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UNIT—1

INTRODUCTION

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1.1 Definition of Research

In the broadest sense of the word, the definition of research includes any gathering of data, information and facts for the advancement of knowledge. Reading a factual book of any sort is a kind of research. Surfing the internet or watching the news is also a type of research.

Science does not use this word in the same way, preferring to restrict it to certain narrowly defined areas. The word 'review' is more often used to describe the learning process which is one of the underlying tenets of the rigid structures defining scientific research.

The Scientific Definition

The strict definition of scientific research is performing a methodical study in order to prove a hypothesis or answer a specific question. Finding a definitive answer is the central goal of any experimental process.

Research must be systematic and follow a series of steps and a rigid standard protocol. These rules are broadly similar but may vary slightly between the different fields of science.

Scientific research must be organized and undergo planning, including performing literature reviews of past research and evaluating what questions need to be answered.

Any type of 'real' research, whether scientific, economic or historical, requires some kind of interpretation and an opinion from the researcher. This opinion is the underlying principle, or question, that establishes the nature and type of experiment.

The scientific definition of research generally states that a variable must be manipulated, although case studies and purely observational science do not always comply with this norm.

1.2 Concept of Research

Research is an often-misused term, its usage in everyday language very different from the strict scientific meaning. In the field of science, it is important to move away from the looser meaning and use it only in its proper context. Scientific research adheres to a set of strict protocols and long established structures.

Often, we will talk about conducting internet research or say that we are researching in the library. In everyday language, it is perfectly correct grammatically, but in science, it gives a misleading impression. The correct and most common term used in science is that we are conducting a literature review.

What is Research? – The Guidelines

For a successful career in science, you must understand the methodology behind any research and be aware of the correct protocols. Science has developed these guidelines over many years as the benchmark for measuring the validity of the results obtained.

Failure to follow the guidelines will prevent your findings from being accepted and taken seriously. These protocols can vary slightly between scientific disciplines, but all follow the same basic structure.

Research is defined as human activity based on intellectual application in the investigation of matter. The primary purpose for applied research is discovering, interpreting, and the development of methods and systems for the advancement of human knowledge on a wide variety of scientific matters of our world and the universe. Research can use the scientific method, but need not do so.

Scientific research relies on the application of the scientific method, a harnessing of curiosity. This research provides scientific information and theories for the explanation of the nature and the properties of the world around us. It makes practical applications possible. Scientific research is funded by public authorities, by charitable organisations and by private groups, including many companies. Scientific research can be subdivided into different classifications according to their academic and application disciplines.

Historical research is embodied in the historical method.

The term research is also used to describe an entire collection of information about a particular subject.

Basic Research

Basic research (also called fundamental or pure research) has as its primary objective the advancement of knowledge and the theoretical understanding of the relations among variables (see statistics). It is exploratory and often driven by

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the researcher's curiosity, interest, and intuition. Therefore, it is sometimes conducted without any practical end in mind, although it may have confounding variables (unexpected results) pointing to practical applications. The terms "basic" or "fundamental" indicate that, through theory generation, basic research provides the foundation for further, sometimes applied research. As there is no guarantee of short-term practical gain, researchers may find it difficult to obtain funding for basic research.

Examples of questions asked in basic research:

- Does string theory provide physics with a grand unification theory?
- Which aspects of genomes explain organismal complexity?
- Is it possible to prove or disprove Goldbach's conjecture? (i.e., that every even integer greater than 2 can be written as the sum of two, not necessarily distinct primes)

Traditionally, basic research was considered as an activity that preceded applied research, which in turn preceded development into practical applications. Recently, these distinctions have become much less clear-cut, and it is sometimes the case that all stages will intermix. This is particularly the case in fields such as biotechnology and electronics, where fundamental discoveries may be made alongside work intended to develop new products, and in areas where public and private sector partners collaborate in order to develop greater insight into key areas of interest. For this reason, some now prefer the term frontier research.

Research Processes

Scientific Research

Generally, research is understood to follow a certain structural process. Though step order may vary depending on the subject matter and researcher, the following steps are usually part of most formal research, both basic and applied:

- Formation of the topic
- Hypothesis
- Conceptual definitions
- Operational definitions
- Gathering of data
- Analysis of data
- Test, revising of hypothesis
- Conclusion, iteration if necessary

A common misunderstanding is that by this method a hypothesis can be proven or tested. Generally a hypothesis is used to make predictions that can be tested by observing the outcome of an experiment. If the outcome is inconsistent with the hypothesis, then the hypothesis is rejected. However, if the outcome is consistent with the hypothesis, the experiment is said to support the hypothesis. This careful language is used because researchers recognize that alternative hypotheses may also be consistent with the observations. In this sense, a hypothesis can never be proven, but rather only supported by surviving rounds of scientific testing and, eventually, becoming widely thought of as true (or better, predictive),

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but this is not the same as it having been proven. A useful hypothesis allows prediction and within the accuracy of observation of the time, the prediction will be verified. As the accuracy of observation improves with time, the hypothesis may no longer provide an accurate prediction. In this case a new hypothesis will arise to challenge the old, and to the extent that the new hypothesis makes more accurate predictions than the old, the new will supplant it.

Historical

The historical method comprises the techniques and guidelines by which historians use historical sources and other evidence to research and then to write history. There are various history guidelines commonly used by historians in their work, under the headings of external criticism, internal criticism, and synthesis. This includes higher criticism and textual criticism. Though items may vary depending on the subject matter and researcher, the following concepts are usually part of most formal historical research:

- Identification of origin date
- Evidence of localization
- Recognition of authorship
- Analysis of data
- Identification of integrity
- Attribution of credibility

Research Methods

The goal of the research process is to produce new knowledge, which takes three main forms (although, as previously discussed, the boundaries between them may be fuzzy):

- Exploratory research, which structures and identifies new problems
- Constructive research, which develops solutions to a problem
- Empirical research, which tests the feasibility of a solution using empirical evidence

Research can also fall into two distinct types:—

- Primary research
- Secondary research

Research is often conducted using the hourglass model Structure of Research. The hourglass model starts with a broad spectrum for research, focusing in on the required information through the methodology of the project (like the neck of the hourglass), then expands the research in the form of discussion and results.

1.3 Steps of the Scientific Process

Setting a Goal

Research in all disciplines and subjects, not just science, must begin with a clearly defined goal. This usually, but not always, takes the form of a hypothesis. For example, an anthropological study may not have a specific hypothesis or principle, but does have a specific goal, in studying the culture of a certain people and trying to understand and interpret their behavior.

The whole study is designed around this clearly defined goal, and it should address a unique issue, building upon previous research and scientifically accepted fundamentals. Whilst nothing in science can be regarded as truth, basic assumptions are made at all stages of the research, building upon widely accepted knowledge.

Interpretation of the Results

Research does require some interpretation and extrapolation of results. In scientific research, there is always some kind of connection between data (information gathered) and why the scientist think that the data looks as it does. Often the researcher looks at the data gathered, and then comes to a conclusion of why the data looks like it does.

A history paper, for example, which just reorganizes facts and makes no commentary on the results, is not research but a review. If you think of it this way, somebody writing a school textbook is not performing research and is offering no new insights. They are merely documenting pre-existing data into a new format.

If the same writer interjects their personal opinion and tries to prove or disprove a hypothesis, then they are moving into the area of genuine research. Science tends to use experimentation to study and interpret a specific hypothesis or question, allowing a gradual accumulation of knowledge that slowly becomes a basic assumption.

Replication and Gradual Accumulation

For any study, there must be a clear procedure so that the experiment can be replicated and the results verified. Again, there is a bit of a grey area for observation-based research, as is found in anthropology, behavioral biology and social science, but they still fit most of the other criteria.

Planning and designing the experimental method, is an important part of the project and should revolve around answering specific predictions and questions. This will allow an exact duplication and verification by independent researchers, ensuring that the results are accepted as real.

Most scientific research looks at an area and breaks it down into easily tested pieces. The gradual experimentation upon these individual pieces will allow the larger questions to be approached and answered, breaking down a large and seemingly insurmountable problem, into manageable chunks.

True research never gives a definitive answer but encourages more research in another direction. Even if a hypothesis is disproved, that will give an answer and generate new ideas, as it is refined and developed. Research is cyclical, with the results generated leading to new areas or a refinement of the original process.

Concluding Remark

The term, research, is much stricter in science than in everyday life. It revolves around using the scientific method to generate hypotheses and provide

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analyzable results. All scientific research has a goal and ultimate aim, repeated and refined experimentation gradually reaching an answer.

These results are a way of gradually uncovering truths and finding out about the processes that drive the universe around us. Only by having a rigid structure to experimentation, can results be verified as acceptable contributions to science.

Some other areas, such as history and economics, also perform true research, but tend to have their own structures in place for generating solid results. They also contribute to human knowledge but with different processes and systems.

1.4 The Aims of Research

- Observe and Describe
- Predict
- Determination of the Causes
- Explain

The ultimate aims of research are to generate measurable and testable data, gradually adding to the accumulation of human knowledge. Ancient philosophers believed that all answers could be achieved through deduction and reasoning, rather than measurement. Science now uses established research methods and standard protocols to test theories thoroughly.

It is important to remember that science and philosophy are intertwined and essential elements of human advancement, both contributing to the way we view the world. Scientific research, however, allows us to test hypotheses and lay solid foundations for future research and study.

No theory or hypothesis can ever be completely proved or disproved, but research enables us to make valid assumptions about the universe. This gradual accumulation of knowledge dictates the overall direction of science and philosophy.

Observation and Description

The first stage of any research is to observe the world around us and to ask questions about why things are happening. Every phenomenon in the universe has a reason behind it, and the aims of research are to understand and evaluate what is happening.

However simple the phenomenon or however easy it appears to be to generate logical and intuitive answers, scientific research demands rigorous testing for a truth to be accepted. Describing the overall behavior of the subject is the first stage of any research, whether it is a case study or a full-blown 'true experimental design'.

Predict

This stage is where you must make a statement of intent and develop a strong hypothesis. This must be testable, with aims of research being to prove or disprove this statement. At this stage, you may express your personal opinion, favoring one side or the other. You must make a statement predicting what you expect the final answer to be.

You must, however, keep an open mind and understand that there is a chance that you may be wrong. Research is never about right or wrong, but about arriving at an answer, which improves our knowledge of natural processes.

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Determination of the Causes

This is often the 'business end' for many areas of scientific research and is where one of the predictions is tested, usually by manipulating and controlling variables. The idea is to generate numerical data that can determine the cause with one of the many statistical tests.

For example, a small-scale global warming study might study Antarctic ice cores to determine the historical levels of carbon dioxide throughout history. In this experiment, time would be the manipulated variable, showing how levels of the greenhouse gas have changed over time.

Statistical procedures are then utilized to either prove or disprove the hypothesis and prediction. Of course, very little research gives such a black and white answer, but opens up new areas of potential study, focusing on a specific direction.

Explain

After determining the causes, the next layer of the research process is to try to find possible explanations of 'Why?' and 'How?' things are happening. For most areas, this stage involves sifting through and reviewing earlier studies about similar phenomena.

Most research is built upon the work of previous researchers, so there should be a wealth of literature resources available.

If we look at a topical example, Global Warming is an area with which most of us are familiar, and has been the subject of thousands of studies. Intuitively, most of us would state that humanity pumping carbon dioxide into the atmosphere is responsible for a worldwide rise in temperatures.

The aims of research may be to establish 'What are the underlying causes and relationships between the different processes fueling this trend?' In most cases, it is necessary to review earlier research and try to separate the better quality sources from the inaccurate or poorly designed studies.

It is equally important to take into account any opposing points of view and accept that they may be equally valid. Explanation is about coming up with viable reasons, and you must try to be as objective and unbiased as possible.

For example, for global warming, there is an opposing view that temperature rises are natural, and that the effect of human society is making little difference. At this stage, personal opinion must be put aside and both sides of the debate must be given equal credence.

New Directions

Whatever the final answer, it can be used to promote a healthy debate and discussion about the validity of the results. The aims of research can then be fine-tuned, or may serve to open up new areas of interest. Either way, the store of human knowledge has been enriched and increased.

1.5 The Purpose of Research

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The purpose of research can be a complicated issue and varies across different scientific fields and disciplines. At the most basic level, science can be split, loosely, into two types, 'pure research' and 'applied research'.

Both of these types follow the same structures and protocols for propagating and testing hypotheses and predictions, but vary slightly in their ultimate purpose. An excellent example for illustrating the difference is by using pure and applied mathematics.

Pure maths is concerned with understanding underlying abstract principles and describing them with elegant theories. Applied maths, by contrast, uses these equations to explain real life phenomena, such as mechanics, ecology and gravity.

Pure Scientific Research

Some science, often referred to as 'pure science', is about explaining the world around us and trying to understand how the universe operates. It is about finding out what is already there without any greater purpose of research than the explanation itself. It is a direct descendent of philosophy, where philosophers and scientists try to understand the underlying principles of existence.

Whilst offering no direct benefits, pure research often has indirect benefits, which can contribute greatly to the advancement of humanity. For example, pure research into the structure of the atom has led to x-rays, nuclear power and silicon chips.

Applied Scientific Research

Applied scientists might look for answers to specific questions that help humanity, for example medical research or environmental studies. Such research generally takes a specific question and tries to find a definitive and comprehensive answer.

The purpose of research is about testing theories, often generated by pure science, and applying them to real situations, addressing more than just abstract principles. Applied scientific research can be about finding out the answer to a specific problem, such as 'Is global warming avoidable?' or 'Does a new type of medicine really help the patients?'

Generating Testable Data

However, they all involve generating a theory to explain why something is happening and using the full battery of scientific tools and methods to test it rigorously. This process opens up new areas for further study and a continued refinement of the hypotheses.

Observation is not accurate enough, with statistically testable and analyzable data the only results accepted across all scientific disciplines. The exact nature of the experimental process may vary, but they all adhere to the same basic principles.

Scientists can be opinionated, like anybody else, and often will adhere to their own theories, even if the evidence shows otherwise. Research is a tool by which they can test their own, and each others' theories, by using this antagonism to find an answer and advance knowledge.

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The purpose of research is really an ongoing process of correcting and refining hypotheses, which should lead to the acceptance of certain scientific truths. Whilst no scientific proof can be accepted as ultimate fact, rigorous testing ensures that proofs can become presumptions. Certain basic presumptions are made before embarking on any research project, and build upon this gradual accumulation of knowledge.

1.6 Scientific Elements

Whilst there can be slight variations between the exact structure and type of study between the various scientific disciplines, there are certain key scientific elements that all must possess to some degree. These elements have evolved over the centuries, and they have become accepted by both scientists and philosophers of science as sound basic principles.

Observations and Review

The initial scientific element is to evaluate and observe possible subjects for experiment. This can be through direct observation or by reviewing literature, and other sources, building upon earlier research. For example, Thomson knew a little about the properties of 'cathode rays', but wanted to delve further. Darwin's observation of Galapagos Finches led to his groundbreaking theory and further investigation by later scientists.

Hypothesis

Ideally, any research must begin with a testable hypothesis, which can be proved or disproved. This hypothesis should be realistic and consider the technology and methods available. Generating a hypothesis should involve looking for the simplest possible explanation for a natural occurrence or phenomena.

Despite the slight differences between the various research techniques, this is the most fundamental of the scientific elements. All scientific methods rely on a hypothesis as the main underlying principle and tool for establishing recognized proofs.

Predictions

This stage is where a researcher attempts to predict the expected results of their experiment. The prediction should be an extension of the hypothesis and express a degree of opinion about what the findings should uncover. Ideally, the prediction should also set out ways in which the results can be analyzed and tested statistically.

Experiment and Measurement

True science requires some type of numerical measurement, which provides quantifiable and analyzable data. This analysis takes into account the uncertainty and inherent errors built into any scientific methodology.

This is the final stage because, if the experiment has been well constructed, a valid answer will have been generated. Using the basic scientific elements ensures that usable knowledge about a process emerges from the initial observations of phenomena.

Whether the prediction is proved or not, further experiments feed back into this process, by refining the initial hypothesis or by generating more accurate predictions.

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Variations

There are many variations on these elements, covering the broad range of science, with this rigid structure tending to be more strongly adhered to by life and natural sciences.

Social sciences may place more emphasis upon the observation and prediction stage, whilst physicists may observe and predict without experimental proof, relying upon pure mathematics to provide answers.

However, all science relies upon this basic formula for theory and hypothesis to be accepted as ultimate proof, separating science from pure philosophy.

1.7 Introduction to the Scientific Method

The scientific method is the process by which scientists, collectively and over time, endeavor to construct an accurate (that is, reliable, consistent and non-arbitrary) representation of the world.

Recognizing that personal and cultural beliefs influence both our perceptions and our interpretations of natural phenomena, we aim through the use of standard procedures and criteria to minimize those influences when developing a theory. As a famous scientist once said, "Smart people (like smart lawyers) can come up with very good explanations for mistaken points of view." In summary, the scientific method attempts to minimize the influence of bias or prejudice in the experimenter when testing an hypothesis or a theory.

The scientific method has four steps:

1. Observation and description of a phenomenon or group of phenomena.
2. Formulation of an hypothesis to explain the phenomena. In physics, the hypothesis often takes the form of a causal mechanism or a mathematical relation.
3. Use of the hypothesis to predict the existence of other phenomena, or to predict quantitatively the results of new observations.
4. Performance of experimental tests of the predictions by several independent experimenters and properly performed experiments.

If the experiments bear out the hypothesis it may come to be regarded as a theory or law of nature (more on the concepts of hypothesis, model, theory and law below). If the experiments do not bear out the hypothesis, it must be rejected or modified. What is key in the description of the scientific method just given is the predictive power (the ability to get more out of the theory than you put in; see Barrow, 1991) of the hypothesis or theory, as tested by experiment. It is often said in science that theories can never be proved, only disproved. There is always the possibility that a new observation or a new experiment will conflict with a long-standing theory.

Testing Hypotheses

As just stated, experimental tests may lead either to the confirmation of the hypothesis, or to the ruling out of the hypothesis. The scientific method requires

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that an hypothesis be ruled out or modified if its predictions are clearly and repeatedly incompatible with experimental tests. Further, no matter how elegant a theory is, its predictions must agree with experimental results if we are to believe that it is a valid description of nature. In physics, as in every experimental science, "experiment is supreme" and experimental verification of hypothetical predictions is absolutely necessary. Experiments may test the theory directly (for example, the observation of a new particle) or may test for consequences derived from the theory using mathematics and logic (the rate of a radioactive decay process requiring the existence of the new particle). Note that the necessity of experiment also implies that a theory must be testable. Theories which cannot be tested, because, for instance, they have no observable ramifications (such as, a particle whose characteristics make it unobservable), do not qualify as scientific theories.

If the predictions of a long-standing theory are found to be in disagreement with new experimental results, the theory may be discarded as a description of reality, but it may continue to be applicable within a limited range of measurable parameters. For example, the laws of classical mechanics (Newton's Laws) are valid only when the velocities of interest are much smaller than the speed of light (that is, in algebraic form, when $v/c \ll 1$). Since this is the domain of a large portion of human experience, the laws of classical mechanics are widely, usefully and correctly applied in a large range of technological and scientific problems. Yet in nature we observe a domain in which v/c is not small. The motions of objects in this domain, as well as motion in the "classical" domain, are accurately described through the equations of Einstein's theory of relativity. We believe, due to experimental tests, that relativistic theory provides a more general, and therefore more accurate, description of the principles governing our universe, than the earlier "classical" theory. Further, we find that the relativistic equations reduce to the classical equations in the limit $v/c \ll 1$. Similarly, classical physics is valid only at distances much larger than atomic scales ($x \gg 10^{-8}\,m$). A description which is valid at all length scales is given by the equations of quantum mechanics.

We are all familiar with theories which had to be discarded in the face of experimental evidence. In the field of astronomy, the earth-centered description of the planetary orbits was overthrown by the Copernican system, in which the sun was placed at the center of a series of concentric, circular planetary orbits. Later, this theory was modified, as measurements of the planets motions were found to be compatible with elliptical, not circular, orbits, and still later planetary motion was found to be derivable from Newton's laws.

Error in experiments have several sources. First, there is error intrinsic to instruments of measurement. Because this type of error has equal probability of producing a measurement higher or lower numerically than the "true" value, it is called random error. Second, there is non-random or systematic error, due to factors which bias the result in one direction. No measurement, and therefore no experiment, can be perfectly precise. At the same time, in science we have standard ways of estimating and in some cases reducing errors. Thus it is important to determine the accuracy of a particular measurement and, when stating quantitative results, to quote the measurement error. A measurement without a quoted error is meaningless. The comparison between experiment and theory is made within the context of experimental errors. Scientists ask, how many standard deviations are the results from the theoretical prediction? Have all sources of systematic and random errors been properly estimated?

Common Mistakes in Applying the Scientific Method

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As stated earlier, the scientific method attempts to minimize the influence of the scientist's bias on the outcome of an experiment. That is, when testing an hypothesis or a theory, the scientist may have a preference for one outcome or another, and it is important that this preference not bias the results or their interpretation. The most fundamental error is to mistake the hypothesis for an explanation of a phenomenon, without performing experimental tests. Sometimes "common sense" and "logic" tempt us into believing that no test is needed. There are numerous examples of this, dating from the Greek philosophers to the present day.

Another common mistake is to ignore or rule out data which do not support the hypothesis. Ideally, the experimenter is open to the possibility that the hypothesis is correct or incorrect. Sometimes, however, a scientist may have a strong belief that the hypothesis is true (or false), or feels internal or external pressure to get a specific result. In that case, there may be a psychological tendency to find "something wrong", such as systematic effects, with data which do not support the scientist's expectations, while data which do agree with those expectations may not be checked as carefully. The lesson is that all data must be handled in the same way.

Another common mistake arises from the failure to estimate quantitatively systematic errors (and all errors). There are many examples of discoveries which were missed by experimenters whose data contained a new phenomenon, but who explained it away as a systematic background. Conversely, there are many examples of alleged "new discoveries" which later proved to be due to systematic errors not accounted for by the "discoverers."

In a field where there is active experimentation and open communication among members of the scientific community, the biases of individuals or groups may cancel out, because experimental tests are repeated by different scientists who may have different biases. In addition, different types of experimental setups have different sources of systematic errors. Over a period spanning a variety of experimental tests (usually at least several years), a consensus develops in the community as to which experimental results have stood the test of time.

Hypothesis, Models, Theories and Laws

In physics and other science disciplines, the words "hypothesis," "model," "theory" and "law" have different connotations in relation to the stage of acceptance or knowledge about a group of phenomena.

An hypothesis is a limited statement regarding cause and effect in specific situations; it also refers to our state of knowledge before experimental work has been performed and perhaps even before new phenomena have been predicted. To take an example from daily life, suppose you discover that your car will not start. You may say, "My car does not start because the battery is low." This is your first hypothesis. You may then check whether the lights were left on, or if the engine makes a particular sound when you turn the ignition key. You might actually check the voltage across the terminals of the battery. If you discover that the battery is not low, you might attempt another hypothesis ("The starter is broken"; "This is really not my car.")

The word model is reserved for situations when it is known that the hypothesis has at least limited validity. A often-cited example of this is the Bohr model of the atom, in which, in an analogy to the solar system, the electrons are described has moving in circular orbits around the nucleus. This is not an accurate depiction of what an atom "looks like," but the model succeeds in mathematically representing the energies (but not the correct angular momenta) of the quantum states of the electron in the simplest case, the hydrogen atom. Another example is Hook's Law (which should be called Hook's principle, or Hook's model), which states that the force exerted by a mass attached to a spring is proportional to the amount the spring is stretched. We know that this principle is only valid for small amounts of stretching. The "law" fails when the spring is stretched beyond its elastic limit (it can break). This principle, however, leads to the prediction of simple harmonic motion, and, as a model of the behavior of a spring, has been versatile in an extremely broad range of applications.

A scientific theory or law represents an hypothesis, or a group of related hypotheses, which has been confirmed through repeated experimental tests. Theories in physics are often formulated in terms of a few concepts and equations, which are identified with "laws of nature," suggesting their universal applicability. Accepted scientific theories and laws become part of our understanding of the universe and the basis for exploring less well-understood areas of knowledge. Theories are not easily discarded; new discoveries are first assumed to fit into the existing theoretical framework. It is only when, after repeated experimental tests, the new phenomenon cannot be accommodated that scientists seriously question the theory and attempt to modify it. The validity that we attach to scientific theories as representing realities of the physical world is to be contrasted with the facile invalidation implied by the expression, "It's only a theory." For example, it is unlikely that a person will step off a tall building on the assumption that they will not fall, because "Gravity is only a theory."

Changes in scientific thought and theories occur, of course, sometimes revolutionizing our view of the world (Kuhn, 1962). Again, the key force for change is the scientific method, and its emphasis on experiment.

Are there circumstances in which the Scientific Method is not applicable?

While the scientific method is necessary in developing scientific knowledge, it is also useful in everyday problem-solving. What do you do when your telephone doesn't work? Is the problem in the hand set, the cabling inside your house, the hookup outside, or in the workings of the phone company? The process you might go through to solve this problem could involve scientific thinking, and the results might contradict your initial expectations.

Like any good scientist, you may question the range of situations (outside of science) in which the scientific method may be applied. From what has been stated above, we determine that the scientific method works best in situations where one can isolate the phenomenon of interest, by eliminating or accounting for extraneous factors, and where one can repeatedly test the system under study after making limited, controlled changes in it.

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There are, of course, circumstances when one cannot isolate the phenomena or when one cannot repeat the measurement over and over again. In such cases the results may depend in part on the history of a situation. This often occurs in social interactions between people.

For example, when a lawyer makes arguments in front of a jury in court, she or he cannot try other approaches by repeating the trial over and over again in front of the same jury. In a new trial, the jury composition will be different. Even the same jury hearing a new set of arguments cannot be expected to forget what they heard before.

Conclusion

The scientific method is intricately associated with science; the process of human inquiry that pervades the modern era on many levels. While the method appears simple and logical in description, there is perhaps no more complex question than that of knowing how we come to know things. In this introduction, we have emphasized that the scientific method distinguishes science from other forms of explanation because of its requirement of systematic experimentation. We have also tried to point out some of the criteria and practices developed by scientists to reduce the influence of individual or social bias on scientific findings.

1.8 Steps of the Scientific Method

The steps of the scientific method are a structure that has been developed over the millennia, since the time of the ancient Greek and Persian philosophers. Whilst there are always minor variations between different scientific disciplines, they all follow the same basic path.

General Question

The starting point of most new research is to formulate a general question about an area of research and begin the process of defining it. This initial question can be very broad, as the later research, observation and narrowing down will hone it into a testable hypothesis.

For example, a broad question might ask 'whether fish stocks in the North Atlantic are declining or not', based upon general observations about smaller yields of fish across the whole area. Reviewing previous research will allow a general overview and will help to establish a more specialized area.

Unless you have an unlimited budget and huge teams of scientists, it is impossible to research such a general field and it needs to be pared down. This is the method of trying to sample one small piece of the whole picture and gradually contribute to the wider question.

Narrowing Down

The research stage, through a process of elimination, will narrow and focus the research area. This will take into account budgetary restrictions, time, available technology and practicality, leading to the proposal of a few realistic hypotheses.

Eventually, the researcher will arrive at one fundamental hypothesis around which the experiment can be designed.

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Designing the Experiment

This stage of the scientific method involves designing the steps that will test and evaluate the hypothesis, manipulating one or more variables to generate analyzable data. The experiment should be designed with later statistical tests in mind, by making sure that the experiment has controls and a large enough sample group to provide statistically valid results.

Observation

This is the midpoint of the steps of the scientific method and involves observing and recording the results of the research, gathering the findings into raw data. The observation stage involves looking at what effect the manipulated variables have upon the subject, and recording the results.

Analysis

The scope of the research begins to broaden again, as statistical analyses are performed on the data, and it is organized into an understandable form. The answers given by this step allow the further widening of the research, revealing some trends and answers to the initial questions.

Conclusions and Publishing

This stage is where, technically, the hypothesis is stated as proved or disproved. However, the bulk of research is never as clear-cut as that, and so it is necessary to filter the results and state what happened and why. This stage is where interesting results can be earmarked for further research and adaptation of the initial hypothesis.

Even if the hypothesis was incorrect, may be the experiment had a flaw in its design or implementation. There may be trends that, whilst not statistically significant, lead to further research and refinement of the process. The results are usually published and shared with the scientific community, allowing verification of the findings and allowing others to continue research into other areas.

Cycles

This is not the final stage of the steps of the scientific method, as it generates data and ideas to recycle into the first stage. The initial and wider research area can again be addressed, with this research one of the many individual pieces answering the whole question.

Building up understanding of a large area of research, by gradually building up a picture, is the true path of scientific advancement. One great example is to look at the work of J J Thomson, who gradually inched towards his ultimate answer.

1.9 Identification of Research Problems

Research forms a cycle. It starts with a problem and ends with a solution to the problem. The problem statement is therefore the axis which the whole research revolves around, beacause it explains in short the aim of the research.

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What is a Research Problem?

A research problem is the situation that causes the researcher to feel apprehensive, confused and ill at ease. It is the demarcation of a problem area within a certain context involving the WHO or WHAT, the WHERE, the WHEN and the WHY of the problem situation.

There are many problem situations that may give rise to research. Three sources usually contribute to problem identification. Own experience or the experience of others may be a source of problem supply. A second source could be scientific literature. You may read about certain findings and notice that a certain field was not covered. This could lead to a research problem. Theories could be a third source. Shortcomings in theories could be researched.

Research can thus be aimed at clarifying or substantiating an existing theory, at clarifying contradictory findings, at correcting a faulty methodology, at correcting the inadequate or unsuitable use of statistical techniques, at reconciling conflicting opinions, or at solving existing practical problems.

Identification of the Problem

The prospective researcher should think on what caused the need to do the research (problem identification). The question that he/she should ask is: Are there questions about this problem to which answers have not been found up to the present?

Research originates from a need that arises. A clear distinction between the Problem and the Purpose should be made. The problem is the aspect the researcher worries about, think about, wants to find a solution for. The purpose is to solve the problem, i.e. find answers to the question(s). If there is no clear problem formulation, the purpose and methods are meaningless.

Keep the following in mind:

- Outline the general context of the problem area.
- Highlight key theories, concepts and ideas current in this area.
- What appear to be some of the underlying assumptions of this area?
- Why are these issues identified important?
- What needs to be solved?
- Read round the area (subject) to get to know the background and to identify unanswered questions or controversies, and/or to identify the the most significant issues for further exploration.

The research problem should be stated in such a way that it would lead to analytical thinking on the part of the researcher with the aim of possible concluding solutions to the stated problem. Research problems can be stated in the form of either questions or statements.

- The research problem should always be formulated grammatically correct and as completely as possible. You should bear in mind the wording (expressions) you use. Avoid meaningless words. There should be no doubt in the mind of the reader what your intentions are.

- Demarcating the research field into manageable parts by dividing the main problem into subproblems is of the utmost importance.

Subproblem(s)

Subproblems are problems related to the main problem identified. Subproblems flow from the main problem and make up the main problem. It is the means to reach the set goal in a manageable way and contribute to solving the problem.

Statement of the Problem

The statement of the problem involves the demarcation and formulation of the problem, ie the WHO/WHAT, WHERE, WHEN, WHY. It usually includes the statement of the hypothesis.

