hand, empirical research relies on experience or observation alone. It is a way of gaining knowledge by means of direct and indirect observation or experience. We can also refer it as experimental type of research. In such a research it is necessary to get the facts and data firstly, their source, and then actively engaged to do certain things to stimulate the production of desired information.

1. **Some Other Types of Research**

Other types of research may be of different types rather than above stated types like form the point of view of time one-time research or longitudinal research. In the former case the research is restricted to a single time-period, while in the latter case the research is carried on over several time-periods. Research can be field-setting research or laboratory research or model research, which will depend upon the environment in which it is to be carried out. Research may be understood as clinical or diagnostic research. Such research follows case-study methods or exhaustively approaches to reach the basic reasons behind the problems. The research may be exploratory or it may be formalized. The objective of exploratory research is the creation of hypotheses rather than their testing, whereas formalized research are those with significant structure and with specific hypotheses to be tested. The term historical research is refers to that which make use of historical resource like documents, papers, leaflets remains, etc. to study events or thoughts of the past, including the philosophy of persons and groups at any point of time. Research can also be classified as conclusion-oriented and decision-oriented. While doing conclusion oriented research, a researcher having freethinking to choose a problem, redesign the queries as he proceeds and is prepared to conceptualize as he wants. Decision-oriented research is always for the need of a decision maker and the researcher in this case is not free to get on research according to his own preference. *Operation Research* is an example of decision orientedresearch since it is a scientific method ofproviding executive department with aquantitative basis for decisions regardingoperation under their control.

**Research approaches**

 Research approaches are plans and the procedures for research that span the steps from broad assumptions to detailed methods of data collection, analysis, and interpretation. This plan involves several decisions, and they need not be taken in the order in which they make sense to me and the order of their presentation here. The overall decision involves which approach should be used to study a topic. Informing this decision should be the philosophical assumptions the researcher brings to the study; procedures of inquiry (called research designs); and specific research methods of data collection, analysis, and interpretation. The selection of a research approach is also based on the nature of the research problem or issue being addressed, the researchers’ personal experiences, and the audiences for the study. Thus, in this book, research approaches, research designs, and research methods are three key terms that represent a perspective about research that presents information in a successive way from broad constructions of research to the narrow procedures of methods.

Three research approaches are advanced: (a) qualitative, (b) quantitative, and (c) mixed methods.

**Qualitative research**: is an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem. The process of research involves emerging questions and procedures, data typically collected in the participant’s setting, data analysis inductively building from particulars to general themes, and the researcher making interpretations of the meaning of the data. The final written report has a flexible structure. Those who engage in this form of inquiry support a way of looking at research that honors an inductive style, a focus on individual meaning, and the importance of rendering the complexity of a situation.

**Quantitative research** is an approach for testing objective theories by examining the relationship among variables. These variables, in turn, can be measured, typically on instruments, so that numbered data can be analyzed using statistical procedures. The final written report has a set structure consisting of introduction, literature and theory, methods, results, and discussion. Like qualitative researchers, those who engage in this form of inquiry have assumptions about testing theories deductively, building in protections against bias, controlling for alternative explanations, and being able to generalize and replicate the findings.

**Mixed methods research** is an approach to inquiry involving collecting both quantitative and qualitative data, integrating the two forms of data, and using distinct designs that may involve philosophical assumptions and theoretical frameworks. The core assumption of this form of inquiry is that the combination of qualitative and quantitative approaches provides a more complete understanding of a research problem than either approach alone.

**Significance of research**

Research promotes the logical habits of thinking. It makes the people critical, rational, and logical about the existing event and issue. The role of research is applied in several fields: economics, business, government, education, health etc. It provides the basis to build policies and systems in different areas. It has its special significance to solve various operational and planning problems of business and industry. It formulates the efficient policies and programme to assist the existing situation of infrastructures; education, health, transport, water supply, and industry, etc. It is also significant to study the social relationship and solve the various social problems of the society. Research can be significant to the different people distinctly as mentioned in the following points:

i. To those students who are to write a master’s or Ph D thesis, research may mean careerism or a way to attain a high position in the social structure;

ii. To professionals in research methodology, research may mean a source of livelihood;

iii. To philosophers and thinkers, research may mean the outlet for new ideas and insights;

iv. To literary men and women, research may mean the development of new style and creative work

v. To analysts and intellectuals, research may mean the development of new theories.

Thus, research is the fountain of knowledge for the sake of knowledge and an important source of providing guidelines for solving the problems of different fields of society, government and business as well.