1.10 Formulation of Research Problems

It was previously mentioned that research forms a circle. It starts with a problem and ends with a solution to the problem. Problem statement is therefore the axis which the whole research revolves around, because it explains in short the aim of the research. Prospective researchers can search within their own subject field for suitable problems. What should, however, be mentioned, is that not all identified problems within a scientific field of study is suitable for research.

The prospective researcher should think on what caused the need to do the research (problem identification). The question that he/she should ask him/herself is: Are there questions about this problem to which answers have not been found up to the present? The research problem should be stated in such a way that it would lead to analytical thinking on the part of the researcher with the aim of possibly concluding solutions to the stated problem.

The following aspects are important when formulating a research problem:

- The research problem should always be formulated grammatically correct and as completely as possible. You should bear in mind the wording (expressions) you use. Avoid meaningless words. There should be no doubt in the mind of the reader what your intentions are.
- Demarcating the research field into manageable parts by dividing the main problem into subproblems is of the utmost importance.

The following serves as an example:

- Main problem (Aim of the research project should be clearly stated)
- Subproblems (Means to reach the set goal in a manageable way contribute to solving the problem)

The main and subproblems should, however, form a research unit. After you have stated the research problem, you should continue to formulate the relevant hypotheses.

Research problems are questions that indicate gaps in the scope or the certainty of our knowledge. They point either to problematic phenomena, observed events that are puzzling in terms of our currently accepted ideas, or to problematic theories, current ideas that are challenged by new hypotheses. This chapter first looks at the role of such questions in the research process, and especially the ongoing debate among social scientists as to when and how problems should be formulated.

Second, we consider methodology's effect on defining problems, and how the multimethod approach can be used to focus research more sharply upon the substance of research problems. Finally, we consider the role of theory in problem formulation, and how the multimethod approach integrates theory and research more closely in posing these research questions.

The Role of Research Problems in the Research Process

The problems of everyday life are difficulties to be avoided, if possible. Research problems are eagerly sought after. The difference is that research problems represent opportunities as well as trouble spots. Because scientific knowledge is provisional, all empirical findings and theories are in principle problematic and are, therefore, subject to further investigation.

But in addition to seeking more exact confirmations of existing claims to knowledge, research has the equally important goal of generating new claims. Problem formulation is the logical first step toward this goal. As Northrop (1966) writes, "Inquiry starts only when something is unsatisfactory, when traditional beliefs are inadequate or in question, when the facts necessary to resolve one's uncertainties are not known, when the likely relevant hypotheses are not even imagined. What one has at the beginning of inquiry is merely the problem".

The formulation of research problems also has an important social function. As Merton, Broom, and Cottrell (1959) suggest, researchers must justify the demands for attention and other scarce resources that research makes: "In conferring upon the scientist the right to claim that a question deserves the concerted attention of others as well as himself, the social institution of science exacts the obligation that he justify the claim".

Achieving significant research results is perhaps the most powerful justification for such claims, but this type of justification can be offered only after the fact, and only in the event that the research is successful. A compelling research problem, by contrast, must marshal support in advance of research and, if it is sufficiently compelling, can even sustain that support through the sometimes fruitless periods that researchers experience.

However, despite research problems' logical priority in inquiry, and their importance as a priori justifications, a problem's formulation, as John Dewey stresses, is in fact a "progressive" matter. Dewey means that problem formulations are themselves problematic and so require continual attention to assure that the questions being asked will direct research toward the desired end: "If we assume, prematurely, that the problem involved is definite and clear, subsequent inquiry proceeds on the wrong track. Hence the question arises; How is the formation of a genuine problem so controlled that further inquiries will move toward a solution?"

When and How to Formulate Problems: A Debate

It sometimes seems that there is little about which social scientists agree, and the most effective procedure for formulating research problems is no exception. In particular, there has been considerable debate over whether or not it is important to define problems explicitly in advance of research and to show how they are linked to prior work. Many social scientists hold that research problems should be formulated by carefully analyzing as much of the relevant research literature as possible, formally stating the problem and the major hypotheses that the literature suggests, and only then collecting the data. Their intention is to give research a clear and firm justification and to encourage hypothesis testing.

This will ensure that each new study does its utmost to add in an orderly fashion to the sum of knowledge. However, there are many other social scientists who are equally convinced that this style of formulating problems tends to stifle questions and prevent discoveries that a more openended approach might stimulate.

This latter group argues instead for letting problems and hypotheses emerge throughout the research process, pushed forth by new empirical observations that encourage the researcher to ask new questions and build new theories. For example, Schatzman and Strauss (1973) write— "The automatic use of formally stated hypotheses, and of statements of 'the problem' may make it easier to program action, but it will also limit the kinds of experience that he (the researcher) will tolerate and deal with. In original research there is less likely to be a conceptual closure to inquiry, for as the work of discovery continues and new kinds of data are conceptualized, new problems and hypotheses will emerge. Consequently far from putting a closure on his new experience the researcher will modify his problem and hypotheses—if indeed he ever stated them explicitly—arrange to handle new ones simultaneously with the old, or do so in serial order. This is how the relationship between the observer and the observed object is altered, and how it becomes possible for new questions to be asked and answered through research.

Stating the problem early and in a highly structured form may indeed lock the researcher into a fixed stance with respect to the situation being observed, and it may also block the emergence of new ideas that might be stimulated by new experience. But open-endedness may have costs as well. For instance, Huber (1973) argues that letting the emergent features of each new research situation continually exert pressure to redefine problems and hypotheses tends to bias the emerging theory in the direction of the status quo.

It gives undue weight to the particular situation being studied at the moment, diverts attention from the problems posed by other theories, and interferes with theory-testing because the same data obviously cannot be used both to form and to test an hypothesis. In this view, prestated problems and hypotheses do much more than make it "easier to program action" (as Schatzman and Strauss [1973] suggest).

They discipline research in the interest of testing theory, accumulating knowledge, and achieving a theoretical standpoint independent of the time and place in which researchers presently find themselves.

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Overcoming Methodological Constraints on Problem Formulation

Both sides in the foregoing debate clearly have merit. However, in practice the decision as to when and how research problems should be defined usually depends less upon the perceived merits of one or the other of these procedures than upon the research style selected. Methods differ in their abilities to predict the kinds, quantities, and quality of the data that may be available in any given instance.

For example, survey researchers or experimentalists can usually say with more certainty than fieldworkers whether or not the data pertinent to a particular research problem can be readily collected. Fieldwork offers the possibility of many data sources, but it is usually hard to say in advance which data will actually be obtainable. Similarly, Selltiz, Jahoda, Deutsch, and Cook (1959) note the need to take a "wait-and-see" attitude in the use of nonreactive data sources such as statistical records: "The use of such data demands a capacity to ask many different questions related to a research problem. . . . The guiding principle for the use of available statistics consists in keeping oneself flexible with respect to the form in which the research questions are asked".

An empirical search for problems is considerably less expensive with some methods than others. Exploratory experiments and surveys are certainly feasible, but pilot field studies and searches through archives generally cost less, except perhaps for the researcher whose personal expenditure of time and energy usually "fund" such studies. Moreover, discoveries arise in different ways for different methods. Fieldworkers and nonreactive researchers are more likely to make discoveries as a result of finding new data sources and examining new situations; while survey researchers and experimentalists are more likely to make discoveries through innovations in techniques of study design, sampling, or data analysis, which can generate unexpected (serendipitous) findings by more precise tests of hypotheses.

Different research styles thus exert different constraints on formulating problems as as open-ended constraints in response to the immediate research situation for fieldwork and non-reactive research or more programmed constraints for surveys and experiments. The multimethod strategy provides the opportunity to overcome these methodological constraints upon problem formulation and thereby gain the advantages of each approach while compensating for its disadvantages.

Sieber (1973), for example, notes Stinchcombe's (1964) reliance upon about six months of fieldwork among the teachers and administrators in a high school to formulate the hypotheses that guided Stinchcombe's analysis of survey data from the same school. Sieber (1973) concludes that "an optimal schedule for theoretical survey research would include a lengthy period of fieldwork prior to the survey" (p. 1346). He further observes that although he could find in the literature few other examples of this practice of deriving a survey's guiding theory from fieldwork, it may be quite common, since "Often, only passing acknowledgement is made of prior personal familiarity with the situation, a familiarity that has produced rather definite ideas for research (p. 1345). Sieber (1973) cites, for instance, Lipset's (1964) autobiographical account of how the childhood experience of his father's membership in the International Typographical Union, along with the classic works of Robert Michels and Alexis de Tocqueville, influenced the research problem that Lipset and his colleagues formulated and tested in the classic survey study, Union Democracy (1956). If, as Dewey suggested, the correct formulation of research problems is crucial to their solution, then it is critical that no source of potentially valid information—no matter how "unscientific" it may seem—be ignored.

Furthermore, Sieber (1973) demonstrates how despite "an historical antagonism between proponents of qualitative fieldwork and survey research," integration between these two research styles has been achieved in numerous studies (p. 1335). He shows how fieldwork has been employed to define the theoretical structure of problems later studied in surveys, to define and gain greater knowledge of the problem relevant populations for surveys, and to reformulate problems by aiding in the interpretation of surprising survey findings and statistical relationships between variables. He likewise shows how surveys have been used to define and pinpoint relevant cases for fieldwork, to verify and establish the generality of field observations, and to cast new light on "hitherto inexplicable or misinterpreted" observations.

Generating Versus Verifying Theories

The issue of when and how to formulate research problems is closely related to another issue: the relative importance of generating new theories versus the verification of existing theories. Both building and testing theories empirically, are important research activities, but they serve very different functions in scientific inquiry.

Since at least the 1960s, the appropriate balance between these two aspects of research has provoked considerable controversy in the social sciences. For example, Glaser and Strauss, writing about sociology in 1967, observe: "Verification is the keynote of current sociology. Some three decades ago, it was felt that we had plenty of theories but few confirmations of them—a position made very feasible by the greatly increased sophistication of quantitative methods. As this shift in emphasis took hold, the discovery of new theories became slighted and, at some universities, virtually neglected".

Glaser and Strauss (1967) argue that the emphasis on verification of existing theories kept researchers from investigating new problem areas; prevented them from acknowledging the necessarily exploratory nature of much of their work, encouraged instead the inappropriate use of verificational logic and rhetoric; and discouraged the development and use of systematic empirical procedures for

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generating as well as testing theories. To compensate for the overemphasis upon verification, Glaser and Strauss urged that research designed to build empirically "grounded" theories must be recognized as a legitimate social scientific pursuit independent of verification. They saw no necessary logical conflict between empirically building and testing theories. But they felt that the social and the psychological conflicts "reflecting the opposition between a desire to generate theory and a trained need to verify it" were so strong that clear designation of theory building as a proper research goal was essential: "when generating 'theory' is not clearly recognized as the main goal of a given research, it can be quickly killed by the twin critiques of accurate evidence and verified hypotheses".

If we accept that generating theories empirically is not a substitute for empirical verification, then building theories without immediate regard for testing poses no special logical problems. However, it may complicate matters methodologically. One serious complication is that theories are often built empirically using research methods that are different from the methods required to verify them.

Each style of social research can be employed either to generate or to verify theories. But in fact, purely generational studies tend to rely more upon fieldwork or nonreactive data sources than upon experiments or surveys, and often more upon qualitative than upon quantitative observation and analysis. The transition from generational to verificational research may therefore involve a methodological shift as well as a change in the focus of problem formulation. Studying a theory with different research methods provides an opportunity for fuller examination of that theory. However, employing a new or different method also creates difficulties. It may be far from obvious how, for instance, concepts and propositions developed through qualitative field studies may be measured and operationalized in terms suitable for quantitative surveys or experiments—or vice versa, how to design a field study to test a theory deriving from surveys or experiments. There may also be questions about the appropriateness of the new method to the theory's content, or about whether or not operational hypotheses that can be tested with that method do in fact adequately represent the theory and so provide a fair and full test.

Bernstein, Kelly, and Doyle (1977) encountered these kinds of difficulties in formulating and testing hypotheses derived from symbolic interactionist theories of deviance. These were theories that had been generated largely in qualitative field studies. Bernstein et al.'s strategy was to combine qualitative field observation with quantitative analysis of interviews and court records collected for a larger sample of criminal defenders. This multimethod approach, which is an example of the transition study described allowed them to use the fieldwork data to aid in both the design and the interpretation of the survey and archival segment of their study. The approach also permitted them to be open and sensitive to the kinds of firsthand field observations that had prompted the initial theories. They thereby retained descriptive realism without sacrificing either the quantitative precision required for verification or the generalizability provided by their larger sample.

The Empirical Unfolding of Research Problems

Once a study is published, it is in many ways irrelevant whether the research problem prompted the study or instead emerged from it. With publication, the study's problem enters the public domain and becomes the responsibility not only of the study's author but of all who are professionally interested in that research area. At that point, the key issue is what to do with the problem next. Research into a problem does not end with a single study. Nor is there truly a final formulation of a problem any more than there is a final solution. All research involves some simplification of the problem being investigated. This is unavoidable given the limitations on our resources, theories, and methods.

However, each of a discipline's separate new studies, or each phase of study in an individual's research program, reveals new aspects of the problem by addressing issues that earlier research could not address. The two modes of formulating research problems that we have just discussed differ in that one looks to past studies, while the other looks to ongoing work. But the two are similar in that both rely upon empirical inquiry rather than upon nonempirical procedures, such as speculation or the purely logical analysis of ideas. This means that whether research problems emerge from current research or instead derive from earlier work, research methods are directly implicated in the process. Every empirically based research problem has a methodological as well as a substantive component, and this methodological component may equally influence our perceptions as to which particular phenomena and theories are problematic. One of the central questions to be posed, therefore, is how do the methods employed in research directly affect the formulation of research problems?

The Substantive Importance of Methodology

Deutscher (1966), for example, posed this question of methodological influence by revealing one of the major *simplifications of social policy research* conducted through the early 1960s. He noted the very heavy reliance upon survey research at that time, and suggested that this reliance upon surveys led social scientists to oversimplify research problems by assuming that verbal responses reflect behavioral tendencies.

Deutscher observed that only by making this assumption were researchers, who were studying issues such as racial and ethnic discrimination, able to make *causal inferences about* behavior solely on the basis of questionnaire and interview data. However, he stressed that this assumption neglected a central problem that had begun to emerge from exploratory field studies as early as the 1930s: People's words and deeds frequently do not agree. To correct this oversimplification, Deutscher urged both that this neglected problem of "attitude versus action" *must be formulated more systematically* and that a new research technology, a multimethod approach, must be developed to capture both attitudinal and behavioral aspects of policy problems.

The problem of attitude versus action is now a major topic of multimethod research. But when Deutscher addressed this problem in 1966, the topic was relatively unexplored. New areas of inquiry, where little is presumably yet known,

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promise productive research problems. However, the actual formulation of the problems may be more difficult than in more developed areas in which consistent bodies of empirical generalizations and theories have already been established. This became evident when Deutscher (1966) set about formulating the problem of attitude versus action:

> "We still do not know much about the relationship between what people say and what they do—attitudes and behavior, sentiments and acts, verbalizations and interactions, words and deeds. We know so little that we can't even find an adequate vocabulary to make the distinction! Under what conditions do they say one thing and behave exactly the opposite? In spite of the fact that all of these combinations have been observed and reported few efforts have been made to order these observations."

As research into a problem proceeds with researchers posing it in different ways, the problem ideally (as Dewey implied) unfolds to reveal new dimensions that facilitate the problem's solution. The variety of available research methods is a key element in this process in that it provides researchers with a multifaceted empirical view of the phenomena and of the theories in question. This enables researchers to formulate problems in a manner that does greater justice both to the complexity of social phenomena and to the complex implications of our theories.

However, employing a variety of methods also complicates the process of problem formulation because different types of research methods very often provide conflicting answers to the same research questions. For example, Deutscher (1966) found the problem of attitude versus action to be complicated by the fact that experimental studies generally reported greater consistency between subjects' words and deeds than did observational field studies. When such methodologically linked contradictions appear in the course of a problem's development, the suspicion is that they may derive from theoretically irrelevant characteristics of the different methods employed rather than from the substantive complexity of the problem.

Inconsistent findings require reformulations of research problems. When these inconsistencies reflect unanticipated substantive complexity, then concepts and propositions must be recast to take account of that complexity. But although more complicated theories are sometimes necessary to achieve theoretical realism, simplicity is preferable. And if, in fact, contradictory research findings are attributable to methodological influences and can be shown to be consistent with existing theories, once those influences have been taken into account, so much the better.

The substance of social life is certainly diverse enough to generate inconsistent findings, but the methods of social research are also diverse. Only by analyzing the methods employed to obtain research findings can it be determined which source of inconsistency any given set of findings reflects. For example, Hovland (1959) observed that textbooks summarizing the effects of communication on opinion-change in the 1950s often reported substantive contradictions in research findings without regard to differences in methodology, despite the fact that stronger effects were generally found in experiments than in surveys. However, Hovland found that upon closer inspection these apparent contradictions might be explained in terms of the idiosyncrasies of these two different types of methods and might not require new theoretical explanations. In sum, although the exclusive use of a single type of research method can oversimplify research problems, the use of different types of research methods, without systematic comparisons of their results and an understanding of possible methodological influences, can make *problems appear to be more complex—or complex in different ways*—than they really are.

1.11 Survey of Literature

A thorough literature study is an indispensable component of all research. It familiarises the researcher with both research which has already been done in his field as well as with current research. A literature study makes the researcher aware of what the current train of thought is, as well as the focus of existing and acceptable thought regarding a specific topic. It also helps him demarcate the boundaries of his research theme. When doing this, he finds ideas for his own research theme and for possibly processing his data.

The researcher also gains personally by his literature review. It fosters a certain attitude and leads to the attainment of certain skills:

- It develops the ability to recognize and select the significant and the relevant, without getting lost in trivialities.
- It helps in gauging the quality of research material and in planning his research accordingly.
- It develops a critical attitude regarding others' research as well as his own efforts.
- It trains him to be an astute observer especially in respect of certain obstacles, making it possible for him to avoid them.
- Knowledge of relevant literature helps the researcher to define the boundaries of his field.

The Role of a Literature Study in Research

The literature study helps the researcher to:

- Select a research problem or theme. Relevant literature enables the researcher to discover where inconsistencies, wrong designs and incorrect statistical conclusions occur.

Often research reports are concluded with recommendations regarding research which still needs to done. The researcher's thinking can be shaped in this way, which in turn will enable him to:

- define the boundaries of his field;
- establish the size and extent of his research;
- consider the procedures and the instruments which he will use in his research. After having considered other researchers' procedures and instruments, the researcher becomes more sophisticated in the choice of his own;

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- see his own problem in better perspective through a better understanding of the underlying theory. This enables him to establish whether his research will make a contribution and what the value of his contribution would be;
- avoid unnecessary (non-purposeful) repetition of research already undertaken. A researcher often develops a brilliant insight into how to tackle a problem, only to discover, through a study of relevant literature, that someone else has already done so;
- better evaluate the significance of his own findings. This applies especially in respect of which techniques were used, and which contributions were made to gaining a better understanding of the problem, etc;
- formulate his hypotheses with sharper insight;
- carry out his research more purposefully. In time he learns to eliminate the unnecessary. He learns from the successes and failures of others.

Types of Literature

In studying works dealing with earlier (and acceptable) research, two types of sources, especially, come to the fore:

- Comprehension literature, ie books and articles by experts in which they state their opinions, experiences, theories and ideas on concepts and constructs within a specific problem area, as well as their opinions on what is good or bad, desirable or undesirable, valuable or worthless regarding insight into specific concepts or constructs. For the young researcher it is very useful because it helps him to understand the validity of correctness of theories (outdated, existing or newly formed) better. It also shows him where there are shortcomings in a specific field (thus requiring research). It also shows its strengths which he may wish to pursue.
- **Research literature:** This includes reporting in respect of research already undertaken in the field (and is currently drawing attention) and gives the researcher a good indication of successes and problems in respect of research procedures, design, hypotheses, techniques and instruments.
- The results of studying these two types of literature are thus a personal frame of reference, i.e. an insight into the body of basic knowledge, possible differences, underlying theories, et cetera.
- It furthermore leads to a greater awareness of those matters within the field which have already sufficiently been demonstrated and proved, as well as those matters still requiring more in-depth research.

Primary and Secondary Sources

Primary sources of a specific type of information are the original works, books, magazine articles, films, sound recordings, et cetera, which reflect the information firsthand. Secondary sources include commentaries, explanations, elucidations et cetera, which other writers have done on the primary sources.

It is desirable (especially in historical research) that, where possible, the primary source should preferably be consulted. There are, however, problems with consulting primary sources.

- The source is out of print, has been destroyed or is unobtainable. Then secondary sources have to be consulted.
- The primary source is in a foreign language, rendering it inaccessible for the researcher. Translations have to be used with the expressed knowledge that such translations are possibly inaccurate or even incorrect. Sometimes it helps to read an expert's comment on the translation.
- The primary source is so complicated and advanced that the researcher cannot understand it. It then helps to read explanations in technical *dictionaries, encyclopaedias or elementary handbooks.*

This, does not mean, however, that secondary sources are of no value whatsoever. The researcher could possibly encounter many useful references to primary sources in his study of secondary sources.

Survey

To conduct research regarding a topic, by implication means that the researcher has obtained sound knowledge with regard to the research topic. It is therefore imperative that the researcher, at the time of the submission of the research proposal, clearly indicates what theoretical knowledge he possesses about the prospective research. A literature search therefore will entail the literature the prospective researcher has already consulted.

An overview of the literature anticipates the background knowledge of the researcher and a possible classification of the content for the purpose of stating the research problem. This should also reveal the importance of the contemplated research. A literature search therefore simplifies the formulation of hypotheses for the researcher.

The aim of a literature study is to:

- give all-round perspectives on the latest research findings regarding the topic;
- indicate the best method, scale of measurements and statistics that can be used;
- interpret the research findings in a better way; and
- determine the relevancy of the prospective research.

It should further noted that the research design must be accompanied by a preliminary list of references consulted by the researcher during the preparation of the research proposal. The list should include the most recent publications on the research topic. It must however be emphasized that this reference list by no means is sufficient to complete the research project; it must be augmented during further literature searches as the research process continues.

1.12 Process of Research

Scientific Research

Generally, research is understood to follow a certain structural process. Though step order may vary depending on the subject matter and researcher, the following steps are usually part of most formal research, both basic and applied:

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- Formation of the topic
- Hypothesis
- Conceptual definitions
- Operational definitions
- Gathering of data
- Analysis of data
- Test, revising of hypothesis
- Conclusion, iteration if necessary

A common misunderstanding is that by this method a hypothesis can be proven or tested. Generally a hypothesis is used to make predictions that can be tested by observing the outcome of an experiment. If the outcome is inconsistent with the hypothesis, then the hypothesis is rejected. However, if the outcome is consistent with the hypothesis, the experiment is said to support the hypothesis. This careful language is used because researchers recognize that alternative hypotheses may also be consistent with the observations.

In this sense, a hypothesis can never be proven, but rather only supported by surviving rounds of scientific testing and, eventually, becoming widely thought of as true (or better, predictive), but this is not the same as it having been proven. A useful hypothesis allows prediction and within the accuracy of observation of the time, the prediction will be verified. As the accuracy of observation improves with time, the hypothesis may no longer provide an accurate prediction. In this case a new hypothesis will arise to challenge the old, and to the extent that the new hypothesis makes more accurate predictions than the old, the new will supplant it.

Choose a Topic

The first step is determining your specific topic. There are many subjects, but each subject has many topics. For example, the subject may be geology, but your topic may be granite, igneous formations, or vulcanism. You can narrow down each of these topics even more specifically. You can narrow vulcanism to cone formation, ash versus lava volcanoes, dome formation, relationship of earthquakes to vulcanism, etc. Here you will concentrate your research. Don't try to study geology—that would take years. Don't try to research vulcanism—that would take months. Research cone formation.

Hypothesis

A hypothesis consists either of a suggested explanation for an observable phenomenon or of a reasoned proposal predicting a possible causal correlation among multiple phenomena. The term derives from the Greek, hypotithenai meaning "to put under" or "to suppose." The scientific method requires that one can test a scientific hypothesis. Scientists generally base such hypotheses on previous observations or on extensions of scientific theories. Even though the words "hypothesis" and "theory" are often used synonymously in common and informal usage, a scientific hypothesis is not the same as a scientific theory. A hypothesis is never to be stated as a question, but always as a statement with an explanation following it. It is not to be a question because it states what he/she thinks or believes will occur.

In early usage, scholars often referred to a clever idea or to a convenient mathematical approach that simplified cumbersome calculations as a hypothesis; when used this way, the word did not necessarily have any specific meaning. Cardinal Bellarmine gave a famous example of the older sense of the word in the warning issued to Galileo in the early 17th century: that he must not treat the motion of the Earth as a reality, but merely as a hypothesis.

In common usage in the 21st century, a hypothesis refers to a provisional idea whose merit requires evaluation. For proper evaluation, the framer of a hypothesis needs to define specifics in operational terms. A hypothesis requires more work by the researcher in order to either confirm or disprove it. In due course, a confirmed hypothesis may become part of a theory or occasionally may grow to become a theory itself. Normally, scientific hypotheses have the form of a mathematical model. Sometimes, but not always, one can also formulate them as existential statements, stating that some particular instance of the phenomenon under examination has some characteristic and causal explanations, which have the general form of universal statements, stating that every instance of the phenomenon has a particular characteristic.

Any useful hypothesis will enable predictions by reasoning (including deductive reasoning). It might predict the outcome of an experiment in a laboratory setting or the observation of a phenomenon in nature. The prediction may also invoke statistics and only talk about probabilities. Karl Popper, following others, has argued that a hypothesis must be falsifiable, and that one cannot regard a proposition or theory as scientific if it does not admit the possibility of being shown false. Other philosophers of science have rejected the criterion of falsifiability or supplemented it with other criteria, such as verifiability (e.g., verificationism) or coherence (e.g., confirmation holism). The scientific method involves experimentation on the basis of hypotheses in order to answer questions and explore observations.

In framing a hypothesis, the investigator must not currently know the outcome of a test or that it remains reasonably under continuing investigation. Only in such cases does the experiment, test or study potentially increase the probability of showing the truth of a hypothesis. If the researcher already knows the outcome, it counts as a "consequence" and the researcher should have already considered this while formulating the hypothesis. If one cannot assess the predictions by observation or by experience, the hypothesis classes as not yet useful, and must wait for others who might come afterward to make possible the needed observations. For example, a new technology or theory might make the necessary experiments feasible.

Scientific Hypothesis

People refer to a trial solution to a problem as a hypothesis often called an "educated guess" because it provides a suggested solution based on the evidence. Experimenters may test and reject several hypotheses before solving the problem.

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According to Schick and Vaughn, researchers weighing up alternative hypotheses may take into consideration:

- *Testability* (compare falsifiability as discussed above)
- *Simplicity* (as in the application of "Occam's razor", discouraging the postulation of excessive numbers of entities)
- *Scope*: the apparent application of the hypothesis to multiple cases of phenomena
- *Fruitfulness:* the prospect that a hypothesis may explain further phenomena in the future
- *Conservatism:* the degree of "fit" with existing recognized knowledge-systems

Conceptual Definition

A conceptual definition is an element of the scientific research process, in which a specific concept is defined as a measurable occurrence. It basically gives you the meaning of the concept. It is mostly used in fields of philosophy, psychology, communication studies. This is especially important when conducting a content analysis.

Examples of ideas that are often conceptually defined include intelligence, knowledge, tolerance, and preference.

Following the establishment of a conceptual definition, the researcher must use an operational definition to indicate how the abstract concept will be measured.

Operational Definition

Operational definition is a demonstration of a process such as a variable, term, or object relative in terms of the specific process or set of validation tests used to determine its presence and quantity. Properties described in this manner must be sufficiently accessible, so that persons other than the definer may independently measure or test for them at will. An operational definition is generally designed to model a conceptual definition.

The most operational definition is a process for identification of an object by distinguishing it from its background of empirical experience. The binary version produces either the result that the object exists, or that it doesnot, in the experiential field to which it is applied. The classifier version results in discrimination between what is part of the object and what is not part of it. This is also discussed in terms of semantics, pattern recognition, and operational techniques, such as regression.

For example, the weight of an object may be operationally defined in terms of the specific steps of putting an object on a weighing scale. The weight is whatever results from following the measurement procedure, which can in principle be repeated by anyone. It is intentionally not defined in terms of some intrinsic or private essence. The operational definition of weight is just the result of what happens when the defined procedure is followed. In other words, what's being defined is how to measure weight for any arbitrary object, and only incidentally the weight of a given object.

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Operationalize means to put into operation. Operational definitions are also used to define system states in terms of a specific, publicly accessible process of preparation or validation testing, which is repeatable at will. For example, 100 degrees Celsius may be crudely defined by describing the process of heating water until it is observed to boil. An item like a brick, or even a photograph of a brick, may be defined in terms of how it can be made. Likewise, iron may be defined in terms of the results of testing or measuring it in particular ways.

One simple, every day illustration of an operational definition is defining a cake in terms of how it is prepared and baked (i.e., its recipe is an operational definition). Similarly, the saying, if it walks like a duck and quacks like a duck, it must be some kind of duck, may be regarded as involving a sort of measurement process or set of tests.

Limitations

If a definition invokes an historical event, such as having weighed an object sometime in the past, it is no longer repeatable, so it fails to qualify as operational. Similarly, a specific brick cannot be operationally defined by the process of making it, because that process is historical. (But see the example of the constellation Virgo below for a discussion of how to avoid this difficulty.)

Operational definitions are inherently difficult; arguably, even impossible to apply to mental entities, because these latter are generally understood to be accessible only to the individual who experiences them and are therefore not independently verifiable. According to this line of thinking, a person's mental image of a brick cannot be operationally defined because it cannot be measured from outside that person's mood. Philosopher Daniel Dennett has argued that first-person operationalism is possible and desirable, using the anthropological version of the scientific method to bring the mind fully into the third-person realm required by science. As part of the Multiple Drafts Model of consciousness, Dennett defines a process he calls heterophenomenology, by which the mental is defined operationally in terms of the observed behavior of the subject.

Usefulness

Despite the controversial philosophical origins of the concept, particularly its close association with logical positivism, operational definitions have undisputed practical applications. This is especially so in the social and medical sciences, where operational definitions of key terms are used to preserve the unambiguous empirical testability of hypothesis and theory. Operational definitions are also important in the physical sciences.

Relevance to Science

The special theory of relativity can be viewed as the introduction of operational definitions for simultaneity of events and of distance, that is, as providing the operations needed to define these terms.

In quantum mechanics the notion of operational definitions is closely related to the idea of observables, that is, definitions based upon what can be measured.

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Operational definitions are at their most controversial in the field of psychology, where intuitive concepts, such as intelligence need to be operationally defined before they become amenable to scientific investigation, for example, through processes such as IQ tests. Such definitions are used as a follow up to a conceptual definition, in which the specific concept is defined as a measurable occurrence.

John Stuart Mill pointed out the dangers of believing that anything that could be given a name must refer to a thing and Stephen Jay Gould and others have criticized psychologists for doing just that. A committed operationalist would respond that speculation about the thing in itself, or noumenon, should be resisted as meaningless, and would comment only on phenomena using operationally defined terms and tables of operationally defined measurements.

A behaviorist psychologist might (operationally) define intelligence as that score obtained on a specific IQ test (e.g., the Wechsler Adult Intelligence Scale test) by a human subject. The theoretical underpinnings of the WAIS would be completely ignored. This WAIS measurement would only be useful to the extent it could be shown to be related to other operationally defined measurements, e.g., to the measured probability of graduation from university.