**CHAPTER TWO**

**RESEARCH AND SCIENTIFIC METHODS**

**Research methods** are the various procedures, schemes and algorithms used in research. All the methods used by a researcher during a research study are termed as research methods. They are essentially planned, scientific and value-neutral. They include theoretical procedures, experimental studies, numerical schemes, statistical approaches, etc. Research methods help us collect samples, data and find a solution to a problem. Particularly, scientific research methods call for explanations based on collected facts, measurements and observations and not on reasoning alone. They accept only those explanations which can be verified by experiments.

**Research methodology** is a systematic way to solve a problem. It is a science of studying how research is to be carried out. Essentially, the procedures by which researchers go about their work of describing, explaining and predicting phenomena are called research methodology. It is also defined as the study of methods by which knowledge is gained. Its aim is to give the work plan of research.

**Scientific Method**

Scientific method refers to a body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge. To be termed scientific, a method of inquiry must be based on gathering observable, empirical and measurable evidence subject to specific principles of reasoning. A scientific method consists of the collection of data through observation and experimentation, and the formulation and testing of hypotheses**.**

The scientific method is a general set of procedures or steps through which the systematic approach is developed. The scientific method and systematic approach are synonymous. It is a more specific research process. A series of steps are used in the scientific method of research

The initial step of the scientific method is that of observing some phenomenon represents an insight into some experience. The need to resolve the problem is felt and the individual prepares to do something about the need.

The second step is to identify the problem more precisely. It involves the formulation of hypotheses based on observed phenomenon.

The third step of the scientific method is to develop and apply a design for the solution of the problem and testing the hypotheses.

The fourth step usually identified is a continuation of the third step - that continued testing hypotheses. Results are subjected to further analyses and tests.

The final step is that of drawing conclusions based on data and “tests and integrating these conclusions with the existing body of knowledge.

**Assumptions of Scientific Method**

The following are the main assumptions of this method

1. It is assumed that we are living in a real world i.e. there exists an objective reality, independent of whether or not. It has been discovered.

2. The assumption of the uniformity of nature is that what has been found to be true will continue to be true and that similarity of circumstances will produce consistently similar results. The assumption relates to the three postulates: (a) Natural kinds (b) Constancy and (c) Determination

(a) The postulate of natural kinds is the principle that natural phenomena can be classified according to common characteristics. We can classify student behaviour or performance

e.g. divisions and grading system.

(b) The postulate of constancy assumes that in nature there is a certain degree of consistency.

The performances of students under certain conditions are expected to be the same as they have been in the past, given the same conditions.

(c) The postulate of determination assumes that within the orderliness of nature, the occurrence of a phenomenon is preceded by certain antecedent events or conditions.

**TYPES OF RESEARCH METHODS**

George J. Mouly has classified research methods into three basic types: Survey, historical and experimental methods. The meanings and their further classification have been given in the following:

**1. Survey Method**

It is concerned with the present and attempts to determine the status of the phenomena under investigation. This method has been further classified into four categories:

(a) Descriptive (b) Analytical (c) School survey and (d) Genetic.

(a) Descriptive survey is of four types:

* Survey testing method,
* Questionnaire survey method,
* Interview survey method.

(b) Analytical survey is of five types:

* Documentary frequency,
* Observational survey,
* Rating survey,
* Critical incident,
* Factor analysis.

(c) School survey and

(d) Genetic survey.

**2. Historical Method**

This method is concerned with the past and which attempts to trace the past as a means for seeing the present prospective.

The historical method can be classified into three types:

(a) Historical, (b) Legal, and (c) Documentary

**3. Experimental Method**

It is oriented towards the discovery of basic relationship among phenomena as means of predicting and eventually, controlling their occurrence.

The experimental method has been further classified into four types as given below:

(a) Simple experimental designs,

(b) Multio-variate analysis,

(c) Case study, and

(d) Predictive or correlation.

**Research Process**

Research process consists of sequence of actions or steps necessary to effectively carry out research and the desired progression of these steps.