Conceptual vs Operational Definition

Conceptual definition		Operational definition
	Weight	
A measurement of gravitational force acting on an object		A result of measurement of an object on a Newton spring scale

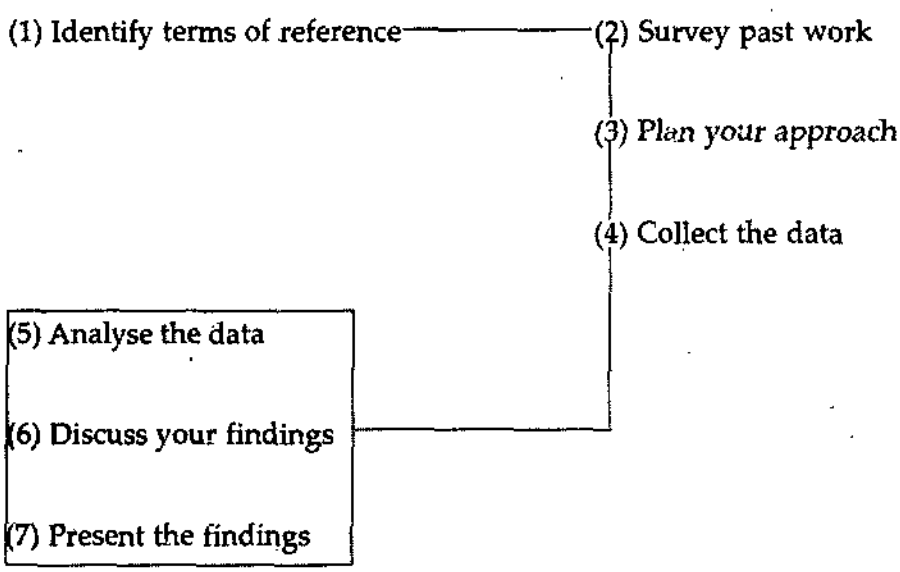
Historical

The historical method comprises the techniques and guidelines by which historians use historical sources and other evidence to research and then to write history. There are various history guidelines commonly used by historians in their work, under the headings of external criticism, internal criticism, and synthesis. This includes higher criticism and textual criticism. Though items may vary depending on the subject matter and researcher, the following concepts are usually part of most formal historical research:

- Identification of origin date
- Evidence of localization
- Recognition of authorship
- Analysis of data
- Identification of integrity
- Attribution of credibility

1.13 General Research Process or Methodology

The research process or methodology is the approach to the entire study, it is the master plan. It is the blueprint for achieving your objectives, one of which is the production of the dissertation. Irrespective of the research you are going to conduct, there are several fundamental stages you will have to go through. The diagram below is a simplified, traditional and highly structured view of the research process.



The diagram shows the systematic nature of the research process. Unfortunately it is not quite so straightforward as many of the stages overlap and there is much 'looping back' to previous stages.

This simplified diagram does not show the underpinning theoretical issues and questions that have to be addressed. The following diagram shows the different aspects to be considered under each section.

As you can see each stage in the process has many aspects and issues to be considered. We cover all of these stages in this unit.

Theory of Research

Superficially the research process can appear to be relatively simple if you carry out the basic steps methodically and carefully, then you should arrive at useful conclusions. However, the nature of research can be very complex and when you are reading textbooks on research methodology you will come across many unfamiliar words and terms. We first look at types of research and explain some of the terms.

Types of Research

The main different types of research can be classified by its purpose, its process and its outcome. These can in turn be broken down further:

- The purpose of the research can be classified as:
  - o exploratory
  - o descriptive
  - o analytical
  - o predictive.

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- The process of the research can be classified as:
  - o quantitative
  - o qualitative.
- The outcome of the research can be classified as:
  - o applied
  - o basic or pure
  - o action.

Let us look at these in more detail.

Purpose of Research

Exploratory Research

This is conducted when there are few or no earlier studies to which references can be made for information. The aim is to look for patterns, ideas or hypotheses rather than testing or confirming a hypothesis. In exploratory research the focus is on gaining insights and familiarity with the subject area for more rigorous investigation later. In an undergraduate dissertation it is likely that you will be drawing on previous studies and so pure exploratory research is not generally appropriate for studies at this level; it is more appropriate for postgraduate research. However, it is possible that you may carry out an initial survey to establish areas of concern (exploratory research) and then research these issues in more depth, perhaps through interviews, to provide a deeper understanding (explanatory research).

Descriptive Research

This describes phenomena as they exist. It is used to identify and obtain information on the characteristics of a particular issue. It may answer such questions as:

- What is the absentee rate amongst a particular group of workers?
- What are the feelings of workers faced with redundancy?

The data collected are often quantitative, and statistical techniques are usually used to summarise the information. Descriptive research goes further than exploratory research in examining a problem since it is undertaken to ascertain and describe the characteristics of the issue.

An undergraduate dissertation may include descriptive research, but it is likely that it will also include one of the following two types (explanatory or predictive) as you are required in your dissertation to go beyond description and to explain or predict.

Analytical or Explanatory Research

This is a continuation of descriptive research. The researcher goes beyond merely describing the characteristics, to analyse and explain why or how something is happening. Thus, analytical research aims to understand phenomena by discovering and measuring causal relations among them. It may answer questions such as:

- How can the number of complaints made by customers be reduced?
- How can the absentee rate among employees be reduced?
- Why is the introduction of empowerment seen as a threat by departmental managers?

Predictive Research

Predictive research goes further by forecasting the likelihood of a similar situation occurring elsewhere. It aims to generalise from the analysis by predicting certain phenomena on the basis of hypothesised, general relationships. It may attempt to answer questions such as:

- *Will the introduction of an employee bonus scheme lead to higher levels of productivity?*
- What type of packaging will improve our products?

Predictive research provides 'how', 'why', and 'where' answers to current events as well as to similar events in the future. It is also helpful in situations where 'What if?' questions are being asked.

Process of Research

There is no consensus about how to conceptualise the actual undertaking of research. There are, however, two main traditions of approaching a research topic— quantitative and qualitative. Each approach demands different research methods.

Quantitative Research

The quantitative approach usually starts with a theory or a general statement *proposing a general relationship between variables.* With this approach it is likely that the researchers will take an objective position and their approach will be to treat phenomena as hard and real. They will favour methods such as surveys and experiments, and will attempt to test hypotheses or statements with a view to generalising from the particular. This approach typically concentrates on measuring or counting and involves collecting and analysing numerical data and applying statistical tests.

Qualitative Research

The alternative tradition is the qualitative approach. Here the investigator views the phenomena to be investigated as more personal and softer. *He or she* will use methods such as personal accounts, unstructured interviews and *participant observation* to gain an understanding of the underlying reasons and motivations for peoples' attitudes, preferences or behaviours. With this approach, the emphasis is more on generating hypotheses from the data collection rather than testing a hypothesis.

In reading around the subject you will find many alternative names for qualitative and quantitative research. It is good to have an understanding of these and to recognise them when you see them in research methods textbooks.

You should note the following points:

- Qualitative and quantitative research methods are not clear-cut nor mutually exclusive; most research draws on both methods.

- Both approaches can generate quantitative and qualitative data.
- The difference between the two methods is in the overall form and in the emphasis and objectives of the study.

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Outcome of Research

Applied Research

Applied research is problem-oriented as the research is carried out to solve a specific problem that requires a decision, for example, the improvement of safety in the workplace, or market research. For your dissertation it is not usually acceptable to carry out applied research as it is very much limited to one establishment or company and you are required to look at issues of wider significance, perhaps to your industry as a whole or to a sector of it. You may have already carried out a problem-based piece of research related to your placement. It is important to understand that the dissertation requires you to carry out some form of basic research.

Basic Research

Basic research is also called fundamental or pure research, and is conducted primarily to improve our understanding of general issues, without any emphasis on its immediate application. It is regarded as the most academic form of research since the principal aim is to make a contribution to knowledge, usually for the general good, rather than to solve a specific problem for one organisation. This may take the form of the following:

- *Discovery*– where a totally new idea or explanation emerges from empirical research which may revolutionise thinking on that particular topic. An example of this would be the Hawthorne experiments. (Gillespie, 1991)
- *Invention*– where a new technique or method is created. An example of this would be the invention of TQM (total quality management).
- *Reflection*– where an existing theory, technique or group of ideas is re-examined possibly in a different organisational or social context. For example, to what extent can Herzberg's theory of motivation be applied to front-line workers in the contract catering sector?

Action Research

This is a form of research where action is both an outcome and a part of the research. The researcher 'interferes' with or changes – deliberately – what is being researched. The critics of action research argue that since the researcher is changing what is being researched during the process of research, the work cannot be replicated. If it cannot be replicated its findings cannot be tested in other situations.

This prevents general knowledge being developed and thus it cannot contribute to theory. Also, as the researcher is involved in the change process there is a loss of critical, detached objectivity. There are two approaches to action research:

- Classical action research begins with the idea that if you want to understand something you should try changing it.

- New paradigm research is based on a new model or framework for research. It claims that research can never be neutral and that even the most static and conventional research exposes the need for change in what is being researched. It involves inquiry into persons and relations between persons, and is based on a close relationship between researcher and those being researched. The research is a mutual activity of a 'co-ownership' involving shared power with respect to the process and the outcomes of the research. Those being researched can, for example, decide how the research will be undertaken, in what form and with what questions being asked. The researcher is a member of a 'community' and brings to it special skills and expertise. The researcher does not dictate what will happen. This type of research is most easily carried out when working with individuals or small groups. It means that the researcher must be highly skilled not only in research methods but also in the interpersonal skills of facilitating others. It is not, therefore, usually appropriate for an undergraduate student who is carrying out a major piece of research for the first time. Action research is often used by educationalists who are trying to improve their own practice by making changes to the delivery of their classes and by observing and asking students which actions work best.

As you can see, there are a number of types of research and not all may be suitable for you in your dissertation. The key points to remember are as follows:

- While the purpose of your dissertation may have some elements of exploratory or descriptive research you should concentrate on research that will mainly fall into the explanatory area, or perhaps predictive research if you are very confident. Explanatory research gives you the opportunity to demonstrate the skills of analysis and evaluation which will help you to score highly in your final marks.
- The process of your research can either be quantitative or qualitative and the different methods that can help you to carry out your research in this way.
- It is likely that you will be carrying out basic or pure research in the reflection mode (rather than applied or action research) as this will give you the best chance of showing that you can test out a theory in a new situation.

1.14 Research Design— Meaning, Purpose and Principles

A plan for collecting and utilizing data so that desired information can be obtained with sufficient precision or so that an hypothesis can be tested properly is called research design.

Research is any form of systematic and arranged investigation to organize facts or gather data, and is often related to a problem that has to be solved. Research is the study of materials, sources, and data in order to get conclusions. Any research is at the center of the process of learning about the world, and it is important that people understand how "good" research is organized. People depend on the

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accumulated knowledge and experience of the civilization. Research is the process the civilization uses to construct further on the store of knowledge.

Research is the process of finding out new data based on facts collected in ways that minimize observer prejudice. Research project comprises a great variety of methods that can be used in order to achieve goals. Sometimes, a research project is designed and worked on by a group of investigators, management decision makers. In this situation collaboration plays a great role in achieving understanding and thus, good results. Here, the proposal is used in order to share the gained experience and find the most effective way of research conducting.

A research project starts from an idea, usually in the mind of a researcher who has done other investigations in the field. The idea may have come from a research done by others. The ideas occur to researchers with a bulk of experience in some field by means of a process of intuitive creative intelligence. A good research differs from a research that falls short of professional quality by set of processes closely connected with each other.

Some researchers point out the cognitive processes of generating creative decisions, gathering expert opinions, assessing the probable results of each alternative. Other researchers point out the problems of good decision-making, such as impatience with gathering data, the consequences of feeling inadequate, dependent. In this situation a hypothesis is used as a form of researchable proposal. Hypothesis is an explanation of observable facts or phenomena that may be verifiable via investigations.

A hypothesis is concerned with an explanation of something previously unknown. It needs some form of investigative process. For the research to be acceptable others must be able to apply the same procedure to get similar outcomes. Hypotheses that can be tested are known as 'testable hypotheses'. It is important to point out that not all investigations have to be concerned with testable hypotheses. Nevertheless, testable hypotheses give a research design that can reliably get high assessment. The purpose of proposal is to suspect the research process before it is carried out and the hypothesis plays a significant role in it.

Research design is a critical part of research. It provides the link between the theory or argument that informed the research, on the one hand, and the empirical material collected on the other. Research design addresses at least three issues. First of all; and most importantly, it must allow the researcher to engage in an on-going debate. Social science proceeds by examining critically the positions in a debate, discover unanswered (or poorly answered) questions, and then engage the debate through an analysis of these weaknesses. Research design therefore has to address the debate, and allow the researcher to make a contribution to that debate. Secondly, and as a result, the design of a research project must aim to include not just the answers that the researcher is trying to give, but also explicitly address the positions in the debate.

Case selection thus becomes an instrument that allows an intervention in the ongoing debate, and therefore needs to be done not just with the researcher's final argument in mind, but also explicitly engaging the most important alternative explanations. Third, the research design must allow the researcher to make the step from argument, over well-specified hypotheses (about the probable outcome of the research) to the actual cases studied. Developing theory or argument, translating them into well-specified hypotheses, and collecting empirical material therefore are steps in the research process that are closely linked to one another. In sum, research design and the selection of cases is an intricate part of building the argument: cases offer analytical leverage.

There are many purposes that research design serve main are as follows:

- Defines, elaborate and explain the research topic.
- Make clear the area of research to other.
- Provide limits and boundaries to a research.
- Give the whole scenario of the research.
- Tell the modes and consequences.
- Ensuring of time and resources is done.

A Standard Design of Research

A. Science, Theory, and Research

Research starts with the researcher, the position where you stand, the world around you, your ethics, etc. The conceptions of the researcher influence the research topic and the methodology with which it is approached. Research is not just a matter of technique or methods.

What is specific to social-science research, as compared to say journalism, is the quest to examine and understand social reality in a systematic way. What is observed is as important as how it is observed.

General outline of a research: theory, conceptualization of theoretical constructs into concepts, formalization of relationships, operationalization, measurement or observation, data analysis or interpretation, report.

1. Science and Reality

Science, as a system of propositions on the world, is a grasp of reality; it is systematic, logical, and empirically founded. Epistemology is the science of knowledge (what is knowledge?), and methodology is the science of gathering knowledge (how to acquire knowledge?). The inferences from science can be causal or probabilistic, and/or it seeks to offer understanding of social processes. Factors that intervene in the process of scientific inquiry include the available tradition of research and the status of the researcher.

Scientific inquiry should reduce errors in observations (mistakes, incorrect inferences), and avoid over-generalizations (e.g. selective observations, only studying that which conforms to a previously found pattern).

Mistakes include: a) ex-post facto reasoning: a theory is made up after the facts are observed, which is not wrong as such, but the derived hypothesis still needs to be tested before it can be accepted as an hypothesis; b) over-involvement of researcher (researcher bias); c) mystification: findings are attributed to supernatural causes; in social-science research, while we cannot understand everything, everything is potentially knowable.

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Basically, the two necessary pillars of science are logics and observation (to retrieve patterns in social life, i.e. at the aggregate level). Note that people are not directly researched: social-science research studies variables and the attributes that compose them.

A variable is a characteristic that is associated with persons, objects or events, and a variable's attributes are the different modalities in which the variable can occur (e.g. the attributes male and female for the variable sex). Theories explain relationships between variables, in terms of causation or understanding. Typically, this leads to identify independent and dependent variables (cause and effect), or situation, actor, and meaning (interpretation).

2. From Theory to Research

Different purposes of social-science research can be identified: (1) to test a theoretical hypothesis, usually a causal relationship (e.g. division of labor produces suicide); (2) to explore unstructured interests, which usually involves a breaking through of the empirical cycle, shifting from induction to deduction (e.g. what is so peculiar about drug-abuse among young black females); (3) applied research, for policy purposes (e.g. market research).

The basic model of research is: (1) theory, theoretical proposition, (2) conceptualization of the theoretical constructs, and formalization of a model, the relationships between variables; (3) operationalization of the variables stated in the theory, so they can be measured (indicators) and (4) observation, the actual measurements. The inquiry can be deductive, from theoretical logic to empirical observations (theory-testing), or inductive, from empirical observations to the search for theoretical understanding of the findings of the observations (theory-construction). (Note that, basically, it's always both, cf. Feyerabend, which is more than just an alternation, it's rather an mutual constituency). The wheel of science.

- *Deduction:* the logical derivation of testable hypotheses from a general theory.
- *Induction:* the development of general principles on the basis of specific observations.

B. Research Design, Measurement, and Operationalization

1. Research Design

Research design concerns the planning of scientific inquiry, the development of a strategy for finding out something. This involves: theory, conceptualization, formalization, operationalization of variables, preparations for observation (choice of methods, selection of units of observation and analysis), observation, data analysis, report (and back to theory).

(a) Purposes of Research

The purposes of research are basically three-fold:

(1) *Exploration:* to investigate something new of which little is known, guided by a general interest, or to prepare a further study, or to develop methods. The disadvantage of most exploratory studies is their lack of representativeness and the fact that their findings are very rudimentary.

(2) *Description:* events or actions are observed and reported (what is going on?). Of course, the quality of the observations is crucial, as well as the issue of generalizability.

(3) *Explanation:* this is research into causation (why is something going on?). This is extremely valuable research of course, but note that most research involves some of all three types.

(b) Units of Analysis

The units of analysis refer to the what or who which is being studied (people, nation-states). Units of analysis can be (and often are) the units of observation, but not necessarily (e.g. we ask questions to individuals about their attitudes towards abortion, but analyze the religious categories they belong to). Units of analysis in social-science research typically include individuals within a certain area at a given period of time; groups (e.g. the family); organizations (e.g. social movements); products of human action (e.g. newspapers in a content-analysis); and so on.

Two common problems are— the ecological fallacy, i.e. making assertions about individuals on the basis of findings about groups or aggregations (e.g. higher crime rates in cities with a high percentage of blacks are attributed to blacks, but could actually be committed by the whites in those areas); and reductionism, i.e. illegitimate inferences from a too limited, narrow (individual-level) conception of the variables that are considered to have caused something broader (societal), (e.g. Durkheim does not explain any individual's suicide, but only the suicide-rates among certain categories of people).

(c) Focus and Time of Research

The focus in a research can be on: (1) characteristics of states of being (e.g. sex of an individual, number of employees in a company); (2) orientations of attitudes (e.g. prejudice of an individual; the political orientation of a group), and (3) actions, what was done (e.g. voting behavior of individuals; the riot participation of a group).

Research, considered in its time dimension, can be (1) cross-sectional at any given point in time; (2) longitudinal over a period of time to trace change or stability (e.g. panel study of the same people after two elections to see if and how their voting behavior changed); (3) quasi-longitudinal by investigating certain variables in a cross-sectional study (e.g. a comparison of older and younger people indicates a process over time).

2. *Conceptualization and Measurement*

(a) Conceptualization

Theories are comprised of statements that indicate relationships between constructs, i.e. particular conceptions which are labeled by a term. These constructs should be conceptualized, i.e. the meaning of the constructs must be specified, as a working agreement, into clearly defined concepts (which are still mental images). Then we can operationalize those concepts, i.e. specify indicators that measure the concept in terms of its different dimensions (e.g. the action or

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the ideas that are referred to by the concept of crime). Note that this process reminds us that terms should not be reified into things.

Concepts, then, should be defined in two steps— first, a nominal definition of the concept gives a more precise meaning to the term, but it cannot yet be observed as such, therefore, second, the operational definition of the concept spells out how it is to be measured or observed, so that the actual measurement can be undertaken. Example: theoretical construct = social control; nominal definition of concept = social control as the individual's bonding to society; operational definition = attachment to primary institutions, which can be high or low; measure = years of education. Note that these specifications are absolutely necessary in explanatory research.

(b) Measurement Quality

Measurements should best be precise, and reliable and valid. Reliability and validity refer to the relationship between measure and concept!!

(1) *Reliability:* does the replication of a measurement technique lead to the same results?

This refers to the consistency of the measurement techniques. Reliability can be achieved through the *test-retest method,* i.e. the replication of a method on a phenomenon that could not, or should not, have changed, or of which the amount of expected change is known (e.g. asking for age, and asking again the next year, should lead to a difference of one year). Another technique for reliability check is the split-half method, e.g. if you have ten indicators for a phenomenon, then use five randomly chosen in one questionnaire, and the other five in the other one, apply to two random-samples, then their should be no differences in the distribution of attributes on the measured variable between the two. Other reliability techniques are the use of established methods, and training of researchers.

(2) *Validity:* does the method of measurement measure what one wants to measure?

This means different things: first, face validity is based on common-sense knowledge (e.g. the number of children is an invalid measure of religiosity); second, criterion or predictive validity is based on other criteria that are related to the measurement (e.g. racist actions should be related to responses to racist attitude scales); third, construct validity is based on logical relationships between variables (e.g. marital satisfaction measurements should correlate with measurements of marital fidelity); finally, content validity refers to the degree to which a measure covers all the meanings of a concept (e.g. racism as all kinds of racism, against women, ethnic groups, etc.).

Note that reliability is all in all an easier requirement, while on validity we are never sure. Note also the tension between reliability and validity, often there is a trade-off between the two (e.g. compare in-depth interviewing with questionnaire surveys).

3. Operationalization

Operationalization is the specification of specific measures for concepts in a research (the determination of indicators). Some guidelines— be clear about

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the range of variation you want included (e.g. income, age), the amount of precision you want, and about the dimensions of a concept you see relevant.

In addition, every variable should have two qualities:— (1) exhaustive: all the relevant attributes of a variable must be included (e.g. the magical 'other' category is best not too big), and (2) attributes should be mutually exclusive (e.g. *whether a person is unemployed or employed is not exclusive, since some people* can be part-time employed and part-time unemployed).

Variables are (1) nominal, when there attributes indicate different, mutually exclusive and fully exhausted qualities (e.g. sex: male or female); (2) ordinal, when the attributes can also be ranked in an order (e.g. type of education); (3) interval, when the distance between attributes in an order is precise and meaningful (e.g. IQ test); and (4) *ratio, when, in addition, these attributes have a* true zero-point (e.g. age). Note that variables do usually not in and by themselves indicate whether they are nominal, ordinal, etc., or that you can convert them from one type to another (e.g. dummy-variables, from nominal to metric).

Finally, note that you can use one or multiple indicators for a variable; sometimes even, a composite measurement is necessary. (note: see questionnaire design for an application of operationalization).

4. Indexes, Scales and Typologies

There are commonalities between indexes and scales; they both typically involve ordinal variables, and they are both composite measures of variables.

An index is constructed by accumulating scores assigned to individual attributes. The requirements of scales are— face validity (each item should measure the same attribute), unidimensionality (only one dimension should be represented by the composite measure). Then you consider all the bivariate relationships between the items in the scale, the relationship should be high, but not perfect

A scale is constructed by accumulating scores assigned to patterns of attributes. The advantage is that it gives an indication of the ordinal nature of the different items, one item is in a sense included in the other (higher ranked).

A typology is a break-down of a variable into two or more. As dependent variables this is a difficult thing, since any one cell in the typology can be under-represented (it's best then to undertake a new analysis, making sure each cell is well represented).

C. Causal Modelling

1. Assumptions of Causal Inquiry

The first step in causal modelling involves conceptualization: what are the relevant concepts, and, second, how to operationalize these concepts. The next step is formalization. i.e. specification of the relationships between the variables. This seems to destroy the richness of the theory, but it helps to achieve comprehensibility and avoids logical inconsistencies. Note that this model is ideally based on a deductive approach, but it does not exclude a more dynamic approach which moves back and forth (from theory to data).

The causal model itself specifies not only the direction (from X to Y) but also the sign of the relationship (positive or negative). A positive relationship means that when X goes up, Y goes up; a negative relationship between X and Y means

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that as X goes up why goes down. between different paths, the signs should be multiplied to determine the net-effect. A causal system is consistent when all the causal chains push the relationship in the same direction (indicated by the fact that all the signs are the same). When some signs are positive, others negative, the system is inconsistent (suppressors).

Please note that the causality is not in reality (perhaps it is), but it is above all put into the model by virtue of the theory. This involves a notion of determinism (for the sake of the model), and that we stop some place in looking for any more causes or effects. Also note that the variables in a causal model are all at the same level of abstraction (ideally).

Causal explanations can be idiographic or nomothetic— (1) idiographic explanations seek to explain a particular events in terms of all its caused (deterministic model); (2) nomothetic explanations seek to explain general classes of actions or events in terms of the most important causes (probabilistic model).

2. *Causal Order: Definitions and Logic*

Prior (unknown or not considered) variables precede the independent variable. Intervening variables are located in between the independent and dependent variable. Consequent variables are all variables coming after the dependent variable (unknown or not considered). Note that the identification of prior, independent, intervening, dependent, and consequent variables is relative to the model at hand.

The causal order between a number of variables is determined by assumptions that determine the causal system that determines the relationship between those variables. (note that variables in a loop have no order, i.e. when the path from X away to other variables returns from those variables back to X).

The following possibilities can be distinguished:

- *X causes Y*
- *X and Y influence eachother*
- *X and Y correlate*

Variable X causes variable Y, when change in X lead to change in Y, or when fixed attributes of X are associated with certain attributes of Y. This implies, of course, that we talk about certain tendencies: X is a (and not the) cause. And this implies correlation as a minimum, necessary condition (the causation itself is theoretical).

3. *Minimum-Criteria for Causality*

Rule 1: Covariation

Two variables must be empirically correlated with one another, they must co-vary, or one of them cannot have caused the other. This leads to distinguish direct from indirect effects.

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Rule 2: Time-order

When Y appears after X, Y cannot have caused X, or in other words, the cause must have preceded the effect in time. Derivative from this is the rule that when X is relatively stable, hard to change, and fertile (it produces many other effects), it is likely to be the independent variable.

Rule 3: Non-Spuriousness

When the observed correlation between two variables is the result of a third variable that influences both of those two separately, then the correlation between the two is spurious. This is indicated by a variable having a causal path to the two variables that correlate.

Basic to causality is the control of variables. Most ideally, this is done by randomization in experiments, then the attributes of any prior variables are randomly distributed over the control and the experimental group. We can also purposely control for prior variables when we select the ones we consider relevant. In bivariate relationships, no variables are controlled, while in partial relationships, one or more of the prior and intervening variables, that might interfere, are controlled. It is better still to identify the necessary and sufficient causes of certain effects but usually we are pleased with either one.

Some common errors are— biased selection of variables to be included in the model, unwarranted interpretation, suppression of evidence, and so on. It is interesting to see the different steps involved in a typical causality-type research and what can go wrong at each step. First, from theory to conceptualization, this step is rarely clear-cut. Second, the step into operationalization is in a way always arbitrary (since the concept indicates more than any measurement). Third, the empirical associations found between measured variables is rarely, if ever, perfect. Finally, any measurement therefore requires additional studies, and any conclusion is in principle falsifiable (variables are shown to be associated, but then the question is how they are associated).

Strategies for causal analysis— When a bivariate non-zero relationship between X and Y is reduced to zero under control of a third variable, then the third variable explains the bivariate relationship, or the relationship is spurious (causality can never be proven by data analysis); Check out for the effect of prior variables; Path analysis.

Sampling Procedures

Sampling refers to the systematic selection of a limited number of elements (persons, objects or events) out of a theoretically specified population of elements, from which information will be collected. This selection is systematic so that bias can be avoided. Observations are made on observation units, which can be elements (individuals) or aggregations of elements (families). A population is theoretically constructed and is often not directly accessible for research. Therefore, the study population, the set of elements from which the sample is actually selected, can (insignificantly) differ from the population. In multi-stage samples, the sampling units refer to elements or sets of elements considered for selection

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at a sampling stage. The sampling frame is the actual list of sampling units from which the samples are selected.

The sampling procedures are designed to best suit the collection of data, i.e. to measure the attributes of the observation units with regard to certain variables. Depending on theoretical concerns and choice of method, probability or non-probability sampling designs are appropriate in research.

1. *Probability Sampling*

Probability sampling is based on principles of probability theory which state that increasing the sample size will lead the distribution of a statistic (the summary description of a variable in the sample) to more closely approximate the distribution of the parameter (the summary description of that variable in the population). The standard error, inversely related to sample size, indicates how closely a sample statistic approximates the population parameter. These conditions are only met when samples are randomly selected out of a population, i.e. when every element in the population has an equal chance of being selected in the sample.

A randomly selected sample of sufficiently large size (absolute size, not size proportionate to the population) is assumed to be more representative for the population because the relevant statistics will more closely approximate the parameters, or the findings in the sample are more generalizable to the population. Representativeness of samples, or generalizability of sample findings, both matters of degree, are the main advantages of probability sampling designs. The accuracy of a sample statistic is described in terms of a level of confidence with which the statistic falls within a specified interval from the parameter (the broader the interval, the higher the confidence). The main disadvantage of probability sampling is that the theoretical assumptions (of infinity) never "really" apply.

(a) Simple Random Sampling

In simple random sampling, each element is randomly selected from the sampling frame. Example: in an alphabetical list of all students enrolled at CU-Boulder, each student is given a number ascending from 1, and 400 students are selected using a table of random numbers.

(b) Systematic Sampling

In systematic sampling, every kth element in a list is selected in the sample, the distance k indicating the sampling interval. The systematic sample has a random start when the first element is randomly chosen (out of numbers between 1 and k). Systematic sampling has the advantage of being more practical but about as (sometimes more) efficient than simple random sampling. A disadvantage is the danger of an arrangement of elements forming a pattern that coincides with the sampling interval. Example: in a list of all students enrolled at CU-Boulder, each 100th student, starting with the randomly chosen 205th, is selected. Later it turned out that every other student in the list was female (and the entire sample female), since the composer of the list though "perfect randomness" would lead to perfect probability samples.

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(c) Stratified Sampling

Stratified sampling is a modification to the use of simple random and systematic sampling. It is based on the principle that samples are more representative when the population out of which they are selected is homogeneous. To ensure samples to be more representative, strata of elements are created that are homogeneous with respect to the (stratification) variables which are considered to correlate with other variables relevant for research (the standard error for the stratification variable equals zero). Example (stratified & systematic): luckily we know how stupid composers of student lists are, so we stratify students by sex (taking every other student in our "perfectly randomized" list); we thus get two strata of students based on sex, and select every 40th student in each stratum.

(d) Cluster Sampling

In cluster sampling, clusters of groups of elements are created, and out of each group, elements are selected. This method is advantageous since often complete lists of the population are unavailable. Cluster sampling is multi-stage when first clusters are selected, then clusters within clusters (on the basis of simple random or systematic sampling, stratified or not), and so on, up until elements within clusters. While cluster sampling is more efficient, the disadvantage is that there are sampling errors (of representativeness) involved at each stage of sampling, a problem which is not only repeated at each stage, but also intensified since sample size grows smaller at each stage. However, since elements in clusters are often found to be homogeneous, this problem can be overcome by selecting relatively more clusters and less elements in each cluster (at the expense of administrative efficiency).

When information is available on the size of clusters (the number of elements it contains), we can decide to give each cluster a different chance of selection proportionate to its size (then selecting a fixed number within each cluster). This method has the advantage of being more efficient: since elements in clusters are typically more homogeneous, only a limited number of elements for each cluster has to be selected. Finally, disproportionate sampling can be useful to focus on any one sample separately, or for the comparison of several samples. In this case, generalizability of sample findings to the entire population should not and cannot be considered.

Example (multi-stage cluster, proportionate to size, stratified): for research on political attitudes of students in the USA, no list of all students are available, but we have a list of all US states; we select a number of states (clusters); they are given a chance of selection proportionate to the "size" of (number of universities in) each state, because, for instance, there are more universities in the north-eastern states (probability proportionate to size); out of the selected states, we select cities (again proportionate to size, since metropolitan areas have more universities), select universities out of each selected city, take the student lists of each selected university, and select a relatively small number of students (assuming homogeneity among them since we know all students in Harvard are conservative and everybody at CU-Boulder is a liberal).

2. Non-Probability Sampling

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The choice between probability or non-probability design is dependent on theoretical premises and choice of method. While probability sampling can avoid biases in the selection of elements and increase generalizability of findings (these are the two big advantages), it is methodologically sometimes not feasible or theoretically inappropriate to undertake them. Then non-probability samplings can be used.

(a) Quota Sampling

In quota sampling, a matrix is created consisting of cells of the same attributes of different variables known to be distributed in the population in a particular way. Elements are selected having all attributes in a cell relative to their proportion in the population (e.g. take 90% white and 10% black because based on census data that is the racial composition of the entire population). Although the information on which the proportionate distribution of elements is based can be inaccurate, quota sampling does strive for representativeness (but it is not based on probability theory).

(b) Purposive Sampling

Purposive or judgmental sampling can be useful in explorative studies or as a test of research instruments. In explorative studies, elements can purposively be selected to disclose data on an unknown issue, which can later be studied in a probability sample. Questionnaires and other research instruments can be tested (on their applicability) by purposively selecting "extreme" elements (after which a probability sample is selected for the actual research).

(c) Sampling by Availability

When samples are being selected simply by the availability of elements, issues of representativeness about the population cannot justifiably be addressed. A researcher may decide to just pick any element that she/he bumps in to. As such, there is nothing wrong with this method, as long as it is remembered that the selection of samples may be influenced by dozens of biases and cannot be assumed to represent anything more than the selected elements.

(d) Theoretical Reasons for Non-Probability Sampling

The previous non-probability sampling designs are related to methodological concerns. In fact, the issue of representativeness does matter in the background of these designs but is conceived not feasible or, worse, purported as feasible but not founded on probability theory. However, more interesting and scientifically valuable are the non-probability sampling designs based on theoretical insight. In some theoretical models, it is unwise to conceive the world in terms of probability, sometimes even not as something to be sampled. (this is a kind of purposive sampling, but now because of theoretical concerns).

First, in field research, the researcher may be interested in acquiring a total, holistic understanding of a natural setting. As such, there is no real sampling of

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anything at all. However, since observations on "everything" or "everybody" can in effect never be achieved, it is best to study only those elements relevant from a particular research perspective (sometimes called "theoretical sampling" or "creative sampling").

Second, when the elements in a natural setting clearly appear in different categories, quota sampling "in the field" can be used. This is the same as regular quota sampling, but the decisions on relevant cells and proportions of elements in cells are based on field observations.

Snowball sampling is used when access to the population is impossible (methodological concern) or theoretically irrelevant. The selection of one element leads to the identification and selection of others and these in turn to others, and so on. (The principle of saturation, indicating the point when no more new data are revealed, determines when the snowball stops). Example (cluster and snowball): in a study of drug-users in the USA, a number of cities (clusters) is randomly selected, a drug-user is selected in each city (e.g. through clinics), is interviewed and asked for friends that use drugs too, and so on. Example (snowball): a researcher is interested in African-American HIV infected males in Hyde Park, Chicago; the research aims at in-depth understanding of this setting, and inferences about other HIV infected males are trivial (apart from being impossible).

Third, the sampling of deviant cases can be interesting to learn more about a general pattern by selecting those elements that do not conform to the pattern. Example: 99% of the students at CU voted for Clinton, so I select those that did not, to find out why they are "deviant".

These samples are purposive samples with a theoretically founded purpose. As long as that is the case, their use may be perfectly justified and, according to some theories, even the only applicable ones. The main disadvantage of non-probability sampling designs is the lack of representativeness for a wider population. But again, based on some theories, these difficulties can precisely be advantages (as long as the methodological and theoretical positions are clearly stated, both probability and non-probability sampling designs can be equally "scientific").

Methods of Observation

A full research design is not just a matter of determining the right methods of observation, there is always (or there better be) theory first. The following procedure can be suggested:

- *First*, there should be a theory that states what is to be researched, and how this connects to the already available body of literature (to ensure, or strive towards, cumulative knowledge). There is no "naked" or mind-less observation.
- *Second*, the theory has to be conceptualized, so that the different variables of the theory are clearly defined and identified. This may also involve acknowledgment of the limitations of the approach.

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- *Third*, the research topic and methodology is formalized into observable phenomena. This involves specification of the research topic (where, when) and the methods of observation (how) as well as the way in which the data are to be analyzed, and what the anticipated findings are.
- *Finally*, after the research is conducted, a report is drawn up, indicating theory, methodology, as well as findings.

A. Experimental Designs

The most important issue in an experiment is randomization (as a matter of internal validity). There are issues of internal and external validity, and the problems and solutions of external validity. Note the strength and limitations with regard to the control of variables, i.e. all the variables we know might interfere.

1. The Structure of Experiments

A classical experiment involves four basic components:

(1) An experiment examines the effect of an independent variable on a dependent variable. Typically, a stimulus is either absent or present. In this way, a hypothesis on the causal influence between two variables can be tested (see logic of causal modelling). Both variables are, of course, operationalized.

(2) An experiment involves pretesting and posttesting, i.e. the attributes of a dependent variable are measured, first before manipulation of the independent variable, and second after the manipulation. Of course, applied to one group, this may affect the validity of the results, since the group is aware of what is being measured (research affects what is being researched).

(3) Therefore, it is better to work with experimental groups and control groups. We select two groups for study, then apply the pretesting-posttesting, and thus conclude that any effect of the tests themselves must occur in both groups. There can indeed be a Hawthorne effect, i.e. the attention given to the group by the researchers affects the group's behavior. Note that there can also be an experimenter bias, which calls for accurate observation techniques of the expected change in the dependent variable.

(4) Selecting Subjects—

Note that there can always be some bias because often students are selected (problem of generalizability). Also, note that samples of 100 or not very representative, and that experiments often have fewer than 100 subjects.

Randomization refers to the fact that the subjects (which are often non-randomly selected from a population) should be randomly assigned to either the experimental or the control group. This does not ensure that the subjects are representative of the wider population from which they were drawn (which they usually are not), but it does ensure that the experimental and the control group are alike, i.e. the variables that might interfere with the results of the experiment will, based on the logic of probability, be equally distributed over the two groups. Note that randomization is related to random-sampling only in the sense that it is based on principles of probability (the two groups together are a "population", and the split into two separate groups is a random-sampling into two samples that mirror eachother and together constitute this "population").

Matching refers to the fact that subjects are purposely assigned by the researcher to either the control or the experimental group on the basis of knowledge of the variables that might interfere with the experiments. This is based on the same logic as quota sampling. Matching has the disadvantage that the relevant variables for matching decisions are often not all known, and that data analysis techniques assume randomness (therefore, randomization is better).

Finally, the experiments should be conducted in such a way that the only difference between the experimental and the control group is the manipulation of a variable during the experiment. Taken together, randomization or matching, and the fact that the manipulation during experimentation is the only difference between the two groups, these techniques allow for the control of all variables, other than the manipulated one, to interfere in the outcome of the experiment (internal validity!).

Note on the One-Shot Case Study:

A single group is manipulated on an independent variable, and then measured on a dependent variable. This method must involved pretest and posttest to be of any significance (otherwise there is nothing to compare), i.e. the one-group pretest-posttest design, but then we are not sure if it was the manipulated variable that caused the observed difference.

2. Internal Validity and External Validity

(a) Internal Validity: did the experimental treatment cause the observed difference?

The problem of internal validity refers to the logic of design, the fact whether other variables that may intervene were controlled, i.e. the integrity of the study. The problem can be that the conclusions of an experiment are not warranted based on what happened during the experiment. This can come about because of: (a) accident: historical events can have occurred during the experiment and affected its outcome; (b) time: people change, mature, during the period of experimentation; (c) testing: the groups are aware of what is being researched; (d) instrumentation: the techniques to measure pretest and posttest results are not identical (reliability); (e) statistical regression: results are biased because the subjects started with extreme values on a variable; and (f) other problems include, that the relationships are temporal but not causal, and that the control group may be frustrated or stuff.

Randomization of subjects into an experimental and a control group (to ensure that only the experimental manipulation intervened, while other variables are controlled), and reliable measurements in pretest and posttest are guards against problems of internal validity.

(b) External Validity: are the results of the experiment generalizable?

The problem of external validity refers to the issue of generalizability: what does the experiment, even when it is internally valid, tell us about the real, i.e. non-manipulated, world?

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A good solution is a four-group experimental design, i.e. first an experimental and a control group with pretest and posttest, and second, an experimental and a control group with posttest only. And better than anything else is a two-group design with posttest only when there is good randomization, since randomization ensures that all variables are evenly distributed between experimental and control group so that we do not have to do a pretest.

An experimental manipulation as close as possible to the natural conditions, without destroying internal validity, are the best methods to ensure external validity.

(c) Note on Ex-Post Facto Experiment

This is not a true experiment since there is (was) no control group. The manipulation of the independent variable has naturally occurred (e.g. earthquake). We are of course not sure, say when we compare with a group were the natural "manipulation" did not take place, that there are (or are not) other variables involved (very bad on the control of variables).

3. Advantages and Disadvantages of Experiments

The isolation of the one crucial variable, when all others are controlled, is the main advantage of experiments (it can lead to hypothesis falsification). Experiments are well-suited for projects with clearly defined concepts and hypotheses, thus it is the ideal model for causality testing. It can also be used in the study of small-group interaction, possibly in a field research, i.e. as a natural experiment. Experiments can also be repeated.

The big disadvantage is the artificial character of the research, and, in the social sciences, they often involve ethical difficulties, or can simply not be executed.

B. Survey Research

Note on quantification, which is quite essential in survey research, that numbers are representations of..., they are created, they represent something, so do not reify them (e.g. they are limited to the sample, and therefore to the sampling procedure - typically a probability sample design). You have to know the process that created the numbers or you cannot make any inferences. The powers of the analytical tools (quantitative data analysis) should not be abused. Note that quantitative methods are generally better on matters of reliability, while qualitative methods are better on validity.

The main advantage of survey research is of course the generalizability of its findings because of the representativeness of the sample (see sampling - as a matter of external validity). Note that a pre-test of the questionnaire is always necessary (as a matter of validity).

1. The Questionnaire

Survey research typically involves administering a questionnaire to a sample of respondents to draw conclusions on the population from which the sample is drawn. The questionnaire is standardized to ensure that the same observation method is used on all respondents. This involves considerations of questionnaire construction, question wording, and the way in which the questionnaire is administered to the respondents.

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(a) Questionnaire Construction

In the construction of the questionnaire, attention is devoted to increase the respondents' cooperation and avoid misunderstanding of the questions. First, the questionnaire format should be presentable, not too densely packed, and clear. This involves using intelligible contingency ("if no/yes go to...") questions, or matrix questions that contain al the items or response options to a question. Second, the effects of question order have to be considered, and this can be pre-tested with different questionnaires, and by being sensitive to the research problem. Third, clear instructions on how to answer the questions should be given, and it is best to divide the questionnaire into different sections that are each preceded with instructions.

(b) Question Wording

The question wording should equally enhance the unambiguous nature of the questionnaire. Several options are available depending on the research perspective: attitudes, for instance, can be measured with Likert scale questions (variation from strongly disagree to strongly agree). Questions can also be open-ended (and coded by the researcher for analysis) or closed-ended (an exhaustive list of mutually exclusive alternatives).

Note that open-ended questions may pose problems for analysis (too many responses), while closed-ended questions may impose too rigid a framework on the respondents. Also, each statement should not be too long, not negatively phrased, and posed in neutral, unambiguous terms to avoid social desirability effects and bias in any one (pro/con) direction. Also avoid double-barreled questions, and make sure to ask comprehensible and relevant questions.

2. The Administration of a Questionnaire

Questionnaires can be administered in a variety of ways.

(a) Self-Administered Questionnaire

In this type of survey, respondents fill out a questionnaire delivered to them by mail, taking precautions to ensure a sufficiently high response rate, or they can be delivered "on the spot", e.g. in a factory or school. The basic problem is the monitoring of returns, which have to be identified, i.e. you have to make up a return graph to indicate the response rate (over 50%), and you have to send follow-up mailings to non-respondents.

(b) Interview Survey

In a (more time-consuming and expensive) interview survey, sensitive and complicated issues can be explored face-to-face. This method also ensures a higher response rate, and a reduction of "don't know" answers. The interviewer has more control over the data collection process (note that observations can be made during the interview) and can clarify, in a standardized way, unclear questions. Since the questionnaire is the main measurement instrument, the interviewer must make sure that the questions have identical meaning to all respondents: interviewers should (and are trained to) be familiar with the questionnaire, dress like the respondents, behave in a neutral way during the interview, follow the given question wording and order, record the answers exactly, and probe for answers. Interview surveys typically have a higher response rate (affecting generalizability).

(c) Telephone Survey

A questionnaire conducted by telephone is a cheaper and less time-consuming method, one moreover in which the researcher can keep an eye on the interviewers, but one on which the respondents can also hang up.

3. Advantages and Disadvantages of Survey Research

Survey research generally has the advantage that, depending on the research objective, it can serve descriptive, explanatory, as well as exploratory purposes. But more important than anything else, depending on sampling techniques, it can generalize findings to large populations, while the standardization of the questionnaire (and the way it is administered) ensures reliability of the measurement instrument. In addition, many respondents can be researched, relatively many topics can be asked about them (flexibility), and statistical techniques allow for accurate analysis. Note that pre-collected data can also be analyzed for a different purpose (secondary data-analysis).

The main weakness of survey research is its rather superficial approach to social life because all subjects are treated in a unified way, the particularities of each cannot be explored in any great detail, and no knowledge is acquired of the social context of the respondents' answers. Also, surveys measure only answers, and not what this actually refers to (you know whether a person has responded to be "conservative" but not whether s/he is). Next, surveys are not so good in measuring action, but rather thoughts about action. This raises questions of validity: perhaps the questionnaire does not reveal anything "real", that is, anything of genuine concern for the respondents themselves.

C. Field Research

While surveys typically produce quantitative data, field research yields qualitative data. Also notice how field-research often not only produces data but also theory (alternation of deduction and induction).

1. Entering the Field

Depending on sampling procedure, a research site is selected and observations will be made and questions asked within the natural setting.

(a) The Role of the Field Researcher

(1) complete participant: the researcher is covertly present in the field and fully participates as if he is a member of the community under investigation; the

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problems are ethical, your mere presence might affect what goes on, and there are practical problems (e.g. when and how to leave the field?); 2) participant-as-observer: the researcher participates yet his identity is known; 3) observer-as-participant: the researcher observes and his identity is known; the latter two, since identity is known, may affect what's going on in the field, and it could cause the researcher to be expelled from the field; 4) complete observer: the researcher merely observes and his identity is not known.

(b) Preparing for the Field and Sampling in the Field

Start with a literature review (as always), then research yourself, why are you interested?, what will you bring to the field?, etc. Then search for informants, gate-keepers, and make a good impression (or simply join the group you want to study). Establishing rapport is very important, and if your identity is known, it is important to tell them what you are there for (although you may choose to lie). Then sample in the field (see above). Remember that the overall goal of field research is to acquire the richest possible data.

2. In-Depth Interviewing

(a) In-Depth Interviewing versus Questionnaire

While standardized questionnaires are typically, though not necessarily, employed in quantitative research, in-depth or unstructured interviewing is closely associated with qualitative field research. Like any interview, an in-depth interview can be defined as a "conversation with a purpose": an interview involves a talk between at least two people, in which the interviewer always has some control since s/he wants to elicit information. In survey interviews, the purpose of the conversation is dominant, especially when it involves the testing of hypotheses (a relationship between two or more variables). In-depth interviewing, in comparison, takes the "human element" more into account, particularly to explore a research problem which is not well defined in advance of the observation process. In-depth interviewing does not use a questionnaire, but the interviewer has a list of topics (an interview-guide) which are freely explored during the interview, allowing the respondent to bring up new issues that may prove relevant to the interviewer. The in-depth interviewer is the central instrument of investigation rather than the interview guide.

(b) Procedure of In-Depth Interviewing

The procedure of in-depth interviewing first involves establishing a relationship with the respondent: even more than is the case with questionnaires, it is crucial that the interviewer gains the trust of the respondent, otherwise the interview will hardly reveal in-depth insight into the respondent's knowledge of, and attitudes towards, events and circumstances. Since the kind of information elicited in the interview is not pre-determined in a questionnaire, tape-recording (and negotiation to get permission) is appropriate. The role of the in-depth interviewer involves a delicate balance between being active and passive: active because she/he guides the respondent tactfully to reveal more information on an issue considered relevant, passive because the interviewer leaves the respondent

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free to bring up issues that were unforeseen but nevertheless turn out to be relevant. Since the interviewer should talk, listen, and think during the interview, his/her experience and skill greatly contributes to the quality of the research findings. Note that in a field research, the interview can be formal or informal: in formal in-depth interviewing the researcher's identity is known and the respondent knows that an interview is going on, while an informal in-depth interview appears to be (to the respondent) just a conversation with someone (who is actually a covert researcher).

(c) Characteristics of In-depth Interviewing

In-depth interviewing has the advantage of being able to acquire a hermeneutic understanding of the knowledge and attitudes specific to the respondent (without an "alien", super-imposed questionnaire). It is often called a more valid research method. However, this assertion needs qualification: both in-depth and survey interviews approach human subjects with a perspective in mind, but only in in-depth interviewing is this perspective amenable to change (given the quest for what is unique to the person being interviewed), while in surveys it is not allowed to change (given the quest for generalizability of the findings).

During a research process involving several in-depth interviews, the "big wheel of science" can freely rotate between induction and deduction (finding new things and asking about them, cf. grounded theory). In addition, the method is beneficial for explorative research on a (sociologically) new issue. The main weakness of in-depth interviewing is its lack of reliability without a fixed questionnaire, the interviewer's flexibility, while allowing for new information, may affect the research findings, not because of respondents' characteristics, but because of the different ways in which they were interviewed.

Since in-depth interviewing often does not rely on random sampling of respondents, issues of generalizability cannot (but often do not have to) be addressed. Finally, the results of in-depth interviews are harder to analyze than survey questionnaire findings, since they cannot easily be transferred into numbers (allowing for statistical analysis) but have to be brought together comprehensively in meaningful categories that do not destroy the uniqueness of the findings (the recent use of computerized techniques of qualitative data-analysis is helpful in this regard).

3. Making Observations

In your observations, be sure to see as much as you can and to remain open-minded on what you see; you want to understand, not to condemn or approve. Once you have taken up your role, do not get over-involved, nor completely disengaged.

Very important is to record what you observe accurately, and best as soon as possible after the event occurred. Therefore, you should keep a field journal (or tape). Field notes include what is observed and interpretations of what is observed. Also, keep notes in stages, first rather sketchy and then more in detail.

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Finally, keep as many notes as you can (anything can turn out to be important). Apart from that, a separate file can be kept on theoretical and methodological concerns, as well as reports of the researcher's own personal experiences and feelings.

As an initial step for analysis, the notes must be kept in files (with multiple entries), to discover patterns of behavior or practices, instances of attitudes and meanings of events for the observed, encounters of people in interaction, episodes of behavior (in which a sudden event can be crucial), and roles, lifestyles and hierarchies. These analytically conceived files should keep the chaos of observation together. Be flexible about your files.

The analysis itself can then proceed to discover similarities and differences: what re-appears in the field, which events seem to indicate the same pattern of behavior or thought, as well as what is "deviant" in the research site, and so on. Note, of course, that it is typical for field research that observing, formulating theory, evaluating theory, and analyzing data, can all occur throughout the research process.

Important tools to avoid problems of mis-interpretation or biased observations include: add quantitative findings to your field observations (triangulation), keep in touch with a supervisor, and ensure your self-awareness (introspection).

In writing up the report, an account of the method of observation and/or participation, as well as reflections of the researcher's experiences and motives are inevitable.

4. Advantages and Disadvantages of Field Research

Field research is especially appropriate if you want to research a social phenomenon as completely as possible (comprehensiveness), within its natural setting, and over some period of time. Also, the method is flexible and can move freely from induction to deduction, it is relatively inexpensive.

With regard to validity, field research is generally stronger than survey research. But as a matter of reliability, the method may be too much tied up to the person that did the research (which is why their methods and experiences have to be reported and evaluated).

Finally, field research lacks generalizability, because of the uniqueness of the researcher's investigative qualities, because the comprehensiveness of research essentially excludes generalizability, and because of selectivity in observations and question asking. Therefore, the findings of field research are suggestive (not definitive).

D. Unobtrusive Research

Survey research and in-depth interviewing affect their object of study in at least (and hopefully only) one way: people are confronted with social-science research! Unobtrusive methods of inquiry, on the other hand, have no impact on what is being studied. There are three methods of unobtrusive research— content analysis, analysis of statistics, and historical analysis.

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1. Content and Document Analysis

Content analysis refers to the quantitative study of written and oral documents. This requires sampling of the units of analysis in a source (best probability sampling), codification of the units, and finally classification of the units to reveal their manifest and latent content.

Document analysis refers to the qualitative study of traces of the past: it involves the in-depth investigation of sources and aims at hermeneutic understanding.

2. Historical Analysis

Historical research refers to the study of the past through an examination of the traces the past has left behind (written documents, oral histories, and artefacts). The procedure of historical research typically involves— (1) selection of sources relevant for research; (2) identification and registration of sources according to formal and substantial criteria; (3) confrontation and (internal/external) critique of sources; (4) interpretation and analysis of sources to determine who said what to whom, why, how, and with what effect.

Three methods of data collection can be used in historical research (note that these methods do not have to be, but can be historical): content analysis, document analysis, and historical study of statistics. The historical investigation of statistics can trace a pattern over time (e.g. crime reports). Of course, you are again stuck to what you found (validity!).

3. Advantages and Disadvantages of Unobtrusive Research

The unobtrusive nature of research is the main advantage of the method: the researcher cannot affect what has happened. Several topics can be studied from this perspective, particularly forms of communication (who says what to whom, why and with what effect). Note that the techniques can be very rigidly applied (good on reliability).

Also, it has the advantage that it saves time and money, and you can study long periods of time. Moreover, unobtrusive historical research can fulfill several purposes: 1) the parallel testing of theories, to apply a theory to several historical cases; 2) the interpretation of contrasting contexts, to reveal the particularities of historical events; and 3) analyzing causalities, to explain why historical events took place.

The main weakness of historical research is the historical fact that it is probably the least developed method of social-science research. Although many reputed sociologists used historical research methods (e.g. Durkheim on the division of labor, Marx and Weber on capitalism, Merton on science and technology), the idea that a study of the past can be meaningful in and by itself, or to grasp the present, only rarely inspires research.

In addition, historical research can only reveal the past inasmuch as it is still present today: important documents, for instance, may be lost or destroyed (bad on validity). Finally, because of the often less rigid nature of this method of inquiry, the researcher can (invalidly) affect his/her picture of what has happened. Therefore, corroboration, the cross-checking of various sources, is helpful.

E. Evaluation Research

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Evaluation research is intended to evaluate the impact of social interventions, as an instance of applied research, it intends to have a real-world effect.

Just about any topic related to occurred or planned social intervention can be researched. Basically, it intends to research whether the intended result of an intervention strategy was produced.

1. Measurement in Evaluation Research

The basic question is coming to grips with the intended result: how can it be measured, so the goal of an intervention program has to be operationalized for it to be assessed in terms of success (or failure).

The outcome of a program has to be measured, best by specifying the different aspects of the desired outcome. The context within which an outcome occurred has to be analyzed. The intervention, as an experimental manipulation, has to be measured too. Other variables that can be researched include the population of subjects that are involved in the program. Measurement is crucial and therefore new techniques can be produced (validity), or older ones adopted (reliability).

The outcome can be measured in terms of whether an intended effect occurred or not, or whether the benefits of an intervention outweighed the costs thereof (cost/benefit analysis). The criteria of success and failure ultimately rest on an agreement.

The evaluation can occur by experiment, or by quasi-experiment. Time-series analysis, for instance, can analyze what happened for a longer period before and after an intervention, and with the use of multiple time-series designs, we can also compare with a pseudo control group.

2. The Context in Evaluation Research

There are a number of problems to be overcome in evaluation research. First, Logistical problems refer to getting the subjects to do what they are supposed to do. This includes getting them motivated, and ensuring a proper administration. Second, ethical problems include concerns over the control group (which is not manipulated, and whose members may experience deprivation).

It is hard to overlook what is done with the findings of an evaluation research, for instance, because the findings are not comprehensible to the subjects, because they contradict 'intuitive' beliefs, or because they run against vested interests.

Note social indicators research *as a special type of evaluation research.* This is the analysis of social indicators over time (pattern of evolution) and/or across societies (comparison). These indicators are aggregated statistics that reflect the condition of a society or a grouping.

3. Advantages and Disadvantages of Evaluation Research

The main advantage is that evaluation research can reveal whether policies work, or at least identify when they do not work (pragmatism), right away (when

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we use experiments) or over a long period of time and across societies (indicators). (different research instruments can be used in evaluation research)

The disadvantages include the special logistic and administrative problems, as well as the ethical considerations. Also, it can usually only measure the means, given certain program goals, but cannot go into questioning those goals themselves.

Sample Questions

1. What are the fundamental aims of research? Discuss.
2. Discuss the essential steps of the scientific method of research.
3. What actual is the importance of hypothesis, models, theories and law in the scientific method of research?
4. How is research problems identified?
5. How is research problems formulated?
6. What are the most valuable importance of literature survey in research?
7. Discuss the general research process in detail.
8. How is research designed, measured and operationalized?
9. Discuss the method of observation in research methodology.

UNIT — II

DATA COLLECTION AND HYPOTHESIS

LEARNING OBJECTIVES

2.1 Introduction

Data refers to information or facts usually collected as the result of experience, observation or experiment or premises. Data may consist of numbers, words, or images, particularly as measurements or observations of a set of variables. Data are often viewed as a lowest level of abstraction from which information and knowledge are derived.

You might be reading a newspaper regularly. Almost every newspaper gives the minimum and the maximum temperatures recorded in the city on the previous day. It also indicates the rainfall recorded, and the time of sunrise and sunset. In your school, you regularly take attendance of children and record it in a register. For a patient, the doctor advises recording of the body temperature of the patient at regular intervals.

If you record the minimum and maximum temperature, or rainfall, or the time of sunrise and sunset, or attendance of children, or the body temperature of the patient, over a period of time, what you are recording is known as data. Here, you are recording the data of minimum and maximum temperature of the city, data of rainfall, data for the time of sunrise and sunset, and the data pertaining to the attendance of children.

As an example, the class-wise attendance of students, in a school, is as recorded in *Table 2.1*.

Table 2.1 Class-wise Attendance of Students

Class	No. of Students Present
VI	42
VII	40

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VIII	41
IX	35
X	36
XI	32
XI1	30
Total	256

Table 2.1 gives the data for class-wise attendance of students. Here the data comprise 7 observations in all. These observations are, attendance for class VI, VII, and so on. So, data refers to the set of observations, values, elements or objects hder consideration.

The complete set of all possible elements or objects is called a population. Each of the elements is called a piece of data. Data also refers to the known facts or things used as basis for inference or reckoning facts, information, material to be processed or stored.

2.2 Types and Sources of Data

For understanding the nature of data, it becomes necessary to study about the various forms of data, as shown below :

- Qualitative and Quantitative Data
- Continuous and Discrete Data
- Primary and Secondary Data

Qualitative and Quantitative Data

Let us consider a set of data given in *Table* 2.2.

Table 2.2 Management-wise Number of Schools

Management	No. of Schools
Government	4
Local Body	8
Private Aided	10
Private Unaided	2
Total	24

In *Table 2.2*, number of schools have been shown according to the management of schools. So the schools have been classified into 4 categories, namely, Government Schools, Local Body Schools, Private Aided Schools and Private Unaided Schools. A given school belongs to any one of the four categories. Such data is shown as Categorical or Qualitative Data. Here the category or the quality referred to is management. Thus categorical or qualitative data result from information which has been classified into categories. Such categories are listed alphabetically or in order of decreasing frequencies or in some other conventional way. Each piece of data clearly belongs to one classification or category.

We frequently come across categorical or qualitative data in the form of schools categorised according to Boys, Girls and Co-educational; Students' Enrolment categorised according to SC, ST, OBC and 'Others'; number of persons employed in various categories of occupations, and so on.

Let us consider another set of data given in *Table* 2.3.

Table 2.3 Number of Schools according to Enrolment

Enrolment	No. of Schools
Upto 50	6
51 - 100	15
101 - 200	12
201 - 300	8
Above 300	4
Total	45

In *Table* 2.3, number of schools have been shown according to the enrolment of students in the school. Schools with enrolment varying in a specified range are grouped together, e.g. there are 15 schools where the students enrolled are any number between 51 and 100. As the grouping is based on numbers, such data are called Numerical or Quantitative Data. Thus, numerical or quantitative data result from counting or measuring. We frequently come across numerical data in newspapers, advertisements etc. related to the temperature of the cities, cricket averages, incomes, expenditures and so on.

Continuous and Discrete Data

Numerical or quantitative data may be continuous or discrete depending on *the nature of the elements or objects being observed.*

Let us consider the *Table* 2.4 depicting the heights of students of a class.

Table 2.4 Heights of Students of a Class

Height	*No. of Students*
4'8"- 4' 10"	2
4'10" - 5'0"	2
5'0" - 5'2"	5
5'2" - 5'4"	8
5'4" - 5'6"	12
5'6" - 5'8"	10
5'8"- 5'10"	2
Total	41

Table 2.4 gives the data pertaining to the heights of students of a class. Here the element under observation is the height of the students. The height varies from 4' 8" to 5' 10". The height of an individual may be anywhere from 4' 8" to 5'10". Two students may vary by almost zero inch height. Even if we take two adjacent points, say 4' 8.00" and 4' 8.01" there may be several values between the two points. Such data are called Continuous Data, as the height is continuous. Continuous Data arise from the measurement of continuous attributes or variables, in which individual may differ by amounts just approaching zero. Weights and heights of children; temperature of a body; intelligence and achievement level of students, etc. are the examples of continuous data.

Let's consider *Table 2.3* showing the number of students enrolled and the number of schools according to enrolment. Let us consider the enrolment of 2 schools as 60 and 61. Now in between 60 and 61, there cannot be any number, as the enrolment will always be in whole numbers. Thus there is a gap of cne unit from 60 to 61. Such data, where the elements being observed have gaps are called Discrete Data.

Discbete Data are characterised by gaps in the scale, for which no real values may ever be found. Such data are usually expressed in whole numbers. The size of a family, enrolment of children, number of books etc. are the examples of discrete data. Generally data arising from meagurement are continuous, while data arising from counting or arbitrary classification are discrete.

The achievement scores of students, though presented in discrete form may be considered to constitute continuous data, since a score of 24 represents any point between 23.5 and 24.5. Actually achievement is a continuous attribute or variable.