Fig. 1: Flow chart of research process

The figure shows that the research process having a number of closely related actions, as shown from step 1 to 7. But these activities should be following in a strictly prescribed sequence otherwise researcher may face the problem in completion of the research. In the research process, each step is specific and they are separate and distinct from each other. However, the following order relating to various steps provides a useful procedural instruction regarding the research process:

1) Identification of research problem

2) Broad literature survey

3) Hypothesis formulation

4) Preparation of research design

5) Determining sample design

6) Data collection

7) Analysis of data

8) Hypothesis testing

9) Generalizations and interpretation

10) Preparation of the report or presentation of the results,

Brief descriptions of the above stated steps are as follows:

1. **Identification of research problem**

There are two types of research problems like, those which relate to states of nature means that denote the hypothetical conditions of what the lives of people might have been like before societies came into existence and those which relate to relationships between different variables. Initially the researcher must recognize the problem he wants to study, i.e., he must decide the general area of interest or part of a subject-matter that he would like to inquire into. At the onset the problem may be discussed in a broad way and then the doubts, if any, relating to the problem may be resolved. Then, the probability of a particular clarification has to be considered before working on formulation of the problem. Basically two steps are involved in formulating the research problem, viz., understanding the problem systematically, and reshape the same into significant terms from an analytical point of view.

The most excellent way of understanding the problem is to discuss it with contemporaries or with those having some knowledge in the related matter. In an academic institution the researcher can take the assistance from a guide who is usually an experienced man and has several research problems in his mind. In private business units or in governmental organizations, the problem is usually allocate by the administrative agencies with whom the researcher can discuss the problem originally that how it is came about and what reflections are involved in its possible clarification.

**EXAMPLES WITH SOME PROBLEMS:**

“The main objective of this work is to contribute to the development of elements of a formal theory for manufacturing systems in order to allow the establishment of a formal methodology for the design and analysis of manufacturing systems”

“The main research questions which have guided this research work are:

Q1: Which are the main characteristics of a collaborative network and of a collaborative networked environment?

Q2: Which are the most relevant conceptual frameworks, architectures, reference models, independent and industry-specific initiatives, ICT platforms and their underlying technologies, targeting interoperability in a collaborative networked environment?

Q3: How can seamless interoperability be achieved?

Q4: Which are the main differences and similarities between existing conceptual frameworks?

Q5: How can conceptual frameworks be compared, and which are the criteria to support such an analysis and evaluation?

Q6: Do the conceptual frameworks and the technological solutions compete or complement each other?

Q7: Which is the path to be followed to allow heterogeneous and geographically distributed organizations to naturally inter-operate?

1. **Broad literature survey**

After the identification of research problem, the researcher must at study all available literature to get himself familiar with the selected problem. He may review two types of literature first is the conceptual literature which is related to the concepts and theories, and second is the empirical literature which consisting of previous studies similar to the proposed research problem. The researcher should undertake vast literature survey concerned with the problem. For this purpose, the abstracting and indexing journals and published or unpublished bibliographies are the first place where researcher can get the information or knowledge. Academic journals, conference proceedings, government reports, books etc., must be hit depending on the nature of the problem. After this the researcher revise the problem into analytical or operational terms i.e., to put the problem in as specific terms as possible. This assignment of formulating, or defining, a research problem is an important step in the entire research process. Once the problem is formulated, a synopsis of it should be written down.

1. **Hypotheses formulation**

After the literature survey, researcher should make a hypothesis or working hypothesis. Working hypothesis is a guess made to test the logical or empirical outcome of a research. A hypothesis assists to explain the research problem and objective into a comprehensive explanation or prediction of the expected results of the study. Hypothesis is derived from the research problem, literature review and conceptual framework. Since Hypothesis is to be tested therefore it should be very specific and limited to the piece of research. It sharpens the researcher’s thinking and focus on the important facts of the problem. Hypothesis formulation could be done by using the following approaches:

1. Discussions with colleagues and experts about the research problem, its source, cause and the objectives in search of a solution;
2. Assessment of data and records,
3. Evaluation of similar previous studies in the area similar problems; and
4. Personal investigation which involves original field survey

Thus, any hypotheses take place as a result of a-prior thinking about the subject, assessment of the available data and material including related previous studies. Formulation of working hypotheses is a basic step of any research process.

**Hypothesis example**

“Shop floor control/supervision reengineering agility can be achieved if manufacturing systems are abstracted as compositions of modularized manufacturing components that can be reused whenever necessary, and whose interactions are specified using configuration rather than reprogramming.”