All measurements of continuous attributes are approximate in character and as such do not provide a basis for distinguishing between continuous and discrete data. The distinction is made on the basis of variable being measured. 'Height' is a continuous variable but number of children would give discrete data.

Primary and Secondary Data

The data collected by or on behalf of the person or people who are going to make use of the data refers to primary data. For example, the attendance of children, the result of examinations conducted by you are primary data. If you contact the parents of the children and ask about their educational qualifications to relate them to the performance of the children, this also gives primary data. Actually, when an individual personally collects data or information pertaining to an event, a definite plan or design, it refers to primary data.

Sometimes an investigator may use the data already collected by you, such as the school attendance of children, or performance of students in various subjects. etc, for his/her study, then the data are secondary data. The data used by a person or people other than the people by whom or for whom the data were collected refers to secondary data. For many reasons we may have to use secondary data, which should be used carefully, since the data could have been collected with a purpose different from that of the investigator and may lose some detail or may not be fully relevant. For using secondary data, it is always useful to know :

(a) how the data have been collected and processed;
(b) the accuracy of data;
(c) how far the data have been summarised;
(d) how comparable the data are with other tabulations; and
(e) how to interpret the data, especially when figures collected for one purpose are used for another purpose.

Secondary Data

In research, Secondary data is collecting and possibly processing data by people other than the researcher in question. Common sources of secondary data for social science include censuses, large surveys, and organizational records. In sociology primary data is data you have collected yourself and secondary data is data you have gathered from primary sources to create new research. In terms of historical research, these two terms have different meanings. A primary source is a book or set of archival records. A secondary source is a summary of a book or set of records.

Advantages to the secondary data collection method are— (1) it saves time that would otherwise be spent collecting data, (2) provides a larger database (usually) than what would be possible to collect on ones own. However; there are disadvantages to the fact that the researcher cannot personally check the data so its reliability may be questioned.

Secondary Data Analysis

There are two different types of sources that need to be established in order to conduct a good analysis. The first type is a primary source which is the initial material that is collected during the research process. Primary data is the data that the researcher is collecting themselves using methods such as surveys,direct observations, interviews, as well as logs(objective data sources).

Primary data is a reliable way to collect data because the researcher will know where it came from and how it was collected and analyzed since they did it themselves. Secondary sources on the other hand are sources that are based upon the data that was collected from the primary source. Secondary sources take the role of analyzing, explaining, and combining the information from the primary source with additional information.

Secondary data analysis is commonly known as second-hand analysis. It is simply the analysis of preexisting data in a different way or to answer a different question than originally intended. Secondary data analysis utilizes the data that was collected by someone else in order to further a study that you are interested in completing.

In contrast to secondary data, primary data comes from observations made by the researchers themselves. This often creates credibility issues that do not arise with secondary data.

Combining Data with Secondary Data

Where It's Used

For what different purposes can data from archives be used? The first and simplest case would be for descriptive purposes, such as a phone book. A particular contribution of the data archives can be made to comparative research, both, across nations and over time. In the early years of data archives, when secondary analysis was not yet a popular research strategy, the idea of comparative research based on archival data was promoted in conferences already some 40 years ago.

In the first case this would allow for comparative analysis over time, in the second for comparative analysis across societies or nations. Therefore, the design of comparative surveys is crucial for making empirical knowledge cumulative over space and time.

Combing Data From a Different Source with Different Time Periods

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Equally important are longitudinal studies which can be compiled over time. For example, in a research project on "Attitudes Towards Technology" it is of crucial importance to include data collected in the fifties and sixties in order to answer the research question whether potential threats from new technologies have decreased the level of technology acceptance or whether tendencies to reject new developments concentrate on particular technologies only, and if so, under what circumstances.

Combining Existing Secondary Data Sources with New Primary Data Sources

Imagine that we could get hold of a good collection of surveys taken in earlier years, such as detailed studies about changes going on in this phase and hopefully additional studies in the years to come. Analyzing this data base over time could give us a good picture of what changes actually have taken place in the orientation of the population and of the extent to which new technical concepts did have an impact on subgroups of the population. Furthermore, data archives can help to prepare studies on change over time by monitoring what questions have been asked in earlier years and alerting principal investigators to important questions which should be repeated in planned research projects. Actually, data archives should consider including funds in their budgets which allow them to collect data for relevant questions in order to avoid interruptions in important time series.

Technical Challenges in Combining Data Sets

A number of methodological and technical requirements have to be observed and should be implemented rigorously. Just to mention the most important: Some methodologists require that the questions should be functionally equivalent, whereas others claim that the question texts must be phrased identically. Frequently, it is not the linguistic identity which matters. Sometimes it is much more important, whether the questions are understood by the respondent in the same way.

Thus, a thermometer or scale used as a representation for intensity of attitudes in the more developed societies may be replaced by a ladder in less developed societies. Both, thermometer and ladder, would still measure the same dimension in the conceptual world of the respective respondents. A second requirement would be comparability of samples, thus, a cross-national representative random sample would be hard to compare with the local quota sample in one community in a different nation. Several other factors have to be controlled as well, in particular contextual influences at the time of field work or political or environmental events, which are related to the topic of the research.

Collecting, Reviewing, and Analyzing Secondary Data

The Design and Purpose of Research

Secondary data analysis consists of collecting data that was compiled through research by another person and using that data to get a better understanding of a concept. A good way to begin your research using secondary data that you are collecting to further support your concept is to clearly define the goals of your research and the design that you anticipate using. An important thing to remember when defining your plan is to ensure that you have established what kind of data you plan on using for your research and the exact goal. Establishing what type of research design is an important component. In terms of using secondary data for research it helps to create an outline of what the final product will look like consisting of all the types of data to be used along with a list of sources that were used to compile the research. In order to use secondary data three steps must be completed:

1. locate the data
2. evaluate the data
3. verify the data

Locating the data can be easily done with the advancements of searching sources online. However, people need to be aware of the details when searching online since pages can be out of date or poorly put together. Therefore, use caution and pay attention to whether it is a reliable data source online and check when the last update was. To evaluate the data a researcher must carefully examine the secondary data they are considering to ensure that it meets their needs and purpose of study. The person must look at the population and what the sample strategy and type were. It is also important to look at when the data was collected, how it was collected, how it was coded and edited, along with the operational definitions of measures that were used. Finally, the data must be verified to ensure good quality material to be used in new research.

Determining the Types of Data and Information Needed to Conduct Analysis

Data and information collection for secondary data analysis will depend entirely upon the subject that is central to the focal point of the study. The purpose of conducting secondary data analysis is to further develop an improved understanding of the subject matter at hand. Some important types of data and information that should be collected and summarized include demographic information, information gathered by government agencies (i.e. the Census), and social science surveys.

There is also the possibility of reanalyzing data that was collected in experimental studies or data collected with qualitative measures that can be applied in secondary data analysis. The most important component is to ensure that the information and data being collected needs to relate to the subject of study.

Determine the Quality of Sources of Data

In secondary data analysis, most individuals who do not have much experience in research training or technical expertise can be trained accordingly. However, this advantage is not without difficulty as the individual must be able to judge the quality of the data or information that has been gathered. These key tips will assist you in assessing the quality of the data: Determine the original purpose of the data collection, attempt to discover the credentials of the source(s) or author(s) of the information, consider if the document is a primary or secondary source, verify that the source well-referenced, and finally find out the: date of the publication; the intended audience, and coverage of the report or document.

Challenges of Secondary Data Analysis

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Advantages

Using secondary data can allow for the analyses of social processes in what would otherwise be inaccessible settings. It also saves time and money since the work has already been done to collect the data. That lets the researcher avoid problems with the data collection process. Using someone else's data can also facilitate a comparison with other data samples and allow multiple sets of data to be combined. There is also the chance that other variables could be included, resulting in a more diverse sample than would have been feasible before.

Disadvantages

There are several things to take into consideration when using preexisting data. Secondary data does not permit the progression from formulating a research question to designing methods to answer that question. It is also not feasible for a secondary data analyst to engage in the habitual process of making observations and developing concepts. These limitations hinder the ability of the researcher to focus on the original research question. Data quality is always a concern because its source may not be trusted. Even data from official records may be bad because the data is only as good as the records themselves. There are six questions that a secondary analyst should be able to answer about the data they wish to analyze.

1. What were the agency's or researcher's goals when collecting the data?
2. What data was collected and what is it supposed to measure?
3. When was the data collected?
4. What methods were used? Who was responsible and are they available for questions?
5. How is the data organized?
6. What information is known about the success of that data collection? How consistent is the data with data from other sources?

METHODS OF DATA COLLECTION

2.3 Primary Data Collection Methods

In primary data collection, you collect the data yourself using methods such as interviews and questionnaires. The key point here is that the data you collect is unique to you and your research and, until you publish, no one else has access to it.

There are many methods of collecting primary data and the main methods include:

- questionnaires
- interviews
- focus group interviews
- observation

- case-studies
- diaries
- critical incidents
- portfolios.

Questionnaires

Questionnaires are a popular means of collecting data, but are difficult to design and often require many rewrites before an acceptable questionnaire is produced.

Advantages:

- Can be used as a method in its own right or as a basis for interviewing or a telephone survey.
- Can be posted, e-mailed or faxed.
- Can cover a large number of people or organisations.
- Wide geographic coverage.
- Relatively cheap.
- No prior arrangements are needed.
- Avoids embarrassment on the part of the respondent.
- Respondent can consider responses.
- Possible anonymity of respondent.
- No interviewer bias.

Disadvantages:

- Design problems.
- Questions have to be relatively simple.
- Historically low response rate (although inducements may help).
- Time delay whilst waiting for responses to be returned.
- Require a return deadline.
- Several reminders may be required.
- Assumes no literacy problems.
- No control over who completes it.
- Not possible to give assistance if required.
- Problems with incomplete questionnaires.
- Replies not spontaneous and independent of each other.
- Respondent can read all questions beforehand and then decide whether to complete or not. For example, perhaps because it is too long, too complex, uninteresting, or too personal.

The Response Process

While the process is simple and straight forward, there are many opportunities for error.

- The question must be read.

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- The question must be understood.
- The respondent must create a response.
- This response must be translated into the categories or values present for the question.

Fundamental Concerns

We are asking about a person's knowledge, attitudes, beliefs, feelings, motivations, anticipations, future plans or past behavior. What can we do to motivate people to respond and to respond truthfully? For example, one older study found that about 20 percent of those without library cards claimed to have one when asked. There is a strong tendency to give answers that are socially desirable, make the respondent look good, or that will please the researcher. While we begin with an assumption of truthfulness, it may be useful to use variants of the same question to capture more of reality.

Another concern is whether or not the respondent knows enough to provide a meaningful answer. Someone who has never used the teen collection may find it difficult to indicate if it is valued.

Validity is the degree to which we are measuring what we need to measure. The questionnaire should gather valid responses. Reliability is the degree to which we receive the same measurement over time. Would we receive the same response if the respondent had answered the questionnaire earlier or later?

Cost

At the beginning and throughout the process, you need to consider these questions:

1. How much money will be needed to collect this data?
2. How much time will be needed to collect this data?
3. Is cost-sharing possible and will that be helped by sponsorship or endorsement?
4. How many completed questionnaires will be needed and what response rate does that require?

If possible, begin with another's questionnaire, especially if you are doing a use and user survey [do receive permission first]. This is less expensive, but there are other advantages. Others should have validated their instrument. You will be able to compare your findings with theirs and built upon previous generalizations. Knowledge can cumulate. Library Literature is also quite useful via the survey tag. Ideally, you would keep changes to a minimum to facilitate comparison, but you may build upon an existing instrument by adding additional questions or making essential changes.

The Process

Ordinarily, there are six steps:

1. Identifying what information is needed
2. Deciding what sort of questionnaire to use
3. Creating the first draft
4. Editing and revising

5. Pre testing and revising
6. Specifying procedures for its use.

A few deep thoughts are needed at the beginning:

- Are you certain that this study is worth doing?
- Are your research questions and key variables clearly identified?
- What answers do you need to have?
- What sort of questions are likely to gather those answers?
- *What problems are likely to be encountered in getting a good response?*

The number of questions must be limited to insure a good response. Response rate declines rapidly as the number of questions, especially those that require time and thought are added. Questions can usually be divided into two categories: (1) absolutely necessary and (2) interesting. Be certain that the information to be gathered is not available elsewhere, i.e. in census data or another report. Respondents are much less likely to respond to a question if they feel the answer is readily available.

Questions will need to be placed in a logical sequence.

Type of Information Sought

Typically, information sought falls into four categories:

1. Attitudes or what people see/understand about certain things
2. Beliefs or what people think is true [more strongly felt than attitudes]
3. Behavior or what people do
4. Attributes or what people are.

Attitude questions ask people to indicate if they favor or oppose, if they prefer or not, should or should not, right versus wrong, desirable versus undesirable. These questions require sensitive, thoughtful wording.

Belief questions ask people if something is true or false, correct or incorrect, accurate or inaccurate.

Behavior questions ask people what they have done, what they do, or what they plan to do.

Attribute or demographic questions ask about age, income, education, and the like.

Question Type

Open-ended Questions

Open-ended questions provide no answer choices. They are easy to ask and allow for a wide variety of responses, including the creative and unusual. Open-ended questions are especially useful when you don't know the likely values or cannot anticipate how the respondent will respond. The information gathered by open-ended questions could then be used to develop appropriate close-ended questions for another questionnaire.

These questions force the respondent to think and allow the respondent to clarify and explain a response. If the respondent takes needed time and makes the effort, responses can be illuminating and yield much useful information.

The response rate will be lower because the blank space is demanding and intimidating, especially for those who don't like to write. Illegible handwriting may be a problem.

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Since responses are not really ordered, analysis requires considerable time and effort. It may be difficult to measure and classify responses. Responses may be off base because there is inadequate guidance from the instrument itself.

Close-ended Questions

These questions provide specific answer choices although there may be an "other" value with brief space for adding an additional value. With close-ended questions, there is always the possibility that the right question will not be asked and valuable information will not be gathered. GIGO certainly applies here.

Ordered

Ordered close-ended questions require respondents to select a particular response. The responses are easily selected. They take little time, at least by most respondents.

These questions require well defined variables and values. They work best when there are a small number of reasonable answer possibilities.

Unordered

Unordered questions ask respondents to rank values and are useful for identifying priorities. Requires well defined variables and values. Unordered close-ended questions are not reliable if there are more than five values. Most respondents find ranking after one or two values to be difficult.

Criteria for ranking must be clearly identified and the order of the values must make sense to the respondent.

Partially close-ended

These questions may be ordered or not, but they do include the "other" option which adds some flexibility and provides the opportunity to add information not otherwise captured by the instrument.

More flexibility may mean better and more valid responses. New values may be selected from the leading "other" values, but this will make analysis more challenging

Number of Values

Close-ended questions may be categorized by the number of values. Two value questions are dichotomous. These questions are easy to ask and are quickly answered. Analysis is straight-forward and quick.

However, two alternatives are usually not enough. Some times, respondents will select the first value so the ordering of the values has some impact. Each value must be exclusive. The researcher must know the notable alternatives.

Multiple choice questions [more than two values]are also easy to analyze, but do require more time and effort. These questions require more time and effort by the respondent. Typically, respondents tend to choose from the top or middle of the list.

Wording Questions

Audience

The first step is to visualize the audience. Next ask two questions:

1. How are these people likely to respond to particular words and phrases?
2. What are they likely to know and be familiar with?

Select Words With Care

Avoid wrong words. Wrong words are vague, too specific, misunderstood, objectionable, irrelevant, and uninteresting. It takes time to select the right word. One researcher went through 41 versions of a question before the words were just right.

Insure that words are uniformly understood and provide brief definitions if needed. For example, how will the patron define "use" when asked questions about the degree of library or information center use. Words like "often," "rarely," "few," and "many" are used flexibly and different people have very different ideas as to what these words mean.

Use simpler, but specific words. For example, "free-time" is better than "leisure time." Substitute specifics for "several," "most," "usually," and the like to insure better reliability. When possible, use shorter words. Clearly define *professional words if the audience is not professional,* for example "volume" and "bibliographic instruction" may mean little to most college students. Insure that each word in a question is necessary. What would happen if that word was removed.

Avoid abbreviations and initialisms. If used, do spell out in the first mention, and again later if at some distance from the first mention. Read and reread for directness and clarity. For example, how clear is "What changes should the government make in its policies toward libraries?"

Avoid the too specific and use ranges instead. Few respondents will know how many books they have checked out from a public library in the last year.

Avoid value-oriented words that might bias the response, i.e. "should the library collection contain filthy books?"

Avoid self-incriminating questions such as "have you ever abused [definition needed] library materials" and attempt a more subtle approach. For example,

- Do you consider abuse of library materials to be a problem?
- Has abuse of library materials increased in the last year?
- Do you know anyone who has abused library materials?
- Have you ever considered abusing library materials?
- Have you ever abused library materials?

Avoid double questions such as "are reference librarians friendly and knowledgeable" and use two separate questions instead.

Avoid negatives such as "should the librarian not be directly responsible to the city manager?"

Insure that choices are exclusive. For example, there is a problem if age choices are " 18-35 years" and "35-50" years. Similarly, asking "how did you learn about our new library service" with the values "from a friend or relative," "at work," or "from the newspaper" is problematic because the values are not exclusive.

Avoid questions that assume too much knowledge such as "do you agree with the governor's stand on regional libraries?"

Do provide appropriate time referents such as "how many times have you gone to the library in November of this year?"

Avoid speculative questions because the response are often not reliable. For example, the question "if the library provided a full-text database on blumpf, how often would you use it?" is likely to yield information of minimal value.

Revise the wording of each question until it is just right.

Response Options

Do include an option for "don't know. Double check to insure that values are exclusive and independent. Balance scales used in close-ended questions with an equal number on each side of the middle position. It is better to arrange values vertically rather than horizontally to eliminate the between the value response.

Sequencing Questions

There are at least three different approaches for you to consider. One is to begin with easy questions in order to build confidence and make the respondent comfortable. The second is to place the more important questions first to motivate and give a sense that the questionnaire is important and well worth the respondent's time. The third is to place general questions first with the more specific ones to follow.

There is some disagreement over the placement of demographic questions. One approach is place them at the beginning because they set the stage and are easily answered. The other approach is to place them at the end because some respondents don't like to answer any "personal" questions. An incomplete response would still yield some useful data.

It is usually helpful to group questions by the type of response required. This makes responding easier. There should be a logical transition, with appropriate text, between question groups.

Objectionable, time-consuming, or especially difficult questions should be at the end. These questions are less likely to skew responses to preceding questions. Respondents have an investment in responding to the questionnaire and are less likely to quit.

Selecting the first question is crucial. It should be clearly related to the problem, be interesting to the respondent, and be easy to respond to. The question should be objective or neutral. It should apply to everyone in the population . Finally, it should establish a visual or graphic precedent for the questions that follow.

General Format

Size, shape, weight, color, paper quality, design, and layout all answer these important questions:

1. Is this questionnaire worth my time?
2. Has the questionnaire been created by a thoughtful professional?
3. Will it be difficult and time-consuming to complete?

The first impression is crucial in improving the response rate.

NOTES

Your job is to make it as easy as possible to complete the questionnaire quickly and with minimal effort. *Consider the traditional negatives associated* with Questionnaires:

- Long
- Difficult to understand or confusing
- Complicated
- Boring
- Poorly organized.

Avoid gimmicks or unusually creative formats.

Use white or off-white paper with black or blue ink. The paper needs to be light enough to reduce postage, but not so light as to appear cheap.

There should be no errors.

Printing or reproduction should be of letter quality and appear original. Print should be dark and clear.

Response spaces should be in the same position on each question and pushed toward the left or right margin where they are easily found. Place column numbers for coding near the question number and in parenthesis. Consider data analysis from the beginning. Construct your code book as soon as your questionnaire has finished pre-testing. All questions and pages should be clearly numbered. If both sides of the paper are used, a large, bold, OVER must appear at the right footer of each verso page.

Your return address should appear at the foot of the questionnaire and probably at the head as well. The study title should be clear, understandable to lay people and in a larger, bold font.

Clear, brief instructions are needed at the head and in the body as needed. Deadline information may or may not be useful. It is an asset by encouraging respondents to reply promptly. It is a liability of potential respondents decide not to reply because the deadline is near or past.

Do provide a reasonable space at the end for comments. *Also at the end,* indicate what will happen next with the study. If dealing with a professional audience, indicate that a copy of the study will be available and how they might get a copy.

Page Format

Introduction

This is a slow process and must be done with care. Pages should be neat and aesthetically pleasing.

Use lower case letters for the questions and upper case letters for the answers [responses]. Each value should be numbered and the number should be circled. Use the same number throughout for the same value. For example, yes should always be "1." Do not split questions between pages.

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Flow and Order

Establish vertical flow with the beginning of the question and the beginning of the answers. Leave enough white space between questions. Directions should appear in parentheses so that they stand out. You may use multiple columns and hats to conserve space as in the example below.

FATHER................................ MOTHER

1.. 1................ NO FORMAL EDUCATION

2.. 2 ....SOME GRADE SCHOOL.

Skipping not applicable questions is always a problem. Use arrows to direct to next applicable question. Indent questions dependent on an earlier response. Use text boxes to direct respondents to the next applicable question.

Use transitions for continuity and to stimulate motivation. Transitions are needed for new topics and to break monotony.

Opening

The opening is extremely important. It should be short, interesting, and stimulate response. In particular, you must convincingly demonstrate why the study is important, why their response is especially important, and how they will benefit from the study. The title of the study, clearly understandable by the lay person, must be included. The name of the principal investigator and the institutional address should appear here.

Close

The close is also important. There should be an opportunity for comment as well as a thank you for participation. The name of the PI and contact information should also be included.

Length

Shorter is better. Ask no unnecessary questions. Ask only questions that can be answered. If the question is longer, it must look easy to respond to. If the audience is really interested in the topic, length is less important.

Pre-testing

Pre-testing is absolutely necessary. Don't be too eager to begin collecting data. Here are typical questions that pre-testing should answer:

- Does each question measure what it is supposed to?
- Are all the words understood?
- Are questions interpreted similarly by each respondent?
- Does each close-ended question have an answer that applies to each respondent?
- Did the questionnaire create a positive impression?
- Are questions answered properly?
- Did any aspect of the questionnaire suggest bias?
- How long did it take to complete?

Pre testing may be done by three types of people. Colleagues are a logical choice, but may give you only a superficial examination. Too, that may not want to offend you with critical comment. Potential users of the data should have substantive knowledge of the topic. Finally, and best, are people drawn from the population to be surveyed. These people cannot then be used in the final study.

Revise and continue to test until your are satisfied that the questionnaire is as good as it can be.

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Pre-cover Letters

These are not typical, but they may be useful in stimulating a better response rate. The evidence regarding cost-benefit is mixed. This alert letter "the questionnaire is coming" – should include:

- Study purpose and importance
- Why the respondent was selected and is important
- What to expect
- When to expect it.

Cover Letters

The major liability of the questionnaire is the low response rate. Causes of poor response include:

- The questionnaire never reached its destination because of poor address
- The questionnaire arrived, but was discarded unopened because it looked like junk mail
- The questionnaire was examined, but there was some question as to who should respond so it was not returned
- The questionnaire was examined, but the respondent was unconvinced of its importance, and it was discarded.
- The questionnaire was examined, but was put aside and forgotten because it would take too much time to complete.
- The questionnaire was examined, but the return envelope was misplaced and so the questionnaire was not returned.

Appeal Elements

There are three typical appeal elements:

- The first is essentially an appeal for help or "will you do me a favor?" Here, we emphasize our personal appreciation and gratitude. This is a weak appeal if much time and effort is required. Follow-ups can be difficult.
- The second appeal focuses on a shared problem that we must solve together. Their help is needed to find a solution that will improve some aspect of their life. Here we have an exchange relationship with each helping the other.
- The third appeal element is rarely used by information professional researchers. Here an incentive is included to help compensate the respondent for her time. These incentives are usually inexpensive tokens, but winning a prize may make a difference. Dr. Bill once won a $100.00 Amazon gift certificate for participating in a study.

You will need to decide how formal or informal you will be in the cover letter. You want to personalize the letter and establish rapport, but you don't want to be too familiar, especially with people you have not met.

An endorsement by an individual or group well known to your audience can increase response rates and is well worth the effort. Can you identify some endorsement possibilities?

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The letter should look like an original with letterhead and an original-looking signature.

Format and Content

The cover letter should be limited to a single page.

The first paragraph should explain what the study is about and convince the respondent that the study is important and useful. How does the study relate to their problems? Why will the study make a difference? How will the results be used? It is best to avoid the words "questionnaire" and "survey" in this paragraph because of their negative associations.

The second paragraph focuses on why the particular respondent is important to the success of the study. Why were you selected? Why the population segment that you represent is important? Who should complete the instrument?

The third paragraph considers the questionnaire itself. It will not take too long to complete and the questions themselves are not difficult. We also emphasize that all responses are confidential and anonymous.

The fourth paragraph looks at social utility. We focus on the difference that the responses may make and how the results will be used to affect change.

The fifth paragraph closes with a statement that the investigator is willing to answer any questions or concerns. There is also a thank you statement.

The Envelope

The envelope must appear professional and be clearly distinguished from junk mail. It should the correct size to hold the questionnaire without unnecessary folding.

Postage

First class mail is best because of its positive impression. Note too that first class mail is delivered more quickly, is forwarded, and is returned to the sender if undeliverable. Interestingly, stamps on the envelope rather than the postage meter seem to increase the response rate.

SASE

The self-addressed stamped envelop is essential, but only use the kind where pay only if the envelope is used [requires postal permit]. This will cost more than first class mail by the piece, but will save money because many of the envelopes will not be used.

Mail out Date

Early in the week works best, but avoid Monday because of mail buildup over the weekend. Avoid holidays, December, and early January.

Follow-ups

A post card reminder/thank you jogs memories and reminds. Send after one or two weeks. This should make the response seem more important. Text includes reminder of the respondent's importance and an invitation to get a replacement questionnaire if needed.

After the third or fourth week, send a letter and a replacement questionnaire with essentially the same message.

After the sixth week, send a final, certified letter and replacement questionnaire [individual researchers are unlikely to afford this step].

Check-in

It is important to have a logical, well ordered process to check in responses as they are received and begin data coding.

Interviews

Interviewing is a technique that is primarily used to gain an understanding of the underlying reasons and motivations for people's attitudes, preferences or behaviour. Interviews can be undertaken on a personal one-to-one basis or in a group.

They can be conducted at work, at home, in the street or in a shopping centre, or some other agreed location.

Personal interview

Advantages:

- Serious approach by respondent resulting in accurate information.
- Good response rate.
- Completed and immediate.
- Possible in-depth questions.
- Interviewer in control and can give help if there is a problem.
- Can investigate motives and feelings.
- Can use recording equipment.
- Characteristics of respondent assessed – tone of voice, facial expression, hesitation, etc.
- Can use props.
- If one interviewer used, uniformity of approach.
- Used to pilot other methods.

Disadvantages:

- Need to set up interviews.
- Time consuming.
- Geographic limitations.
- Can be expensive.
- Normally need a set of questions.
- Respondent bias – tendency to please or impress, create false personal image, or end interview quickly.
- Embarrassment possible if personal questions.
- Transcription and analysis can present problems – subjectivity.
- If many interviewers, training required.

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Types of interview

Structured:

- Based on a carefully worded interview schedule.
- Frequently require short answers with the answers being ticked off.
- Useful when there are a lot of questions which are not particularly contentious or thought provoking.
- Respondent may become irritated by having to give over-simplified answers.

Semi-structured

The interview is focused by asking certain questions but with scope for the respondent to express him or herself at length.

Unstructured

This also called an in-depth interview. The interviewer begins by asking a general question. The interviewer then encourages the respondent to talk freely. The interviewer uses an unstructured format, the subsequent direction of the interview being determined by the respondent's initial reply. The interviewer then probes for elaboration – 'Why do you say that?' or, 'That's interesting, tell me more' or, 'Would you like to add anything else?' being typical probes.

The following section is a step-by-step guide to conducting an interview. You should remember that all situations are different and therefore you may need refinements to the approach.

Planning an interview:

- List the areas in which you require information.
- Decide on type of interview.
- Transform areas into actual questions.
- Try them out on a friend or relative.
- Make an appointment with respondent(s) – discussing details of why and how long.
- Try and fix a venue and time when you will not be disturbed.

Conducting an interview:

• Personally	–	arrive on time be smart smile employ good manners find a balance between friendliness and objectivity.
• At the start	–	introduce yourself re-confirm the purpose assure confidentiality – if relevant specify what will happen to the data.
• The questions	–	speak slowly in a soft, yet audible tone of voice control your body language know the questions and topic ask all the questions.

• Responses	–	recorded as you go on questionnaire written verbatim, but slow and time-consuming summarised by you taped – agree beforehand – have alternative method if not acceptable consider effect on respondent's answers proper equipment in good working order sufficient tapes and batteries minimum of background noise.
• At the end	–	ask if the respondent would like to give further details about anything or any questions about the research thank them.

Telephone interview

This is an alternative form of interview to the personal, face-to-face interview.

Advantages:

- Relatively cheap.
- Quick.
- Can cover reasonably large numbers of people or organisations.
- Wide geographic coverage.
- High response rate – keep going till the required number.
- No waiting.
- Spontaneous response.
- Help can be given to the respondent.
- Can tape answers.

Disadvantages:

- Often connected with selling.
- Questionnaire required.
- Not everyone has a telephone.
- Repeat calls are inevitable – average 2.5 calls to get someone.
- Time is wasted.
- Straightforward questions are required.
- Respondent has little time to think.
- Cannot use visual aids.
- Can cause irritation.
- Good telephone manner is required.
- Question of authority.

Getting started

Locate the respondent:

- Repeat calls may be necessary especially if you are trying to contact people in organisations where you may have to go through secretaries.

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- You may not know an individual's name or title – so there is the possibility of interviewing the wrong person.
- You can send an advance letter informing the respondent that you will be telephoning. This can explain the purpose of the research.

Getting them to agree to take part:

- You need to state concisely the purpose of the call scripted and similar to the introductory letter of a postal questionnaire.
- Respondents will normally listen to this introduction before they decide to co-operate or refuse.
- When contact is made respondents may have questions or raise objections about why they could not participate. You should be prepared for these.

Ensuring quality

- *Quality of questionnaire* – follows the principles of questionnaire design. However, it must be easy to move through as you cannot have long silences on the telephone.
- *Ability of interviewer* – follows the principles of face-to-face interviewing.

Smooth implementation

- *Interview schedule* – each interview schedule should have a cover page with number, name and address. The cover sheet should make provision to record which call it is, the date and time, the interviewer, the outcome of the call and space to note down specific times at which a call-back has been arranged. Space should be provided to record the final outcome of the call – was an interview refused, contact never made, number disconnected, etc.
- *Procedure for call-backs* – a system for call-backs needs to be implemented. Interview schedules should be sorted according to their status: weekday call-back, evening call-back, weekend call-back, specific time call-back.

Comparison of postal, telephone and personal interview surveys

The table below compares the three common methods of postal, telephone and interview surveys – it might help you to decide which one to use.

Table 2.5: Comparison of the three common methods of surveys

	Postal survey	Telephone survey	Personal interview
Cost (assuming a good response rate)	Often lowest	Usually in-between	Usually highest
Ability to probe	No personal contact or observation	Some chance for gathering additional data through elaboration on questions, but no personal observation	Greatest opportunity for observation, building rapport, and additional probing

Respondent ability to complete at own convenience	Yes	Perhaps, but usually no	Perhaps, if interview time is prearranged with respondent
Interview bias	No chance	Some, perhaps due to voice inflection	Greatest chance
Ability to decide who actually responds to the questions	Least	Some	Greatest
Impersonality	Greatest	Some due to lack of face-to-face contact	Least
Complex questions	Least suitable	Somewhat suitable	More suitable
Visual aids Potential negative respondent reaction	Little opportunity 'Junk mail'	No opportunity 'Junk calls'	Greatest opportunity Invasion of privacy
Interviewer control over interview environment	Least	Some in selection of time to call	Greatest
Time lag between soliciting and receiving response	Greatest	Least	May be considerable if a large area involved
Suitable types of questions	Simple, mostly dichotomous (yes/no) and multiple choice	Some opportunity for open-ended questions especially if interview is recorded	Greatest opportunity for open-ended questions
Requirement for technical skills in conducting interview	Least	Medium	Greatest
Response rate	Low	Usually high	High

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Focus group interviews

A focus group is an interview conducted by a trained moderator in a non-structured and natural manner with a small group of respondents. The moderator leads the discussion. The main purpose of focus groups is to gain insights by listening to a group of people from the appropriate target market talk about specific issues of interest.

Observation

Observation involves recording the behavioural patterns of people, objects and events in a systematic manner. Observational methods may be:

- structured or unstructured
- disguised or undisguised
- natural or contrived
- personal
- mechanical
- non-participant
- participant, with the participant taking a number of different roles.

Structured or unstructured

In structured observation, the researcher specifies in detail what is to be observed and how the measurements are to be recorded. It is appropriate when the problem is clearly defined and the information needed is specified.

In unstructured observation, the researcher monitors all aspects of the phenomenon that seem relevant. It is appropriate when the problem has yet to be formulated precisely and flexibility is needed in observation to identify key components of the problem and to develop hypotheses. The potential for bias is high. Observation findings should be treated as hypotheses to be tested rather than as conclusive findings.

Disguised or undisguised

In disguised observation, respondents are unaware they are being observed and thus behave naturally. Disguise is achieved, for example, by hiding, or using hidden equipment or people disguised as shoppers.

In undisguised observation, respondents are aware they are being observed. There is a danger of the Hawthorne effect – people behave differently when being observed.

Natural or contrived

Natural observation involves observing behaviour as it takes place in the environment, for example, eating hamburgers in a fast food outlet.

In contrived observation, the respondents' behaviour is observed in an artificial environment, for example, a food tasting session.

Personal

In personal observation, a researcher observes actual behaviour as it occurs. The observer may or may not normally attempt to control or manipulate the phenomenon being observed. The observer merely records what takes place.

Mechanical

Mechanical devices (video, closed circuit television) record what is being observed. These devices may or may not require the respondent's direct participation. They are used for continuously recording on-going behaviour.

Non-participant

The observer does not normally question or communicate with the people being observed. He or she does not participate.

Participant

In participant observation, the researcher becomes, or is, part of the group that is being investigated. Participant observation has its roots in ethnographic studies (study of man and races) where researchers would live in tribal villages, attempting to understand the customs and practices of that culture. It has a very extensive literature, particularly in sociology (development, nature and laws of human society) and anthropology (physiological and psychological study of man). Organisations can be viewed as 'tribes' with their own customs and practices.

The role of the participant observer is not simple. There are different ways of classifying the role:

- Researcher as employee.
- Researcher as an explicit role.
- Interrupted involvement.
- Observation alone.

Researcher as employee

The researcher works within the organisation alongside other employees, effectively as one of them. The role of the researcher may or may not be explicit and this will have implications for the extent to which he or she will be able to move around and gather information and perspectives from other sources. This role is appropriate when the researcher needs to become totally immersed and *experience the work or situation at first hand.*

There are a number of dilemmas. Do you tell management and the unions? Friendships may compromise the research. What are the ethics of the process? Can anonymity be maintained? Skill and competence to undertake the work may be required. The research may be over a long period of time.

Researcher as an explicit role

The researcher is present every day over a period of time, but entry is negotiated in advance with management and preferably with employees as well. The individual is quite clearly in the role of a researcher who can move around, observe, interview and participate in the work as appropriate. This type of role is the most favoured, as it provides many of the insights that the complete observer would gain, whilst offering much greater flexibility without the ethical problems that deception entails.

Interrupted involvement

The researcher is present sporadically over a period of time, for example, moving in and out of the organisation to deal with other work or to conduct interviews with, or observations of, different people across a number of different organisations. It rarely involves much participation in the work.

Observation alone

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The observer role is often disliked by employees since it appears to be 'eavesdropping'. The inevitable detachment prevents the degree of trust and friendship forming between the researcher and respondent, which is an important component in other methods.

Choice of roles

The role adopted depends on the following:

- *Purpose of the research:* Does the research require continued longitudinal involvement (long period of time), or will in-depth interviews, for example, conducted over time give the type of insights required?
- *Cost of the research:* To what extent can the researcher afford to be committed for extended periods of time? Are there additional costs such as training?
- *The extent to which access can be gained:* Gaining access where the role of the researcher is either explicit or covert can be difficult, and may take time.
- *The extent to which the researcher would be comfortable in the role:* If the researcher intends to keep his identity concealed, will he or she also feel able to develop the type of trusting relationships that are important? What are the ethical issues?
- *The amount of time the researcher has at his disposal:* Some methods involve a considerable amount of time. If time is a problem alternate approaches will have to be sought.

Case-Studies

Case study research excels at bringing us to an understanding of a complex issue or object and can extend experience or add strength to what is already known through previous research. Case studies emphasize detailed contextual analysis of a limited number of events or conditions and their relationships. Researchers have used the case study research method for many years across a variety of disciplines. Social scientists, in particular, have made wide use of this qualitative research method to examine contemporary real-life situations and provide the basis for the application of ideas and extension of methods. Researcher Robert K. Yin defines the case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used.

Critics of the case study method believe that the study of a small number of cases can offer no grounds for establishing reliability or generality of findings. Others feel that the intense exposure to study of the case biases the findings. Some dismiss case study research as useful only as an exploratory tool. Yet researchers continue to use the case study research method with success in carefully planned and crafted studies of real-life situations, issues, and problems. Reports on case studies from many disciplines are widely available in the literature.

This unit explains how to use the case study method and then applies the method to an example case study project designed to examine how one set of users, non-profit organizations, make use of an electronic community network. The study examines the issue of whether or not the electronic community network is beneficial in some way to non-profit organizations and what those benefits might be.

Many well-known case study researchers such as Robert E. Stake, Helen Simons, and Robert K. Yin have written about case study research and suggested techniques for organizing and conducting the research successfully. This introduction to case study research draws upon their work and proposes six steps that should be used:

- Determine and define the research questions
- Select the cases and determine data gathering and analysis techniques
- Prepare to collect the data
- Collect data in the field
- Evaluate and analyze the data
- Prepare the report

Step 1. Determine and Define the Research Questions

The first step in case study research is to establish a firm research focus to which the researcher can refer over the course of study of a complex phenomenon or object. The researcher establishes the focus of the study by forming questions about the situation or problem to be studied and determining a purpose for the study. The research object in a case study is often a program, an entity, a person, or a group of people. Each object is likely to be intricately connected to political, social, historical, and personal issues, providing wide ranging possibilities for questions and adding complexity to the case study. The researcher investigates the object of the case study in depth using a variety of data gathering methods to produce evidence that leads to understanding of the case and answers the research questions.

Case study research generally answers one or more questions which begin with "how" or "why." The questions are targeted to a limited number of events or conditions and their inter-relationships. To assist in targeting and formulating the questions, researchers conduct a literature review. This review establishes what research has been previously conducted and leads to refined, insightful questions about the problem. Careful definition of the questions at the start pinpoints where to look for evidence and helps determine the methods of analysis to be used in the study. The literature review, definition of the purpose of the case study, and early determination of the potential audience for the final report guide how the study will be designed, conducted, and publicly reported.

Step 2. Select the Cases and Determine Data Gathering and Analysis Techniques

During the design phase of case study research, the researcher determines what approaches to use in selecting single or multiple real-life cases to examine in

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depth and which instruments and data gathering approaches to use. When using multiple cases, each case is treated as a single case. Each cases conclusions can then be used as information contributing to the whole study, but each case remains a single case. Exemplary case studies carefully select cases and carefully examine the choices available from among many research tools available in order to increase the validity of the study. Careful discrimination at the point of selection also helps erect boundaries around the case.

The researcher must determine whether to study cases which are unique in some way or cases which are considered typical and may also select cases to represent a variety of geographic regions, a variety of size parameters, or other parameters. A useful step in the selection process is to repeatedly refer back to the purpose of the study in order to focus attention on where to look for cases and evidence that will satisfy the purpose of the study and answer the research questions posed. Selecting multiple or single cases is a key element, but a case study can include more than one unit of embedded analysis. For example, a case study may involve study of a single industry and a firm participating in that industry. This type of case study involves two levels of analysis and increases the complexity and amount of data to be gathered and analyzed.

A key strength of the case study method involves using multiple sources and techniques in the data gathering process. The researcher determines in advance what evidence to gather and what analysis techniques to use with the data to answer the research questions. Data gathered is normally largely qualitative, but it may also be quantitative. Tools to collect data can include surveys, interviews, documentation review, observation, and even the collection of physical artifacts.

The researcher must use the designated data gathering tools systematically and properly in collecting the evidence. Throughout the design phase, researchers must ensure that the study is well constructed to ensure construct validity, internal validity, external validity, and reliability. Construct validity requires the researcher to use the correct measures for the concepts being studied. Internal validity (especially important with explanatory or causal studies) demonstrates that certain conditions lead to other conditions and requires the use of multiple pieces of evidence from multiple sources to uncover convergent lines of inquiry. The researcher strives to establish a chain of evidence forward and backward. External validity reflects whether or not findings are generalizable beyond the immediate case or cases; the more variations in places, people, and procedures a case study can withstand and still yield the same findings, the more external validity. Techniques such as cross-case examination and within-case examination along with literature review helps ensure external validity. Reliability refers to the stability, accuracy, and precision of measurement. Exemplary case study design ensures that the procedures used are well documented and can be repeated with the same results over and over again.

Step 3. Prepare to Collect the Data

Because case study research generates a large amount of data from multiple sources, systematic organization of the data is important to prevent the researcher from becoming overwhelmed by the amount of data and to prevent the researcher from losing sight of the original research purpose and questions. Advance preparation assists in handling large amounts of data in a documented and systematic fashion. Researchers prepare databases to assist with categorizing, sorting, storing, and retrieving data for analysis.

Exemplary case studies prepare good training programs for investigators, establish clear protocols and procedures in advance of investigator field work, and conduct a pilot study in advance of moving into the field in order to remove obvious barriers and problems. The investigator training program covers the basic concepts of the study, terminology, processes, and methods, and teaches investigators how to properly apply the techniques being used in the study. The program also trains investigators to understand how the gathering of data using multiple techniques strengthens the study by providing opportunities for triangulation during the analysis phase of the study. The program covers protocols for case study research, including time deadlines, formats for narrative reporting and field notes, guidelines for collection of documents, and guidelines for field procedures to be used. Investigators need to be good listeners who can hear exactly the words being used by those interviewed. Qualifications for investigators also include being able to ask good questions and interpret answers. Good investigators review documents looking for facts, but also read between the lines and pursue collaborative evidence elsewhere when that seems appropriate. Investigators need to be flexible in real-life situations and not feel threatened by unexpected change, missed appointments, or lack of office space. Investigators need to understand the purpose of the study and grasp the issues and must be open to contrary findings. Investigators must also be aware that they are going into the world of real human beings who may be threatened or unsure of what the case study will bring.

After investigators are trained, the final advance preparation step is to select a pilot site and conduct a pilot test using each data gathering method so that problematic areas can be uncovered and corrected. Researchers need to anticipate key problems and events, identify key people, prepare letters of introduction, establish rules for confidentiality, and actively seek opportunities to revisit and revise the research design in order to address and add to the original set of research questions.

Step 4. Collect Data in the Field

The researcher must collect and store multiple sources of evidence comprehensively and systematically, in formats that can be referenced and sorted so that converging lines of inquiry and patterns can be uncovered. Researchers carefully observe the object of the case study and identify causal factors associated with the observed phenomenon. Renegotiation of arrangements with the objects of the study or addition of questions to interviews may be necessary as the study progresses. Case study research is flexible, but when changes are made, they are documented systematically.

Exemplary case studies use field notes and databases to categorize and reference data so that it is readily available for subsequent reinterpretation. Field notes record feelings and intuitive hunches, pose questions, and document the

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work in progress. They record testimonies, stories, and illustrations which can be used in later reports. They may warn of impending bias because of the detailed exposure of the client to special attention, or give an early signal that a pattern is emerging. They assist in determining whether or not the inquiry needs to be reformulated or redefined based on what is being observed. Field notes should be kept separate from the data being collected and stored for analysis.

Maintaining the relationship between the issue and the evidence is mandatory. The researcher may enter some data into a database and physically store other data, but the researcher documents, classifies, and cross-references all evidence so that it can be efficiently recalled for sorting and examination over the course of the study.

Step 5. Evaluate and Analyze the Data

The researcher examines raw data using many interpretations in order to find linkages between the research object and the outcomes with reference to the original research questions. Throughout the evaluation and analysis process, the researcher remains open to new opportunities and insights. The case study method, with its use of multiple data collection methods and analysis techniques, provides researchers with opportunities to triangulate data in order to strengthen the research findings and conclusions.

The tactics used in analysis force researchers to move beyond initial impressions to improve the likelihood of accurate and reliable findings. Exemplary case studies will deliberately sort the data in many different ways to expose or create new insights and will deliberately look for conflicting data to disconfirm the analysis. Researchers categorize, tabulate, and recombine data to address the initial propositions or purpose of the study, and conduct cross-checks of facts and discrepancies in accounts. Focused, short, repeat interviews may be necessary to gather additional data to verify key observations or check a fact.

Specific techniques include placing information into arrays, creating matrices of categories, creating flow charts or other displays, and tabulating frequency of events. Researchers use the quantitative data that has been collected to corroborate and support the qualitative data which is most useful for understanding the rationale or theory underlying relationships. Another technique is to use multiple investigators to gain the advantage provided when a variety of perspectives and insights examine the data and the patterns. When the multiple observations converge, confidence in the findings increases. Conflicting perceptions, on the other hand, cause the researchers to pry more deeply.

Another technique, the cross-case search for patterns, keeps investigators from reaching premature conclusions by requiring that investigators look at the data in many different ways. Cross-case analysis divides the data by type across all cases investigated. One researcher then examines the data of that type thoroughly. When a pattern from one data type is corroborated by the evidence from another, the finding is stronger. When evidence conflicts, deeper probing of the differences is necessary to identify the cause or source of conflict. In all cases, the researcher treats the evidence fairly to produce analytic conclusions answering the original "how" and "why" research questions.

Step 6. Prepare the report

Exemplary case studies report the data in a way that transforms a complex issue into one that can be understood, allowing the reader to question and examine the study and reach an understanding independent of the researcher. The goal of the written report is to portray a complex problem in a way that conveys a vicarious experience to the reader. Case studies present data in very publicly accessible ways and may lead the reader to apply the experience in his or her own real-life situation. Researchers pay particular attention to displaying sufficient evidence to gain the readers confidence that all avenues have been explored, clearly communicating the boundaries of the case, and giving special attention to conflicting propositions.

Techniques for composing the report can include handling each case as a separate chapter or treating the case as a chronological recounting. Some researchers report the case study as a story. During the report preparation process, researchers critically examine the document looking for ways the report is incomplete.

The researcher uses representative audience groups to review and comment on the draft document. Based on the comments, the researcher rewrites and makes revisions. Some case study researchers suggest that the document review audience include a journalist and some suggest that the documents should be reviewed by the participants in the study.

Applying the Case Study Method to an Electronic Community Network

By way of example, we apply these six steps to an example study of multiple participants in an electronic community network. All participants are non-profit organizations which have chosen an electronic community network on the World Wide Web as a method of delivering information to the public. The case study method is applicable to this set of users because it can be used to examine the issue of whether or not the electronic community network is beneficial in some way to the organization and what those benefits might be.

Step 1. Determine and Define the Research Questions

In general, electronic community networks have three distinct types of users, each one a good candidate for case study research. The three groups of users include people around the world who use the electronic community network, the non-profit organizations using the electronic community network to provide information to potential users of their services, and the "community" that forms as the result of interacting with other participants on the electronic community network.

In this case, the researcher is primarily interested in determining whether or not the electronic community network is beneficial in some way to non-profit organization participants. The researcher begins with a review of the literature to determine what prior studies have determined about this issue and uses the literature to define the following questions for the study of the non-profit organizations providing information to the electronic community network:

Why do non-profit organization participants use the network?

How do non-profit organization participants determine what to place on the electronic community network?

Do the non-profit organization participants believe the community network serves a useful purpose in furthering their mission? How?

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Step 2. Select the Cases and Determine Data Gathering and Analysis Techniques

Many communities have constructed electronic community networks on the World Wide Web. At the outset of the design phase, the researcher determines that only one of these networks will be studied and further sets the study boundaries to include only some of the non-profit organizations represented on that one network. The researcher contacts the Board of Directors of the community network, who are open to the idea of the case study. The researcher also gathers computer generated log data from the network and, using this data, determines that an in-depth study of representative organizations from four categories— health care, environmental, education, and religious is feasible. The investigator applies additional selection criteria so that an urban-based and a rural-based non-profit are represented in the study in order to examine whether urban non-profits perceive more benefits from community networks than rural organizations.

The researcher considers multiple sources of data for this study and selects document examination, the gathering and study of organizational documents such as administrative reports, agendas, letters, minutes, and news clippings for each of the organizations. In this case, the investigator decides to also conduct open-ended interviews with key members of each organization using a check-list to guide interviewers during the interview process so that uniformity and consistency can be assured in the data, which could include facts, opinions, and unexpected insights. In this case study, the researcher cannot employ direct observation as a tool because some of the organizations involved have no office and meet infrequently to conduct business directly related to the electronic community network. The researcher instead decides to survey all Board members of the selected organizations using a questionnaire as a third data gathering tool. Within-case and cross-case analysis of data are selected as analysis techniques.

Step 3. Prepare to Collect the Data

The researcher prepares to collect data by first contacting each organization to be studied to gain their cooperation, explain the purpose of the study, and assemble key contact information. Since data to be collected and examined includes organizational documents, the researcher states his intent to request copies of these documents, and plans for storage, classification, and retrieval of these items, as well as the interview and survey data. The researcher develops a formal investigator training program to include seminar topics on non-profit organizations and their structures in each of the four categories selected for this study. The training program also includes practice sessions in conducting open-ended interviews and documenting sources, suggested field notes formats, and a detailed explanation of the purpose of the case study. The researcher selects a fifth case as a pilot case, and the investigators apply the data gathering tools to the pilot case to determine whether the planned timeline is feasible and whether or not the interview and survey questions are appropriate and effective. Based on the results of the pilot, the researcher makes adjustments and assigns investigators particular cases which become their area of expertise in the evaluation and analysis of the data.

Step 4. Collect Data in the Field

Investigators first arrange to visit with the Board of Directors of each non-profit organization as a group and ask for copies of the organization's mission, news clippings, brochures, and any other written material describing the organization and its purpose. The investigator reviews the purpose of the study with the entire Board, schedules individual interview times with as many Board members as can cooperate, confirms key contact data, and requests that all Board members respond to the written survey which will be mailed later.

Investigators take written notes during the interview and record field notes after the interview is completed. The interviews, although open-ended, are structured around the research questions defined at the start of the case study.

Research Question: Why do non-profit organization participants use the network?

Interview Questions: How did the organization make the decision to place data on the World Wide Web community network? What need was the organization hoping to fulfill?

Research Question: How do non-profit organization participants determine what to place on the electronic community network?

Interview Questions: What process was used to select the information that would be used on the network? How is the information kept up to date?

Research Question: Do the non-profit organization participants believe the community network serves a useful purpose in furthering their mission? How?

Interview Questions: How does the organization know if the electronic community network is beneficial to the organization? How does the electronic community network further the mission of the organization? What systematic tracking mechanisms exist to determine how many or what types of users are accessing the organization information?

The investigator's field notes record impressions and questions that might assist with the interpretation of the interview data. The investigator makes note of stories told during open-ended interviews and flags them for potential use in the final report. Data is entered into the database.

The researcher mails written surveys to all Board members with a requested return date and a stamped return envelope. Once the surveys are returned, the researcher codes and enters the data into the database so that it can be used independently as well as integrated when the case study progresses to the point of cross-case examination of data for all four cases.

Step 5. Evaluate and Analyze the Data

Within-case analysis is the first analysis technique used with each non-profit organization under study. The assigned investigator studies each organization's written documentation and survey response data as a separate case

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to identify unique patterns within the data for that single organization. Individual investigators prepare detailed case study write-ups for each organization, categorizing interview questions and answers and examining the data for within-group similarities and differences.

Cross-case analysis follows. Investigators examine pairs of cases, categorizing the similarities and differences in each pair. Investigators then examine similar pairs for differences, and dissimilar pairs for similarities. As patterns begin to emerge, certain evidence may stand out as being in conflict with the patterns. In those cases, the investigator conducts follow-up focused interviews to confirm or correct the initial data in order to tie the evidence to the findings and to state relationships in answer to the research questions.

Step 6. Prepare the Report

The outline of the report includes thanking all of the participants, stating the problem, listing the research questions, describing the methods used to conduct the research and any potential flaws in the method used, explaining the data gathering and analysis techniques used, and concluding with the answers to the questions and suggestions for further research. Key features of the report include a retelling of specific stories related to the successes or disappointments experienced by the organizations that were conveyed during data collection, and answers or comments illuminating issues directly related to the research questions. The researcher develops each issue using quotations or other details from the data collected, and points out the triangulation of data where applicable. The report also includes confirming and conflicting findings from literature reviews. The report conclusion makes assertions and suggestions for further research activity, so that another researcher may apply these techniques to another electronic community network and its participants to determine whether similar findings are identifiable in other communities. Final report distribution includes all participants.

Applicability to Library and Information Science

Case study research, with its applicability across many disciplines, is an appropriate methodology to use in library studies. In Library and Information Science, case study research has been used to study reasons why library school programs close (Paris, 1988), to examine reference service practices in university library settings (Lawson, 1971), and to examine how questions are negotiated between customers and librarians (Taylor, 1967). Much of the research is focused exclusively on the librarian as the object or the customer as the object. Researchers could use the case study method to further study the role of the librarian in implementing specific models of service.

For example, case study research could examine how information-seeking behavior in public libraries compares with information-seeking behavior in places other than libraries, to conduct in-depth studies of non-library community based information services to compare with library based community information services, and to study community networks based in libraries.

Conclusion

Case studies are complex because they generally involve multiple sources of data, may include multiple cases within a study, and produce large amounts of data for analysis. Researchers from many disciplines use the case study method to build upon theory, to produce new theory, to dispute or challenge theory, to explain a situation, to provide a basis to apply solutions to situations, to explore, or to describe an object or phenomenon. The advantages of the case study method are its applicability to real-life, contemporary, human situations and its public accessibility through written reports. Case study results relate directly to the common reader's everyday experience and facilitate an understanding of complex real-life situations.

2.4 Hypothesis and Testing Hypothesis

A hypothesis consists either of a suggested explanation for an observable phenomenon or of a reasoned proposal predicting a possible causal correlation among multiple phenomena. The term derives from the Greek, hypotithenai meaning "to put under" or "to suppose." The scientific method requires that one can test a scientific hypothesis. Scientists generally base such hypotheses on previous observations or on extensions of scientific theories. Even though the words "hypothesis" and "theory" are often used synonymously in common and informal usage, a scientific hypothesis is not the same as a scientific theory. A Hypothesis is never to be stated as a question, but always as a statement with an explanation following it. It is not to be a question because it states what he/she thinks or believes will occur.

In early usage, scholars often referred to a clever idea or to a convenient mathematical approach that simplified cumbersome calculations as a hypothesis; when used this way, the word did not necessarily have any specific meaning. Cardinal Bellarmine gave a famous example of the older sense of the word in the warning issued to Galileo in the early 17th century: that he must not treat the motion of the Earth as a reality, but merely as a hypothesis.

In common usage in the 21st century, a hypothesis refers to a provisional idea whose merit requires evaluation. For proper evaluation, the framer of a hypothesis needs to define specifics in operational terms. A hypothesis requires more work by the researcher in order to either confirm or disprove it. In due course, a confirmed hypothesis may become part of a theory or occasionally may grow to become a theory itself. Normally, scientific hypotheses have the form of a mathematical model. Sometimes, but not always, one can also formulate them as existential statements, stating that some particular instance of the phenomenon under examination has some characteristic and causal explanations, which have the general form of universal statements, stating that every instance of the phenomenon has a particular characteristic.

Any useful hypothesis will enable predictions by reasoning (including deductive reasoning). It might predict the outcome of an experiment in a laboratory setting or the observation of a phenomenon in nature. The prediction

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may also invoke statistics and only talk about probabilities. Karl Popper, following others, has argued that a hypothesis must be falsifiable, and that one cannot regard a proposition or theory as scientific if it does not admit the possibility of being shown false. Other philosophers of science have rejected the criterion of falsifiability or supplemented it with other criteria, such as verifiability (e.g., verificationism) or coherence (e.g., confirmation holism). The scientific method involves experimentation on the basis of hypotheses in order to answer questions and explore observations.

In framing a hypothesis, the investigator must not currently know the outcome of a test or that it remains reasonably under continuing investigation. Only in such cases does the experiment, test or study potentially increase the probability of showing the truth of a hypothesis. If the researcher already knows the outcome, it counts as a "consequence" and the researcher should have already considered this while formulating the hypothesis. If one cannot assess the predictions by observation or by experience, the hypothesis classes as not yet useful, and must wait for others who might come afterward to make possible the needed observations. For example, a new technology or theory might make the necessary experiments feasible.

An alternative way of posing a research question is to state a hypothesis (plural hypotheses). A hypothesis is a proposition about the area that you are studying and is expressed as a statement of fact or what you believe to be true. You then try to find out whether the statement is true or false.

A 'good' hypothesis is:

- based on current knowledge and understanding (facts, theory)
- compares two variables
- can be tested by the collection and analysis of data.

A hypothesis is worded such that it implies that the two variables are independent of each other. Strictly this is called the null hypothesis. If we consider the example on the type of degrees obtained by younger and older students, we can state the (null) hypothesis as:

- There is no difference in the level of degree obtained by younger and older students. or
- Younger and older students do not differ in the level of degree attained.

This hypothesis is then tested by trying to disprove it by saying, 'let us look for evidence that would show the hypothesis to be incorrect'. In this example this means trying to show that there is a difference in the level of degree obtained. If we could find sufficient evidence to show a difference we would reject the null hypothesis:

- There is no difference in the level of degree obtained by younger and older students

in favour of the alternative hypothesis:

- There is a difference in the level of degree obtained by younger and older students.

Of course, if you show there is a difference it introduces the questions, 'What is the difference and why?'

The notion of a hypothesis is a difficult one and may not be necessary for your research. However, it is a good exercise to try to phrase your research in this way as it helps to clarify your ideas.

Another type of hypothesis is a statistical hypothesis. These hypotheses tend to be used when researchers are dealing with large amounts of numerical data. Also theoretical statistical tests are used to prove or disprove the null hypothesis. Such hypotheses are unlikely to concern you as you will be handling smaller amounts of data.

Scientific Hypothesis

People refer to a trial solution to a problem as a hypothesis — often called an "educated guess" — because it provides a suggested solution based on the evidence. Experimenters may test and reject several hypotheses before solving the problem.

According to Schick and Vaughn, researchers weighing up alternative hypotheses may take into consideration:

- *Testability* (compare falsifiability as discussed above)
- *Simplicity* (as in the application of "Occam's razor", discouraging the postulation of excessive numbers of entities)
- *Scope* - the apparent application of the hypothesis to multiple cases of phenomena
- *Fruitfulness* - the prospect that a hypothesis may explain further phenomena in the future
- *Conservatism* - the degree of "fit" with existing recognized knowledge-systems

Testing of Hypothesis

All hypothesis tests are conducted the same way. The researcher states a hypothesis to be tested, formulates an analysis plan, analyzes sample data according to the plan, and accepts or rejects the null hypothesis, based on results of the analysis.

- *State the hypothesis*— Every hypothesis test requires the analyst to state a null hypothesis and an alternative hypothesis. The hypotheses are stated in such a way that they are mutually exclusive. That is, if one is true, the other must be false; and vice versa.
- *Formulate an analysis plan*— The analysis plan describes how to use sample data to accept or reject the null hypothesis. It should specify the following elements.
- *Significance level*— Often, researchers choose significance levels equal to 0.01, 0.05, or 0.10; but any value between 0 and 1 can be used.
- *Test method*— Typically, the test method involves a test statistic and a sampling distribution. Computed from sample data, the test statistic might be a mean score, proportion, difference between means, difference

between proportions, z-score, t-score, chi-square, etc. Given a test statistic and its sampling distribution, a researcher can assess probabilities associated with the test statistic. If the test statistic probability is less than the significance level, the null hypothesis is rejected.

- *Analyze sample data*— Using sample data, perform computations called for in the analysis plan.
- *Test statistic*— When the null hypothesis involves a mean or proportion, use either of the following equations to compute the test statistic.

  Test statistic = (Statistic - Parameter) / (Standard deviation of statistic)

  Test statistic = (Statistic - Parameter) / (Standard error of statistic)

where Parameter is the value appearing in the null hypothesis, and Statistic is the point estimate of Parameter. As part of the analysis, you may need to compute the standard deviation or standard error of the statistic. Previously, we presented common formulas for the standard deviation and standard error.

When the parameter in the null hypothesis involves categorical data, you may use a chi-square statistic as the test statistic. Instructions for computing a chi-square test statistic are presented in the lesson on the chi-square goodness of fit test.

- *P-value*— The P-value is the probability of observing a sample statistic as extreme as the test statistic, assuming the null hypotheis is true.
- *Interpret the results*— If the sample findings are unlikely, given the null hypothesis, the researcher rejects the null hypothesis. Typically, this involves comparing the P-value to the significance level, and rejecting the null hypothesis when the P-value is less than the significance level.

State the Hypotheses

Every hypothesis test requires the analyst to state a null hypothesis and an alternative hypothesis. The hypotheses are stated in such a way that they are mutually exclusive. That is, if one is true, the other must be false; and vice versa. The table below shows three sets of hypotheses. Each makes a statement about how the population mean μ is related to a specified value *M*. (In the table, the symbol $\neq$ means " not equal to ".)

Set	Null hypothesis	Alternative hypothesis	Number of tails
1	$\mu = M$	$\mu \neq M$	2
2	$\mu \geq M$	$\mu < M$	1
3	$\mu \leq M$	$\mu > M$	1

The first set of hypotheses (Set 1) is an example of a two-tailed test, since an extreme value on either side of the sampling distribution would cause a researcher to reject the null hypothesis. The other two sets of hypotheses (Sets 2 and 3) are one-tailed tests, since an extreme value on only one side of the sampling distribution would cause a researcher to reject the null hypothesis.

Formulate an Analysis Plan

The analysis plan describes how to use sample data to accept or reject the null hypothesis. It should specify the following elements.