1. **Preparation of research design**

A good research design will be prepared if a research problem should be stated clearly. In other words, the purpose of research design is refers as general procedure that you choose to combine the various components of the study in a consistent and logical way. It comprises the outline for the collection, measurement, and analysis of data. A flexible research design which offers the opportunity for allowing the different aspects of a problem is considered suitable if the purpose of the research study is to be clear. There are several research designs, such as, Descriptive (e.g., case-study, naturalistic observation, survey), Correlational (e.g., case-control study, observational study), Semi-experimental (e.g., field experiment, quasi-experiment), Experimental (experiment with random assignment), Review (literature review, systematic review) and Meta-analytic (meta-analysis) out of which the researcher should select one for his task.

1. **Determining sample design**

Every object that involve in any type of inquiry constitute a ‘universe’ or ‘population’. A complete detail of any object in the ‘population’ is known as a census inquiry. It can be supposed that in such type of inquiry all the items are covered and not a single element is left and highest accuracy is obtained. But in practical way this may not be true because a single element of bias in such inquiry will get larger the number of observations increases. Moreover, there is no way of scrutiny the element of bias or its level except through a resurvey or use of sample checks. Besides, such type of inquiry comprises a lot of time, money and energy. Apart from this, census inquiry is not possible practically under many conditions. For example, blood sugar testing is done only on sample basis. Hence, quite often we select only a few items from the population for our study purposes. The selection of items in such type of manner is technically called a sample.

The researcher must decide the way of selecting a sample or choose a sample design for his study. In other words, a sample design is an exact sketch determined prior to any type of data collection for obtaining a sample from a given universe. There are two types of sampling: non-probability and probability sampling. Non-probability sampling uses a subjective method of selecting units from a universe, and is generally easy, quick, and economical. Therefore, it is useful to perform preliminary studies, focus groups or follow-up studies. Probability samples are based on simple random sampling, stratified sampling, systematic sampling, cluster/area sampling whereas non-probability samples are those based on straightforward sampling, judgment sampling and quota sampling techniques. There is brief description of some important sample designs as follows:

1. **Deliberate sampling**

Deliberate sampling is also called as non-probability or purposive sampling. This sampling method consists of purposive selection of particular items of the universe to represent a sample. When samples are selected from a population on the basis of ease of access, it can be called convenience sampling. If a researcher wants to collect the data from students, he may select a fixed number of universities and colleges to conduct the interviews. This is a simple example of convenience sample. Sometimes this type of sampling may give biased results particularly when the universe is not homogeneous. On the other hand, in judgment sampling this is based on the judgment of researcher and used for selecting items from a given population.

For example, a judgment sample of office staff might be taken to secure reactions to a new rule of office. Judgment sampling is used regularly in qualitative research.

**ii. Simple random sampling**:

This type of sampling is also called as probability sampling or chance sampling where each item in the population has an equal chance of inclusion in the sample and each sample having the probability of being selected in the sampling procedure. For example, names of 20 employees being selected out of 250 employees in a company. In this case, the population is all 250 employees, and the sample is random because each employee has an equal chance of being chosen. There are basically three methods to conduct a random sampling. If we select a sample of 300 items from a population of 2,000 items, then we can write up the names of all the 2,000 items on slips of paper and conduct a lottery. This is called Lottery method. The second method of random sampling is using a random number table and third method is by using the computer in which the computer is used for selecting a sample of prize- winners, a sample of Hajj applicants, and a sample of applicants for residential plots and for various other purposes.

**iii. Systematic sampling:**

Whenever a researcher choose some specific name or number from the population then this type of sampling is known as systematic sampling. In some example the most practical way of sampling is to select every 10th name in an index, every 15th shop on single side of a street etc. A component of unpredictability is generally commenced into this type of sampling by using random numbers to pick and choose up the item with which to start. This method is helpful when sampling frame is available in the form of a list. In such type of sample design the practice of selection process begins by picking some random point in the list and then every nth item is selected until the desired number is secured.

**iv. Stratified sampling**:

In stratified sampling the researcher divides the population into separate groups, called strata or we can say that Stratification is the process of dividing members of the population into homogeneous subgroups before sampling. In this technique, the population is divided into a number of non-overlapping subpopulations or strata and sample elements are selected from each stratum. If the item selected from each stratum is based on simple random sampling technique in complete process of sampling means first stratification and then simple random sampling, this type of 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 judgment. 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 judgment 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 are usually accentuated. The clustering approach can, however, make the sampling procedure relatively easier and increase the efficiency of field work, especially 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.

1. **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 investigators own observation, without interviewing the respondents. The information obtained relates to 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 these factors but much depends upon the ability and experience of the researcher.

1. **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.

1. **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.

1. **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.

1. **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.