- *Significance level*— Often, researchers choose significance levels equal to 0.01, 0.05, or 0.10; but any value between 0 and 1 can be used.
- *Test method*— Use the one-sample t-test to determine whether the hypothesized mean differs significantly from the observed sample mean.

Analyze Sample Data

Using sample data, conduct a one-sample t-test. This involves finding the standard error, degrees of freedom, test statistic, and the P-value associated with the test statistic.

- *Standard error:*— Compute the standard error (SE) of the sampling distribution.

$$SE = s * sqrt\{ (1/n) * (1 - n/N) * [N / (N - 1)] \}$$

where s is the standard deviation of the sample, N is the population size, and n is the sample size. When the population size is much larger (at least 10 times larger) than the sample size, the standard error can be approximated by:

$$SE = s / sqrt(n)$$

- *Degrees of freedom*— The degrees of freedom (DF) is equal to the sample size (n) minus one. Thus, DF = n - 1.
- *Test statistic*— The test statistic is a t-score (t) defined by the following equation.

$$t = (x - \mu) / SE$$

where x is the sample mean, μ is the hypothesized population mean in the null hypothesis, and SE is the standard error.

- *P-value*— The P-value is the probability of observing a sample statistic as extreme as the test statistic. Since the test statistic is a *t*-score, use the *t* Distribution Calculator to assess the probability associated with the *t*-score, given the degrees of freedom computed above.

Interpret Results

If the sample findings are unlikely, given the null hypothesis, the researcher rejects the null hypothesis. Typically, this involves comparing the P-value to the significance level, and rejecting the null hypothesis when the P-value is less than the significance level.

2.5 Exploratory, Descriptive and Causal Research Designs

Exploratory research

Exploratory research is a type of research conducted because a problem has not been clearly defined. Exploratory research helps determine the best research design, data collection method and selection of subjects. Given its fundamental nature, exploratory research often concludes that a perceived problem does not actually exist.

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Exploratory research often relies on secondary research such as reviewing available literature and/or data, or qualitative approaches such as informal discussions with consumers, employees, management or competitors, and more formal approaches through in-depth interviews, focus groups, projective methods, case studies or pilot studies.

The results of exploratory research are not usually useful for decision-making by themselves, but they can provide significant insight into a given situation. Although the results of qualitative research can give some indication as to the "why", "how" and "when" something occurs, it cannot tell us "how often" or "how many."

Exploratory research is not typically generalizable to the population at large.

A defining characteristic of causal research is the random assignment of participants to the conditions of the experiment; e.g., an Experimental and a Control Condition.. Such assignment results in the groups being comparable at the beginning of the experiment. Any difference between the groups at the end of the experiment is attributable to the manipulated variable. Observational research typically looks for difference among "in-tact" defined groups. A common example compares smokers and non-smokers with regard to health problems. Causal conclusions can't be drawn from such a study because of other possible differences between the groups; e.g., smokers may drink more alcohol than non-smokers. Other unknown differences could exist as well. Hence, we may see a relation between smoking and health but a conclusion that smoking is a cause would not be warranted in this situation.

Social Science

In many social science circles, exploratory research "seeks to find out how people get along in the setting under question, what meanings they give to their actions, and what issues concern them. The goal is to learn 'what is going on here?' and to investigate social phenomena without explicit expectations." (Russell K. Schutt, Investigating the Social World, 5th ed.. This methodology can is also at times referred to as a 'grounded theory' approach to 'qualitative research' or 'interpretive research', and is an attempt to 'unearth' a theory from the data itself rather than from a pre-disposed hypothesis.

There are three types of objective in a marketing research project.

- Exploratory Research
- Descriptive research
- Causal research

Exploratory Research: The objective of exploratory research is to gather preliminary information that will help define problems and suggest hypotheses.'

Descriptive Research: The objective of descriptive research is to describe things, such as the market potential for a product or the demographics and attitudes of consumers who buy the product.' (Kotler et al. 2006, p. 122)

Causal Research: The objective of causal Research is to test hypotheses about cause-and-effect relationships.

Descriptive Research

Descriptive research, also known as statistical research, describes data and characteristics about the population or phenomenon being studied. Descriptive research answers the questions who, what, where, when and how.

Although the data description is factual, accurate and systematic, the research cannot describe what caused a situation. Thus, descriptive research cannot be used to create a causal relationship, where one variable affects another. In other words, descriptive research can be said to have a low requirement for internal validity.

The description is used for frequencies, averages and other statistical calculations. *Often the best approach, prior to writing descriptive research, is to* conduct a survey investigation. Qualitative research often has the aim of description and researchers may follow-up with examinations of why the observations exist and what the implications of the findings are.

In short descriptive research deals with everything that can be counted and studied. But there are always restrictions to that. Your research must have an impact to the lives of the people around you. For example, finding the most frequent disease that affects the children of a town. The reader of the research will know what to do to prevent that disease thus, more people will live a healthy life.

Descriptive research can be of two types:

(i) Quantitative descriptive research emphasizes on what is, and makes use of quantitative methods to describe, record, analyze and interpret the present conditions.

(ii) Qualitative descriptive research also emphasizes on what is, but makes use of non-quantitative research methods in describing the conditions of the present.

Sometimes referred to as non-experimental or correlational research, descriptive research studies the relationships among non-manipulated variables only. In this type of research, the investigator selects the relevant variables from the events/conditions that have already occurred or exist at present, and analyzes their relationship without introducing any manipulations to the variables. In descriptive research, we study the events or human behaviour in natural settings, because sometimes it would be difficult to manipulate the variables, and because sometimes it is unethical. For example, if you want to study the effect of smoking on the chances of cancer development, it would be totally unethical to deliberately assign subjects in the group that will smoke and in that who will not so that a comparative study could be done. So, this and other types of relationships between and among the variables are studied under natural conditions of the classroom, home, factory, offices, etc. Because of its ease in use, descriptive research is the most popular and widely used method in educational research. The descriptive research method is easy to use because in this method, the research data can be very easily obtained and interpreted. The results of descriptive research provide us with a platform to make important decisions and also generate more research ideas to be tested by the future researchers.

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Purpose of Descriptive Research

The broad purpose of descriptive research in 'Education' is to study the present problems of the students, teachers, administration, curriculum, teaching learning process, and the like, and to suggest some solutions to these problems. For example, Frederic Jones (1979) conducted a descriptive research on classroom discipline and used the collected information to formulate a 'system of discipline' which now has been used by many teachers in their classrooms to maintain discipline among students.

Significance of Descriptive Research

The following points prove the significance of descriptive research in the field of education:

(i) *Description of the Present:* The descriptive research studies describe the current and present educational phenomena, problems and/or opinions possessed by the teachers, students, etc. about their educational environment or scenario.

(ii) *Easy and Direct:* This method is very easy and direct in use and, hence, is a very popular and widely used research method.

(iii) *Only Means:* Many times we find the manipulation of the variables a tough job. Therefore, we use this method in which we study the existing relationship between or among the variables without any manipulation.

(iv) *Suggesting Solutions:* Descriptive research not only describes the current problem but also many times suggests valuable solutions to the educational problems. The descriptive investigation of F. Jones (1979) noted above is a good example.

(v) *Developing Data Collection Tools:* The descriptive research is also very useful and helpful in developing the data collection tools like questionnaires, schedules, checklists, etc.

(vi) *Development of Generalizations, Principles or Theories:* By dealing with the relationships between or among the variables, the descriptive research is also very useful in developing new generalizations, principles or theories which possess universal validity and utility.

Types of Descriptive Research

Descriptive research can be divided into the following categories :

(i) The survey : The term survey is derived from two words: 'Sur' or 'Sor,' which means "over" and 'Veeir' or 'vor,' which means, "to see." Accordingly, the term survey means to look over or to oversee. Webster's New Collegiate Dictionary defines survey as a "critical inspection, often official, to provide exact information, often a study of an area with respect to a certain condition or its prevalence, e.g. a survey of the school."

In survey, we collect the data from a large number of people at some particular time about some particular phenomenon. It is a very skillful activity that not only requires imaginative and expert planning of the study, but also accurate data collection, careful analysis and logical interpretation of the collected data, and intelligent reporting of the results and conclusions.

Surveys can further be of many types:

a. *School Survey* : The main purpose of a school survey is to judge the overall effectiveness of the school programme and suggest some improvement if and where necessary. The very first formal survey was conducted in 1910 of the school of Boise, Idaho (USA), and now a days it has become the necessity of each nation and state to evaluate the effectiveness of its schools as a functional unit.

   A single comprehensive school survey may well comprise of any or more of the following :

   (i) Survey Testing
   (ii) Achievement Testing
   (iii) Intelligence Testing
   (iv) Personality Testing
   (v) Curriculum Studies
   (vi) Status Studies
   (vii) Financial Studies
   (viii) Building Surveys
   (ix) School Appraisal

b. *Job Survey* : It mainly refers to job analysis. In the field of education, in job surveys, we collect relevant information about the general and specific duties and responsibilities of the teachers, non-teaching staff and administrative personnel, the working conditions in which they work, the nature and type of facilities they enjoy, etc. These types of information will further help the employers and administrators to improve their working conditions so that jobs must become so attractive and remunerative that they will attract the right people for the right types of jobs at the right time.

c. *Documentary Survey* : It closely relates to historical research since in such surveys we study the existing documents. But it is different from historical research in which our emphasis was on the study of the past; and in the descriptive research we emphasised on the study of the present. Descriptive research in the field of education may focus on describing the existing school practices, attendance rate of the students, health records, etc.

d. *Public Opinion Survey* : Sometimes, by the help of questionnaires or interviews, we collect the public opinion on various educational issues like implementation of co-education at school or college level, privatization of education, etc. These help us know what the public thinks about our selected topic on the basis of which we might take important and crucial decisions.

e. *Social Surveys* : These are also known as community surveys. Since there is very close relationship between the school and the community, researchers often conduct community surveys to determine the educational needs of a particular society or to assess and enhance the schools' performance for the benefit of the society at large.

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(ii) Correlational studies: In this type of studies we determine the extent to which two variables are correlated, the direction of their correlation (positive or negative), and whether the correlation (represented by the letter r) is significant or not. In any direction (positive or negative), variables may be highly, moderately or lowly correlated, or they may not be correlated at all (i.e. zero correlation). One very simple example of a correlational study in the field of education may be to study the correlation between teacher reinforcement and student performance.

(iii) Causal-comparative studies: This is a type of research in educational studies in which we suggest the cause and effect or we suggest what causes the other thing, e.g. high motivational level causes better performance. But this type of research possesses a serious limitation in that it cannot manipulate the causes (or independent variables) to prove this suggested relationship.

(iv) Developmental studies: These types of descriptive studies deal with the changes that take place as a function of time. These studies are of two types :

a. *Growth Studies* : Longitudinal or cross-sectional studies can be conducted to study the nature and rate of changes that occur in human organism and influence his/her various aspects of life.
b. *Trend Studies* : These types of descriptive studies aim at collecting social, political or economic data to analyze them in order to explore the current trend; and, on the basis of this, these studies try to predict what may happen in the future. In the field of education, trend studies may investigate the current trends in educational settings and may suggest some steps, etc. to be taken in future to meet the future demands or to solve the future problems.

Steps in Descriptive Research

The steps followed in descriptive research are almost similar to the ones followed in other forms of research. Following are the steps adopted in describing and interpreting the existing conditions :

- *Selection of the Problem:* A researcher, from the area of his/her interest, may select any problem to study the existing conditions or phenomena. He/she should clearly state the problem and define the variables in operational terms.
- *Formulation of Hypothesis:* The research hypothesis guides us throughout the research process in solving our research problems. We should formulate the hypotheses on the basis of the existing theories and facts.
- *Identification of Data:* It is necessary to identify the appropriate type of (qualitative or quantitative) data to be collected so that our hypothesis may be correctly tested.
- *Selection or Development of a Research Tool:* After deciding the nature of the data to be collected, it becomes easy for us to select the appropriate measurement tool and if any standardized tool of our interest is not available we have to develop our own tool as per our research requirements.

- *Selection of the Sample:* While selecting the sample to be studied, we must choose a representative sample and apply randomization techniques in sample selection, if possible.
- *Data Collection:* After finalizing the tools to be used and sample to be studied, we begin our actual data collection.
- *Treatment or Analysis of the Data:* The data collected is then treated with the appropriate statistical techniques.
- *Interpretation:* While interpreting our obtained findings we should also emphasize the existing theories and interpret our results in their light. We should also see if our findings build a new theory or conform to the old ones.
- *Report Writing:* It is the last and most important step of a research study, i.e. to write an appropriate and clear report of what we have done and found, so that people may also take advantage of this new knowledge.

Causal Research

If the objective is to determine which variable might be causing a certain behaviour, i.e. whether there is a cause and effect relationship between variables, causal research must be undertaken. In order to determine causality, it is important to hold the variable that is assumed to cause the change in the other variable(s) constant and then measure the changes in the other variable(s). This type of research is very complex and the researcher can never be completely certain that there are not other factors influencing the causal relationship, especially when dealing with people's attitudes and motivations. There are often much deeper psychological considerations, that even the respondent may not be aware of.

There are two research methods for exploring the cause and effect relationship between variables:

1. Experimentation, and
2. Simulation

Causal-comparative research-a type of descriptive research-is also referred to as "ex post facto" research, which means after the fact or from a thing done afterwards. This simply implies that the researcher is studying the cause-effect relationship that already exists, without attempting any control or change in either the cause or the effect. In other words, it refers to some type of subsequent action taken after something has occurred or happened, and how we want to study or evaluate its effect in terms of the causal relationship.

According to Kerlinger (1973), "Ex post facto research is systematic empirical inquiry in which the scientist does not have direct control of independent variables because their manifestations have already occurred or because they are inherently not manipulabe. Inferences about relations among variables are made, without direct intervention, from concomitant variation of independent and dependent variables." Thus, in this type of research, we are unable to control or manipulate the causes or independent variables and now we simply try to explore how and why are they related to the effects or the dependent variables. Although this method also studies cause and effect relationship, yet it is technically different from experimental research in which we prove this cause-effect relationship by manipulating the independent variables. But, in causal-comparative research, it is neither possible nor practical to manipulate the cause because genetics, time or circumstances fix it. And, thus, we have to logically establish the cause-effect relationship, we cannot prove it "experimentally." For example, if we wish to study the delinquency, we cannot manipulate the causes of delinquency.

Nature of Causal-Comparative Research

The causal-comparative research is based upon John Stuart Mill's method of exploring causal relationships. According to Mill's Method of Agreement (1846), "If two or more instances of the phenomenon under investigation have only one circumstances in common, the circumstance in which alone all the instances agree, is the cause (or effect) of the given phenomena."

Actually, this research begins with the observation of any dependent variable or the effect. Then, the researcher starts exploring the possible independent variables or causes that may be related to that dependent variable.

Consider the following simple example. Suppose a family goes out for a dinner. All enjoy the dinner. After the dinner, both the kids and the mother demand some ice cream and enjoy it, except the father who does not accompany them in this item because he does not like it. Then, after some time, they come back home. After an hour or two, the mother and kids start experiencing some ache in their abdominal. They go to the doctor who asks them about the food they ate at the restaurant and found that each and every item was shared by all of them except ice cream which was not taken by the father. Conforming unknowingly the Mill's Method of Agreement, he concluded that ice cream was the cause of their abdominal pain. Because it was this, and only this item, that was consumed by all the ill family members in common.

And to confirm this hypothesis, the doctor (again unknowingly) applies Mill's Joint Method of Agreement and Differences that the family members who experienced abdominal pain had had ice cream in common, and that the father who did not experience this pain had not consumed this item. So, the doctor, concluded that ice cream (independent variable or cause) was causally related to the abdominal pain (dependent variable or effect) of the sufferers.

Now let us note that, just like the above mentioned example, there are certain conditions and situations in which a researcher can neither manipulate the cause nor establish the controls that are essential for an experiment. For example, if you want to study delinquency or emotional maladjustment (the effects), you may find yourself unable to manipulate or control the causes in studying the cause-effect relationships here. Besides, you may find out several causes of the effect but it depends on your skills to logically demonstrate the existing cause-effect linkage and to make a convincing case for the relationship between cause and effect. For this purpose, you can make strong and persuasive arguments because, in this research, you cannot experimentally demonstrate the obtained cause-effect relationship.

Importance of Causal-Comparative Research

No doubt, the experimental method is the best, but in many situations we find it impractical or costly in terms of time, money and efforts. Also, in some other situations, ethical considerations may not permit a researcher to use experimental method. D. B. Van Dalen (1973) rightly remarks that, "Respect for living things, prevents an investigator from inflicting unnecessary pain, hardship, or harm on others, or from interfering in any way with the normal growth and development of an individual." Here then, we have to make use of causal-comparative research. Most of the educational research studies employ the method of causal-comparative research since, in education, the independent variables are often difficult or impossible to manipulate or control. This method helps us study the problems that cannot be investigated under laboratory controls and provide valuable information about the causal relationships between two events.

Steps in Causal-Comparative Research

Although steps involved in causal-comparative research do not differ much from steps involved in other types of research, yet some points are to be taken care of while conducting a causal-comparative research. These are given as follows:

- *Selection of a Problem* : In causal-comparative research, you should select such a problem, the independent variables of which can neither be manipulated nor be controlled.
- *Formulation of the Hypothesis* : Mostly, the hypotheses are stated in the null form in causal-comparative research.
- *Data and Tools* : Generally, in causal-comparative research, we collect biographical data, because our main purpose here is to detect past causes for the present effects or behaviour patterns. And, as far as tools are concerned, so as to find out the causal factors we may use standardized tests, questionnaires, schedules, interviews, observation, etc.
- *Procedure of Data Collection* : Your main skill required here is to identify the groups of subjects which are demonstrably different from each other on the phenomenon or the characteristic you are interested in, e.g., delinquency. Up to this stage, you also possess in your mind some possible causes of these differences causes that cannot be manipulated. Then, you try to collect the data that will allow you to logically establish that this particular difference is the cause of this particular phenomenon or characteristic.
- *Data Analysis* : After measuring the existing dependent variable of groups of subjects, we may then test the differences between the groups for significance through 'difference between means' (or t test),' or may apply chi-square or analysis of variance.
- *Data Interpretation* : If your data reveal that both the different groups actually differ on the dependent variable, you may interpret it as a causal relationship between your selected cause and effect. Here, you must provide logical arguments to build your case to be strong that this

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particular effect is the result of this particular cause. For effective interpretation, you may do the following:

(i) Provide suitable and relevant examples which show that without this cause, the effect could not have occurred.

(ii) Show whether, to produce this effect, your identified cause is sufficient or enough by itself.

(iii) Show whether there are some other conditions also that could be equally responsible for causing of this particular effect.

- *Using the Findings* : Although, as it is clear till now, you can do nothing to manipulate or control the causes, yet finding causal relationships is highly beneficial because it enables us to anticipate, adapt to, and make provisions for the future "effects."
- *Report Writing* : You might have noted that causal-comparative research requires highly skillful and careful steps to be taken during the research process. It is also required while writing your research report which is the last step of the research process.

Limitations of Causal-Comparative Research

These studies suffer from the following limitations that are difficult to remove:

- We lack controls in causal-comparative research.
- Identification of relevant causes is difficult.
- Generally, causes are multiple rather than single.
- Causes may differ from situation to situation for the same effect.
- Even after establishing a relationship between variables, it becomes difficult to determine which is the cause and which is the effect.
- Selecting subjects and assigning them to dichotomous categories is also very difficult.

Despite all these limitations, causal-comparative research is very useful, and a good substitute of experimental studies, where we cannot manipulate or control the independent variables and we have to establish some causal relationship between or among the variables.

2.6 Basic Principles and Types of Sampling

Sampling is that part of statistical practice concerned with the selection of individual observations intended to yield some knowledge about a population of concern, especially for the purposes of statistical inference. Each observation measures one or more properties (weight, location, etc.) of an observable entity enumerated to distinguish objects or individuals. Survey weights often need to be applied to the data to adjust for the sample design. Results from probability theory and statistical theory are employed to guide practice.

The sampling process comprises several stages:

- Defining the population of concern
- Specifying a sampling frame, a set of items or events possible to measure

- *Specifying a sampling method for selecting items or events from the frame*
- Determining the sample size
- Implementing the sampling plan
- Sampling and data collecting
- Reviewing the sampling process

Population Definition

Successful statistical practice is based on focused problem definition. In sampling, this includes defining the population from which our sample is drawn. A population can be defined as including all people or items with the characteristic one wishes to understand. Because there is very rarely enough time or money to gather information from everyone or everything in a population, the goal becomes finding a representative sample (or subset) of that population.

Sometimes that which defines a population is obvious. For example, a manufacturer needs to decide whether a batch of material from production is of high enough quality to be released to the customer, or should be sentenced for scrap or rework due to poor quality. In this case, the batch is the population.

Although the population of interest often consists of physical objects, sometimes we need to sample over time, space, or some combination of these dimensions. For instance, an investigation of supermarket staffing could examine checkout line length at various times, or a study on endangered penguins might aim to understand their usage of various hunting grounds over time. For the time dimension, the focus may be on periods or discrete occasions.

In other cases, our 'population' may be even less tangible. For example, Joseph Jagger studied the behaviour of roulette wheels at a casino in Monte Carlo, and used this to identify a biased wheel. In this case, the 'population' Jagger wanted to investigate was the overall behaviour of the wheel (i.e. the probability distribution of its results over infinitely many trials), while his 'sample' was formed from observed results from that wheel. Similar considerations arise when taking repeated measurements of some physical characteristic such as the electrical conductivity of copper.

This situation often arises when we seek knowledge about the cause system of which the observed population is an outcome. In such cases, sampling theory may treat the observed population as a sample from a larger 'superpopulation'. For example, a researcher might study the success rate of a new 'quit smoking' program on a test group of 100 patients, in order to predict the effects of the program if it were made available nationwide. Here the superpopulation is "everybody in the country, given access to this treatment"— a group which does not yet exist, since the program isn't yet available to all.

Note also that the population from which the sample is drawn may not be the same as the population about which we actually want information. Often there is large but not complete overlap between these two groups due to frame issues etc. Sometimes they may be entirely separate for instance we might study rats in order to get a better understanding of human health, or we might study records from people born in 2008 in order to make predictions about people born in 2009.

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Time spent in making the sampled population and population of concern precise is often well spent, because it raises many issues, ambiguities and questions that would otherwise have been overlooked at this stage.

Sampling Frame

In the most straightforward case, such as the sentencing of a batch of material from production (acceptance sampling by lots), it is possible to identify and measure every single item in the population and to include any one of them in our sample. However, in the more general case this is not possible. There is no way to identify all rats in the set of all rats. There is no way to identify every voter at a forthcoming election (in advance of the election).

These imprecise populations are not amenable to sampling in any of the ways below and to which we could apply statistical theory.

As a remedy, we seek a sampling frame which has the property that we can identify every single element and include any in our sample. The most straightforward type of frame is a list of elements of the population (preferably the entire population) with appropriate contact information. For example, in an opinion poll, possible sampling frames include:

- Electoral register
- Telephone directory

Not all frames explicitly list elements of the population. For example, a street map can be used as a frame for a door-to-door survey; although it doesn't show individual houses, we can select streets from the map and then visit all houses on those streets. (One advantage of such a frame is that it would include people who have recently moved and are not yet on the list frames discussed above.)

The sampling frame must be representative of the population and this is a question outside the scope of statistical theory demanding the judgment of experts in the particular subject matter being studied. All the above frames omit some people who will vote at the next election and contain some people who will not; some frames will contain multiple records for the same person. People not in the frame have no prospect of being sampled. Statistical theory tells us about the uncertainties in extrapolating from a sample to the frame. In extrapolating from frame to population, its role is motivational and suggestive.

"To the scientist, however, representative sampling is the only justified procedure for choosing individual objects for use as the basis of generalization, and is therefore usually the only acceptable basis for ascertaining truth." (Andrew A. Marino). It is important to understand this difference to steer clear of confusing prescriptions found in many web pages.

In defining the frame, practical, economic, ethical, and technical issues need to be addressed. The need to obtain timely results may prevent extending the frame far into the future.

The difficulties can be extreme when the population and frame are disjoint. This is a particular problem in forecasting where inferences about the future are made from historical data. In fact, in 1703, when Jacob Bernoulli proposed to Gottfried Leibniz the possibility of using historical mortality data to predict the probability of early death of a living man, Gottfried Leibniz recognized the problem in replying:

"Nature has established patterns originating in the return of events but only for the most part. New illnesses flood the human race, so that no matter how many experiments you have done on corpses, you have not thereby imposed a limit on the nature of events so that in the future they could not vary."

A frame may also provide additional 'auxiliary information' about its elements; when this information is related to variables or groups of interest, it may be used to improve survey design. For instance, an electoral register might include name and sex; this information can be used to ensure that a sample taken from that frame covers all demographic categories of interest. (Sometimes the auxiliary information is less explicit; for instance, a telephone number may provide some information about location.)

Having established the frame, there are a number of ways for organizing it to improve efficiency and effectiveness.

It's at this stage that the researcher should decide whether the sample is in fact to be the whole population and would therefore be a census.

Probability and Nonprobability Sampling

A probability sampling scheme is one in which every unit in the population has a chance (greater than zero) of being selected in the sample, and this probability can be accurately determined. The combination of these traits makes it possible to produce unbiased estimates of population totals, by weighting sampled units according to their probability of selection.

Example: We want to estimate the total income of adults living in a given street. We visit each household in that street, identify all adults living there, and randomly select one adult from each household. (For example, we can allocate each person a random number, generated from a uniform distribution between 0 and 1, and select the person with the highest number in each household). We then interview the selected person and find their income.

People living on their own are certain to be selected, so we simply add their income to our estimate of the total. But a person living in a household of two adults has only a one-in-two chance of selection. To reflect this, when we come to such a household, we would count the selected person's income twice towards the total. (In effect, the person who is selected from that household is taken as representing the person who isn't selected.)

In the above example, not everybody has the same probability of selection; what makes it a probability sample is the fact that each person's probability is known. When every element in the population does have the same probability of selection, this is known as an 'equal probability of selection' (EPS) design. Such designs are also referred to as 'self-weighting' because all sampled units are given the same weight.

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Probability sampling includes: Simple Random Sampling, Systematic Sampling, Stratified Sampling, Probability Proportional to Size Sampling, and Cluster or Multistage Sampling. These various ways of probability sampling have two things in common: 1) Every element has a known nonzero probability of being sampled and 2) involves random selection at some point.

Nonprobability sampling is any sampling method where some elements of the population have no chance of selection (these are sometimes referred to as 'out of coverage'/'undercovered'), or where the probability of selection can't be accurately determined. It involves the selection of elements based on assumptions regarding the population of interest, which forms the criteria for selection. Hence, because the selection of elements is nonrandom, nonprobability sampling does not allow the estimation of sampling errors. These conditions place limits on how much information a sample can provide about the population. Information about the relationship between sample and population is limited, making it difficult to extrapolate from the sample to the population.

Example: We visit every household in a given street, and interview the first person to answer the door. In any household with more than one occupant, this is a nonprobability sample, because some people are more likely to answer the door (e.g. an unemployed person who spends most of their time at home is more likely to answer than an employed housemate who might be at work when the interviewer calls) and it's not practical to calculate these probabilities.

Nonprobability Sampling includes: Accidental Sampling, Quota Sampling and Purposive Sampling. In addition, nonresponse effects may turn any probability design into a nonprobability design if the characteristics of nonresponse are not well understood, since nonresponse effectively modifies each element's probability of being sampled.

Sampling Methods

It is incumbent on the researcher to clearly define the target population. There are no strict rules to follow, and the researcher must rely on logic and judgment. The population is defined in keeping with the objectives of the study.

Sometimes, the entire population will be sufficiently small, and the researcher can include the entire population in the study. This type of research is called a census study because data is gathered on every member of the population.

Usually, the population is too large for the researcher to attempt to survey all of its members. A small, but carefully chosen sample can be used to represent the population. The sample reflects the characteristics of the population from which it is drawn.

Sampling methods are classified as either probability or nonprobability. In probability samples, each member of the population has a known non-zero probability of being selected. Probability methods include random sampling, systematic sampling, and stratified sampling. In nonprobability sampling, members are selected from the population in some nonrandom manner. These

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include convenience sampling, judgment sampling, quota sampling, and snowball sampling. The advantage of probability sampling is that sampling error can be calculated. Sampling error is the degree to which a sample might differ from the population. When inferring to the population, results are reported plus or minus the sampling error. In nonprobability sampling, the degree to which the sample differs from the population remains unknown.

Random sampling is the purest form of probability sampling. Each member of the population has an equal and known chance of being selected. When there are very large populations, it is often difficult or impossible to identify every member of the population, so the pool of available subjects becomes biased.

Systematic sampling is often used instead of random sampling. It is also called an Nth name selection technique. After the required sample size has been calculated, every N^{th} record is selected from a list of population members. As long as the list does not contain any hidden order, this sampling method is as good as the random sampling method. Its only advantage over the random sampling technique is simplicity. Systematic sampling is frequently used to select a specified number of records from a computer file.

Stratified sampling is commonly used probability method that is superior to random sampling because it reduces sampling error. A stratum is a subset of the population that share at least one common characteristic. Examples of stratums might be males and females, or managers and non-managers. The researcher first identifies the relevant stratums and their actual representation in the population. Random sampling is then used to select a sufficient number of subjects from each stratum. "Sufficient" refers to a sample size large enough for us to be reasonably confident that the stratum represents the population. Stratified sampling is often used when one or more of the stratums in the population have a low incidence relative to the other stratums.

Convenience sampling is used in exploratory research where the researcher is interested in getting an inexpensive approximation of the truth. As the name implies, the sample is selected because they are convenient. This nonprobability method is often used during preliminary research efforts to get a gross estimate of the results, without incurring the cost or time required to select a random sample.

Judgment sampling is a common nonprobability method. The researcher selects the sample based on judgment. This is usually and extension of convenience sampling. For example, a researcher may decide to draw the entire sample from one "representative" city, even though the population includes all cities. When using this method, the researcher must be confident that the chosen sample is truly representative of the entire population.

Quota sampling is the nonprobability equivalent of stratified sampling. Like stratified sampling, the researcher first identifies the stratums and their proportions as they are represented in the population. Then convenience or judgment sampling is used to select the required number of subjects from each stratum. This differs from stratified sampling, where the stratums are filled by random sampling.

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Snowball sampling is a special nonprobability method used when the desired sample characteristic is rare. It may be extremely difficult or cost prohibitive to locate respondents in these situations. Snowball sampling relies on referrals from initial subjects to generate additional subjects. While this technique can dramatically lower search costs, it comes at the expense of introducing bias because the technique itself reduces the likelihood that the sample will represent a good cross section from the population.

Sampling and Data Collection

Good data collection involves:

- Following the defined sampling process
- Keeping the data in time order
- Noting comments and other contextual events
- Recording non-responses

Most sampling books and papers written by non-statisticians focus only in the data collection aspect, which is just a small though important part of the sampling process.

2.7 Precision and Accuracy of Sample Based Research

The best sampling method is the sampling method that most effectively meets the particular goals of the study in question. The effectiveness of a sampling method depends on many factors. Because these factors interact in complex ways, the "best" sampling method is seldom obvious. Good researchers use the following strategy to identify the best sampling method.

- List the research goals (usually some combination of accuracy, precision, and/or cost).
- Identify potential sampling methods that might effectively achieve those goals.
- Test the ability of each method to achieve each goal.
- Choose the method that does the best job of achieving the goals.

It is important to distinguish from the start a different between accuracy and precision:—

(1) Accuracy is the degree to which information in a digital database matches true or accepted values. Accuracy is an issue pertaining to the quality of data and the number of errors contained in a dataset or map.

- The level of accuracy required for particular applications varies greatly.
- Highly accurate data can be very difficult and costly to produce and compile.

(2) Precise attribute information may specify the characteristics of features in great detail. It is important to realize, however, that precise data—no matter how carefully measured—may be inaccurate. Surveyors may make mistakes or data may be entered into the database incorrectly.

- The level of precision required for particular applications varies greatly. Engineering projects such as road and utility construction require very precise information measured to the millimeter or tenth of an inch. Demographic analyses of marketing or electoral trends can often make do with less, say to the closest zip code or precinct boundary.

- *Highly precise data can be very difficult and costly to collect.*

High precision does not indicate high accuracy nor does high accuracy imply high precision. But high accuracy and high precision are both expensive.

Two additional terms are used as well:

1. Data quality refers to the relative accuracy and precision of a particular database. These facts are often documented in data quality reports.
2. Error encompasses both the imprecision of data and its inaccuracies.

Quality of Survey Results

When researchers describe the quality of survey results, they may use one or more of the following terms.

- *Accuracy:* Accuracy refers to how close a sample statistic is to a population parameter. Thus, if you know that a sample mean is 99 and the true population mean is 100, you can make a statement about the sample accuracy. For example, you might say the sample mean is accurate to within 1 unit.
- *Precision:* Precision refers to how close estimates from different samples are to each other. For example, the standard error is a measure of precision. When the standard error is small, estimates from different samples will be close in value; and vice versa. Precision is inversely related to standard error. When the standard error is small, sample estimates are more precise; when the standard error is large, sample estimates are less precise.
- *Margin of error:* The margin of error expresses the maximum expected difference between the true population parameter and a sample estimate of that parameter. To be meaningful, the margin of error should be qualified by a probability statement. For example, a pollster might report that 50% of voters will choose the Democratic candidate. To indicate the quality of the survey result, the pollster might add that the margin of error is +5%, with a confidence level of 90%. This means that if the same sampling method were applied to different samples, the true percentage of Democratic voters would fall within the margin of error 90% of the time.

The margin of error is equal to half of the width of the confidence interval In a previous lesson, the tutorial described how to construct a confidence interval.

Sample Design

A sample design can be described by two factors.

- *Sampling method:* Sampling method refers to the rules and procedures by which some elements of the population are included in the sample.
- *Estimator:* The estimation process for calculating sample statistics is called the estimator. Different sampling methods may use different estimators.

For example, the formula for computing a mean score with a simple random sample is different from the formula for computing a mean score with a stratified sample. Similarly, the formula for the standard error may vary from one sampling method to the next.

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The "best" sample design depends on survey objectives and on survey resources. For example, a researcher might select the most economical design that provides a desired level of precision. Or, if the budget is limited, a researcher might choose the design that provides the greatest precision without going over budget. Or other factors might guide the choice of sample design.

2.8 Sampling and Non-Sampling Errors

Estimates derived from sample surveys are subject to two types of errors—sampling errors and nonsampling errors. Nonsampling errors can be attributed to many sources, such as response differences, definitional difficulties, differing respondent interpretations, and respondent inability to recall information.

Sampling errors (the focus of this presentation) occur when estimates are derived from a sample rather than a census of the population. The sample used for a particular survey is only one of a large number of possible samples of the same size and design that could have been selected. Even if the same questionnaire and instructions were used, the estimates from each sample would differ from the others. This difference, termed sampling error, occurs by chance, and its variability is measured by the standard error associated with a particular survey.

Assessing the Accuracy of Estimates

Having estimated a population quantity such as a mean or total, it is desirable to assess the accuracy of the estimate. The customary approach is to construct a confidence interval within which one is sufficiently sure the true population value lies. The standard error of a survey estimate measures the precision with which an estimate from one sample approximates the true population value, and thus can be used to construct a confidence interval for a survey parameter to assess the accuracy of the estimate. Let $\hat{\theta}$ be an estimator of a parameter of interest θ with a standard error $SE(\hat{\theta})$. If the sample size is large, then an approximate $(1-\alpha)100$ percent confidence interval for θ is

$$\{\hat{\theta} - z_{\alpha/2} SE(\hat{\theta}), \hat{\theta} + z_{\alpha/2} SE(\hat{\theta})\},$$

where $z_{\alpha/2}$ is the upper $\alpha/2$ percentage point of the normal distribution with mean zero and variance one.

If the process of selecting a sample from the population were repeated many times and an estimate and its standard error calculated for each sample, then:

- Approximately 90 percent (α=0.10) of the intervals from 1.645 (= $z_{.05}$) standard errors below the estimate to 1.645 standard errors above the estimate will include the true population value.
- Approximately 95 percent (α=0.05) of the intervals from 1.96 (= $z_{.025}$) standard errors below the estimate to 1.96 standard errors above the estimate will include the true population value.

- Approximately 99 percent (α=0.01) of the intervals from 2.575 ($=z_{\alpha}$) standard errors below the estimate to 2.575 standard errors above the estimate will include the true population value.

With an estimate of the standard error and the factors above (1.645, 1.96, or 2.575), a data user may construct a confidence interval. or range of values, that includes the true population value with the given probability α (=0.10, 0.05, or 0.01).

Sampling Error

In statistics, sampling error or estimation error is the error caused by observing a sample instead of the whole population.

An estimate of a quantity of interest, such as an average or percentage, will generally be subject to sample-to-sample variation. These variations in the possible sample values of a statistic can theoretically be expressed as sampling errors, although in practice the exact sampling error is typically unknown. Sampling error also refers more broadly to this phenomenon of random sampling variation.

The likely size of the sampling error can generally be controlled by taking a large enough random sample from the population, although the cost of doing this may be prohibitive; see sample size and statistical power for more detail. If the observations are collected from a random sample, statistical theory provides probabilistic estimates of the likely size of the sampling error for a particular statistic or estimator. These are often expressed in terms of its standard error.

Sampling error can be contrasted with non-sampling error. Non-sampling error is a catch-all term for the deviations from the true value that are not a function of the sample chosen, including various systematic errors and any random errors that are not due to sampling. Non-sampling errors are much harder to quantify than sampling error.

Non-Sampling Error

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In a census or sample survey, we obtain observations through personal enquiry, direct observation, direct questionnaire, mail enquiry or other methods on age, income, saving, buying performance, attitude on a particular problem, occupation, business activities or other characteristics of a person, household, farm business, area or other unit.

The planning of the statistical enquiry needs detailed and systematic planning to obtain the relevant, accurate and timely data to satisfy the objectives set. The set of measurements or observations recorded in the data collection operation are normally examined for internal consistency and acceptability, certain corrections made and some of the entries are coded to identify them in a classification system. The results are then summarized into frequency tables as well as various types of statistics such as tables, averages, correlations or other

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relevant statistical measures. The pre data collection activities are parts of the process of specification of various parameters for systematic preparation of the whole statistical enquiry. The mistakes or faults occurring in these activities are called the specification mistakes or faults made by the survey designer. The data collection and processing operations constitute the measurement process and are the sources of measurement errors. The above mentioned faults and errors are collectively called as non-sampling errors.

Classification of Non-Sampling Errors

There are several types of non-sampling errors. A detailed study of the sources, measurement and control of these errors requires that they be broken down and categorized in ways that facilitate understanding of their nature. Several schemes for classifying non-sampling errors are possible; none is perfect, each serve a purpose.

Errors by stage of survey process

One approach is to classify non-sampling errors by the stage of the survey in which they occur. The three major stages are

1. Survey design and preparation
2. Data collection
3. Data processing and analysis

Each of these stages can be subdivided. The subdivisions could be made as follows—

Survey design and preparation could make mistakes in the activities,

- Determination of the purpose of survey
- Developing concepts and definition of survey data items
- Designing the questionnaire and guiding the way to complete the form
- Selecting and training of interviewers
- Preparation of survey area
- Selecting the data collection method of enquiry

Data collection could involve errors such as—

- interviewers omit some survey units
- Interviewers omit to do coding
- Interviewers omit the survey items
- Interviewers record the survey data items on the inquiry sheets themselves
- Interviewers ask the questionnaires through other person
- Interviewee does not remember the event
- Interviewee gives wrong answers intentionally

Data processing and analysis could mark errors in the following activities—

- Receiving inquiry sheets
- checking inquiry sheet, encoding and checking the encoding of information written in inquiry sheets

- Checking the result of entering information
- Entering omitted codes
- Entering coincided, omitted codes

This classification is especially useful in studying the non-sampling errors at each stage in the planning and execution of a household survey.

Sources of non-sampling errors

A second method of classifying non-sampling error is on the basis of the source or type of error.

Sources and Type of non-sampling errors

Non-sampling errors arise due to various causes right from the initial stage when the survey is being planned to the final stage when the data are processed and analysed.

A household survey program is a set of rules which specify various operations. The rules, for instance, describe the population under coverage, specify concepts, definitions to be used, methods of data collection and measurements to be made and tabulation. If various survey operations are carried out according to the rules laid down, it is possible to obtain a true value of the characteristics under study for every unit in the population. However, it is rarely achieved in practice even though the survey operations are strictly carried out according to the set rules. This is due to a large number of factors, some of which are uncontrollable, which may affect the conduct of the survey operations.

In general, non-sampling may arise from one or more of the following factors.

a. Data specifications being inadequate and/or inconsistent with the objectives of survey
b. Duplication or omission of units due to the imprecise of the boundaries of area units, incomplete or wrong identification particulars of units or faulty methods of enumerations
c. Inappropriate methods of interview, observation or measurement using ambiguous questionnaires, definitions or instructions
d. lack of trained and experienced field enumerators including lack of good field supervisors
e. Difficulties involved in actual field data collection arising from recall error and other types of errors on the part of respondents (including non-response)
f. Inadequate scrutiny of the basic data
g. Errors in data processing operations such as coding, keying, verification and tabulation
h. Errors during presentation and publications

These source errors are not exhaustive but are given to indicate the possible sources of errors. In a sample survey, non-sampling may also arise due to defective frame and faulty selection of sampling units.

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Types of non-sampling errors

Biemer and Lyberg (2003) identify five major components of non-sampling errors, namely (a)specification, (b)frame, (c)non–response, (d) measurement and (e) processing errors. Although frame, non-response and measurement errors are thought of as occurring in the data collecting phase of the survey, frequently they are the result of poor decision or choices in the survey design and preparation phase.

(a) Specification Errors

Imperfections in the initial specifications lead to non-sampling error. This occurs when the concept implied by the question is different from the underlying construct that should b measured. Survey planners should, at an early stage, develop a fairly precise definitions of each of the key variables. Variables such as household, income, labour force status, education, literacy, food consumption, medical care, disability etc. cannot be translated into sets of survey questions unless they are defined into considerable details. In a disability survey, a general question asking people whether or not they have a disability can be subject to different interpretations depending on the severity of impairment or the respondent's perception of disability. People with a minor disability may perceive themselves to have no disability. Unless the right screening and filter questions are included in the questionnaire, the answer may not bring out the total number of people with disability. Furthermore, there will be no chance of measuring and controlling non-sampling errors unless the concept is clearly defined in sufficient details.

(b) Frame Errors

In most area surveys primary sampling units comprise clusters of geographic units which are generally called enumeration units (EA). It is common that the demarcation of EAs is not properly carried out during census mapping. Thus households may be omitted or duplicated in the second stage frame.

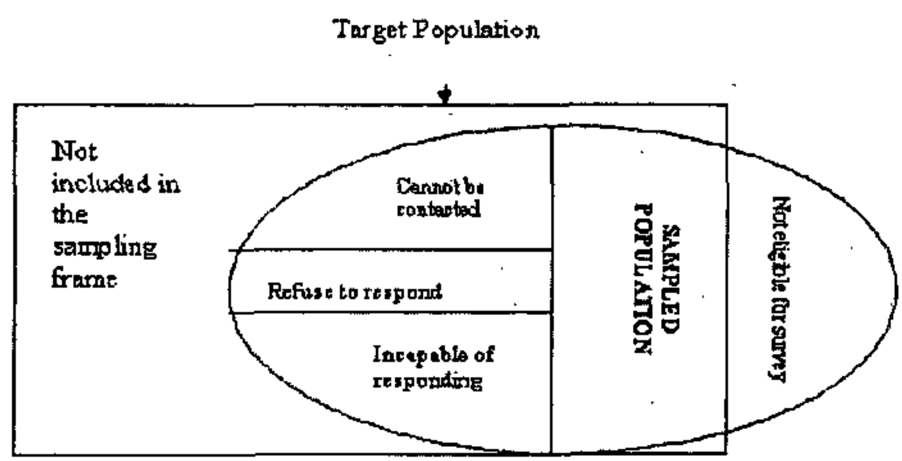

Fig. 2.1 Sampling Frame Imperfections

Frame imperfection can bias the estimates in the following ways: if units are not represented in the frame but should have been part of the frame, this results in zero probability of selection for these units omitted from the frame. If some units are duplicated, this results in over coverage with some units having larger probabilities of selection. The frame imperfections may be depicted in the following *figure 2.1.*

Errors associated with the frame can, therefore, result in both over coverage and under coverage. Under coverage is the most common form in large scale surveys in developing countries. In multi-stage household surveys which is commonly used in large scale surveys, sampling involves a number of stages, such as selection of area units in one or more stages, listing and selection of households; and listing and selection of persons within selected households. Coverage error can arise in any of these stages. It is important to note that neither the magnitude nor the effect of coverage error is easy to estimate because it requires the information not only external to the sample bur also by definition, external to the sampling frame used.

Non-coverage denotes failure to include some sample units of a defined survey population in the sampling frame. Because such units have zero probability of selection, they are effectively excluded from the survey results. It is important to note that non-coverage does not refer to deliberate and explicit exclusion of sections of a larger population from survey population. For example, attitudinal surveys on marriage may exclude persons under the minimum age for legal marriage.

When computing non-coverage rates, members of groups deliberately and explicitly excluded should not be counted either in survey population or under non-coverage. In this regard defining the Non-coverage also refers to missed *elements, omission due to faulty execution of survey operations.* Non-coverage refers to the negative errors resulting from failure to include elements that would under normal circumstances, belong to the sample. Positive errors of over coverage also occur due to inclusion in the sample of elements that do not belong there.

The term gross coverage error refers to the sum of absolute values errors of non-coverage and over coverage error rates. The net non-coverage refers to the excess of non-coverage over over-coverage. It is therefore their algebraic sum. The net non-coverage error is the gross coverage error only if the over coverage is absent. In most social surveys, non-coverage is a much more common problem than over-coverage.

Corrections and weightings for non-coverage are much more difficult than for non-response because coverage rates cannot be obtained from the sample itself, but only from outside sources.

Reducing frame errors

The most effective way to reduce frame errors is to improve the frame by excluding the erroneous units and duplicates as well as updating the frame through field work to identify missing units from the frame. It is also important to undertake a good mapping exercise during the preparatory stages of a population and housing census. However, the frame prepared during the census should be updated regularly. It is also important to put in place procedures that will ensure the coverage of all selected sample units.

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Kish provided useful fourfold classification of frame problems and possible solutions. The four problems with suggested solutions are

(i) *Missing elements:* The problem occurs when some population elements are not included in the frame. Missing elements may occur because the frame is inadequate meaning that it is not intended to cover the whole of the target population or because it is incomplete meaning that it fails to include some elements from the target population.

The problem may be sidestepped by defining by defining the survey population to exclude the missing elements. The imperfect solution is often used when the exclude group is a negligible proportion of the total population.

A preferable solution is to find supplementary frames to cover the missing elements when no suitable supplementary frame is available, as is often the case, linking procedures to attach missing elements to specified listing may be used.

(ii) *Clusters:* This problems occurs when some listing refers to group of elements, not to the individual elements. When a sample of persons or households is required but the list of sampling frame is a list of dwellings. One possible solution is to include all the elements in the selected clusters of the sample. This solution has the benefit of giving the elements the same chance of appearing in the sample as their listings. This also works well for household surveys because most dwelling units contain only one household and this selection reduced fieldwork difficulties. But this "take-all" solution leads to large design effect. Moreover, a contamination of responses within a cluster occurs.

(iii) *Blanks or foreign elements* : This problem occurs when some listing do not relate to elements of survey population. Blanks or foreign elements are listings for elements that no longer exist in the population such as persons who have died or migrated or dwellings that have been demolished or listings for elements that are correctly on the frame but outside the scope of the survey such as unemployed people in a survey of wage earners.

The straightforward way is simply to ignore the selection if a blank is drawn. This will result in reduced sample size. If we substitute the next element on the list when a blank is being sampled as in systematic selection, it will increase the probability of selection for the next element.

(iv) *Duplicated listings:* This problem occurs when some population listings have more than one listings and often arises when a sampling frame is composed of several lists and some elements occur on more than one list.

One obvious way is to remove the duplicates from the whole frame, but often this is not feasible. The second possibility is to get a unique identification associated with each element with one the listing, normally the first oldest listing and treating the other listing for that element as blanks. Since the substantial proportion of the survey cost is incurred in making contact with respondents, it is uneconomical to reject some selections at interviews.

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Non-response

Non-response is an error of non-observation like an coverage error. However, non-response differs from coverage error in that non-response reflects an successful attempt to obtain the desired information from an eligible unit, whereas the coverage error reflect the failure to have the sample unit uniquely defined in the frame.

In most cases, non-response is not evenly spread across the sample units but is concentrated in some groups. As a result of differential non-response, the distribution of the achieved sample across the sub-groups will deviate from that of the selected sample. This deviation is likely to give the non-response bias if the survey variables are also related to the subgroups.

There are two types of non-response: unit non-response and item non-response. Unit non-response implies that no information is obtained from certain sample elements. This may be because respondents cannot be contacted or they refuse to participate in the survey when contacted. The magnitude of unit non-response is indicative of the general acceptability, complexity, organization and management of the survey. Item non-response refers to a situation where for some units the information collected is incomplete. Reasons may be due to refusals and incapacity by respondents or omissions by enumerators. The extent of item non-response is indicative of the complexity, clarity and acceptability of particular items in a questionnaire and the quality of the interviewer work in handling these items.

Reducing non-response

It is important in designing and executing a household survey to develop good survey procedures aimed at increasing response rates, in a bid to minimize response bias. A number of procedures can be used in survey design in an attempt to reduce the number of refusals. For example in face-to-face interviews, interviewers are supposed to be carefully trained in strategies to avoid refusals, and they are to return to conduct an interview at the convenience of the respondent. The objectives and value of the surveys should generally and carefully be explained to respondents so that they can appreciate and cooperate. Assurance of confidentiality can help to alleviate fear respondents may have about the use of their responses for purposes other than those stipulated for the survey.

The following are some of the steps that can be undertaken to reduce non-response on household surveys:

a. *Good frames:* In many developing countries there are problems of locating sample units. This results in some form of non-response error. In such cases it would be helpful to have good frames of both area units and housing listings, to facilitate easy identification of all respondents. In addition, the workloads of enumeration staff should be manageable within the allotted time frame for the survey. This enables them to reach all sample units

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within the assigned cluster or enumeration area. During listing of households, for example, enough auxiliary information should be collected to facilitate distinction and easy location of the sample unit. Whenever, possible enumerators should know the area they work in very well and should preferably be stationed in the assigned work areas.

b. *Interview training, selection and supervision:* In personal interview surveys, the enumerator can play an important role in maximising response from respondents. The way interviewers introduce themselves, what they say about the survey, the identity they carry, and the courtesy they show to respondents matter. In most household surveys the enumerator is the only link between the survey organisation and respondent. It is for this reason that enumerators and their supervisors should be carefully selected, well trained and motivated. Close supervision of enumerator's work and feedback on achieved response rate is of paramount importance.

c. *Follow up of non-responding units:* There should be follow up of non-respondents or make all effort to collect information from a sub-sample of the units who did not respond in the first place. This can be treated as a different stratum, from the responding stratum, in which better enumerators or supervisors may be assigned to interview respondents. The extent of refusals will depend on the subject matter of the survey (sensitive subjects are prone to high refusals), length of and complexity of the questionnaire and skills of the survey team. The not-at-home respondents should be followed up. Depending on the resources and duration of the survey in face-to-face interviews at least four callbacks are recommended. These should be made during different days and different times of the day (villages give example of farming period).

Measurement Error

This type of error arises from the failure of the recorded responses to reflect the true characteristics of the respondents. These errors centre on the content of the survey such as definition of survey objectives, their transformation into questionnaires, obtaining response record responses. These errors concern the accuracy of measurement at the level of the individual unit.

Sources of Measurement Errors

The following are possible general sources of measurement errors.

- The specification problems relating to wrong or misleading definitions and concepts on frame construction and questionnaire design which lead to incomplete coverage and varied interpretations by different interviewers leading to inaccuracies in the collected data
- Inadequate instructions with vague and unclear instructions leave enumerators to use their own judge their own judgment in carrying out field work. Sometimes sample units in the population lack precise definitions resulting in defective frames
- Interviewers record wrong information on some item due to inadequate training

- Age reporting is another common measurement problem through age heaping and digital preference. Depending on the type and nature of enquiry or information, these errors may be due to the interviewer or respondent or both
- Measurement devices may be defective or techniques may be defective and may cause observational errors and due to inadequate supervision of interviewers, inadequately trained and experienced field staff, problems involved in data collection and other type of errors on the part of the respondents arise
- Different procedures of observation on data collection mode (e.g. mail, telephone or in person). Respondents may answer questions differently in the presence of interviewers, over the phone or by themselves
- Respondents also may introduce errors because of the following reasons.
  - o Failure to understand the question
  - o Careless and incorrect answer from the respondent due to lack of understanding the objectives of the survey. The respondents may not give sufficient time to think over the questions
  - o Deliberate inclination to give wrong answers, for example, in surveys dealing with sensitive issues, such as income and stigmatized disease
  - o Memory lapses if there is a large reference period, for example, collecting information on non-durable commodities in expenditure survey

Measurement Error control and assessment

Measurement errors can be due to the cumulative effect from different sources which may be considerable since errors from different sources may not cancel. The net effect of such error can be a large bias. In interview survey , the interview error is major source of error. Three different means to control interviewer errors are—

Training: Many believe that the standardization of the measurement process especially as it relates to interviewers' task leads to decrease in interviewers' effects. Standardization can be achieved through a training program of sufficient length to cover interviewer's skills and techniques as well as information on the specific survey.

Supervision or Monitoring: These are essential ingredients of a quality control system to monitor interviewer performance though monitoring and performance statistics and identify problem questions. Reinterview programs and field observation are conducted to evaluate individual performance.

Workload Manipulation: This way of controlling is from a bias point of view in to change the average workload ; however, interviewer bias increases as average workload increases.

The respondent effect is another major measurement error. Both the traditional models of interviewer process and the cognitive science will play a ro;e on the survey response of the respondent. The five sequential stages in the formulation and provision o answers by survey respondent are Encoding of information, Comprehension of survey question, Retrieval of information from memory, Judgment of appropriate answer and communication of the response. There are many survey processes that can affect the quality of the respondent response.

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Record Check Study A comparison of the survey results for individual sample cases with an external source generally assumed to have the true value for the survey variables. Such studies are used to estimate the response bias resulting from the joint effect of all sources of measurement errors.

Processing Error

Processing error comprise

- editing error
- coding error
- data entry error

Since processing error are often considered part of the administration or operation of the survey, it is often emphasized to use process control techniques and continuous quality management.

While programming errors in survey instruments or other gross errors in preparing data processing systems can occur, it is assumed that adequate review processes are implemented to avoid them.

Editing errors: Editing refers to procedures designed and used for detecting erroneous or questionable survey data with the goal of correcting these as much as possible.

Coding Errors: Some type of pre-edit coding of the survey returns is required before they can be further processed in editing, imputation and summary systems. Item response coding involves coding an actual response for a survey question into a category. This is the case in the industry and occupation coding. The recording of open-ended responses into a category variable by coders who interpret and catalogue each response.

Data Entry errors: These errors occur in the process of transferring collected data to an electronic medium. Quality control mechanisms to ensure the quality of captured data such as double key entry should be put in place to ensure that data entry errors are kept to an absolute minimum.

2.9 Sampling Distribution

In statistics, a sampling distribution is the probability distribution, under repeated sampling of the population, of a given statistic (a numerical quantity calculated from the data values in a sample).

The formula for the sampling distribution depends on the distribution of the population, the statistic being considered, and the sample size used. A more precise formulation would speak of the distribution of the statistic as that for all possible samples of a given size, not just "under repeated sampling".

For example, consider a very large normal population (one that follows the so-called bell curve). Assume we repeatedly take samples of a given size from the population and calculate the sample mean ($\bar{x}$, the arithmetic mean of the data values) for each sample. Different samples will lead to different sample means. The distribution of these means is the "sampling distribution of the sample mean" (for the given sample size). This distribution will be normal since the population ws normal. (According to the central limit theorem, if the population is not normal but *"sufficiently well behaved", the sampling distribution of the sample mean* will still be approximately normal provided the sample size is sufficiently large.)

Thus, the mean of the sampling distribution is equivalent to the expected value of any statistic. For the case where the statistic is the sample mean:

$$\mu_{\bar{x}} = \mu$$

The standard deviation of the sampling distribution of the statistic is referred to as the standard error of that quantity. For the case where the statistic is the sample mean, the standard error is:

$$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$$

where σ is the standard deviation of the population distribution of that quantity and n is the size (number of items) in the sample.

A very important implication of this formula is that you must quadruple the sample size *(4×)* to achieve half *(1/2)* the measurement error. When designing statistical studies where cost is a factor, this may have a factor in understanding cost-benefit tradeoffs.

Alternatively, consider the sample median from the same population. It has a different sampling distribution which is generally not normal (but may be close under certain circumstances).

Sample Questions

1. Differentiate between qualitative and quantitative data.
2. What are relevance of primary and secondary data in research?
3. How is primary data collected for research?
4. What is hypothesis? How is hypothesis tested?
5. Discuss Descriptive and casual research designs.
6. Write a short notes on probability and non-probability sampling.
7. Discuss an acurate sampling method of research.
8. How is sampling and non-sampling errors differentiated?
9. Discuss the sampling distribution method.

UNIT— III

NOTES

PRESENTATION AND ANALYSIS OF DATA

LEARNING OBJECTIVES

3.1 Introduction

In general, most evaluations conducted by local programs would lend themselves to descriptive analysis of data. Descriptive analysis is a way of summarizing and aggregating results from groups. If an evaluation has been conducted which employs a control group, or measures changes in program participants over time, then it might be appropriate to employ inferential analysis in which a decision is made about whether the particular results of the study are "real". More emphasis will be placed on descriptive analysis in this fact sheet.

Verbal Description of Data

Many reports rely on narrative information to present most, if not all, of the necessary information. Narrative information may be presented in three ways: standard writing style; tables; and/or, figures, diagrams, maps, and charts.

Standard writing style, that is, the use of sentences and paragraphs, is often the best way to present information, especially to audiences that are not accustomed to working with charts, graphs, tables, numbers, etc. It is the only way to present information such as examples and explanations. If standard writing style is used to summarize the results of open ended questions ("What do you like most about the program?"), it is often useful to give some indication of how often a particular response was given.

Tables represent narrative or numerical information in tabular fashion. A table arranges information in rows or columns, so that data elements may be referred to easily. They provide a clear and succinct way to present data, and are often more simple and understandable than standard writing style. They also facilitate the interpretation of data.

Figures, diagrams, maps and charts present verbal information visually. They often describe information more clearly than several paragraphs of

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description. Common forms of figures are flow charts; organization charts; GANT charts; and/or maps.

- Flow charts are particularly useful for presenting relationships and/or describing the sequence of events and the location and result of decisions.
- Organization charts are useful for presenting the chain of responsibility in a program.
- GANT charts list a set of tasks. They indicate the time each task is to be performed and by whom.
- Maps visually describe certain geographical areas. They are useful in describing different conditions for individual geographical areas.

Numerical Description of Data

Data are not only described in narrative, they are often described numerically. Three of the most basic types of summarization are:

- frequency distribution;
- percent; and
- average.

Each of these types of summarization may be presented as part of the text or arranged in tables or figures (graphs). Inclusion as part of text ("The average age for children served was 18 months") is an obvious way to report data.

Frequency distribution determines the number of units (e.g., people) which fall into each of a series of specified categories. In order to do a frequency distribution one must have categories. Reporting on age, for example, requires that you group the data first before constructing a frequency distribution (e.g., "birth to 2 years," or "3 to 5 years"). The evaluation might look to see how many parents were members of particular racial or ethnic categories, how many were known to protective services, or how many were referred from a range of referral sources.

Percent is another useful way of describing data. A frequency count can be converted to percent by dividing the number of units for a particular category by the total number of units and multiplying by 100. Percents are often more easily understood than the corresponding frequency counts. Percents can be represented in the same manner as frequency counts. In addition, a pie chart is useful in breaking the total group of people into the percentage of the total represented by each category.

An average is a way of summarizing all of the information into one number. It can be used with data which is non-categorical numerical data. You cannot have a numerical average for gender or race, for example. Using a numerical average is very powerful, but it can also be misleading. A few data points which are very different from the others could substantially change the numerical average. For example, if the ages of children you serve are generally between 1 and 3 years, but you get one child who is 18, the average may be thrown off. Averages can be represented in tables or graphs.

Analysis of Data

The purpose of analysing data is to obtain usable and useful information. The analysis, irrespective of whether the data is qualitative or quantitative, may:

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- describe and summarise the data
- identify relationships between variables
- compare variables
- identify the difference between variables
- forecast outcomes.

Before we look at the various ways of analysing, presenting and discussing data, we need to clarify the differences between qualitative research, quantitative research, qualitative data and quantitative data. Earlier, we distinguished between qualitative research and quantitative research. It is highly unlikely that your research will be purely one or the other – it will probably be a mixture of the two approaches. For instance, you may have taken a small sample (normally associated with qualitative research) but then conducted a structured interview or used a questionnaire (normally associated with quantitative research) to determine people's attitudes to a particular phenomenon (qualitative research). It is therefore likely that your 'mixed' approach will take a qualitative approach some of the time and a quantitative approach at others. It depends on where you are in the research process.

A misconception, and source of confusion for many people, is the belief that qualitative research generates just qualitative data (text, words, opinions, etc) and that quantitative research generates just quantitative data (numbers). Sometimes this is the case, but both types of data can be generated by each approach. For instance, a postal questionnaire or structured 'interview (quantitative research) will often gather factual information, for example, age, salary, length of service (quantitative data) – but may also seek opinions and attitudes (qualitative data).

A second misconception is that statistical techniques are only applicable for quantitative data. Once again, this is not so. There are many statistical techniques that can be applied to qualitative data, such as ratings scales, that has been generated by a quantitative research approach.

Unfortunately, many people are worried about numbers, and in particular about statistics, and everything that word implies. Quantitative research and the analysis of quantitative data is consequently something to be avoided. But as we have indicated above, this is rarely possible because qualitative data can also be analysed using statistics. An understanding of basic statistical terms and ideas and the ability to carry out some statistical analysis (elementary or otherwise) is essential for most researchers. Also competence in these techniques, even at a basic level, is a useful skill in its own right.

A third misconception is that qualitative data analysis is easy. There are many ways of conducting qualitative research and thus many ways of analysing the resulting (qualitative) data. For example, having conducted an interview, transcription and organisation of data are the first stages of analysis. This would then be continued by systematically analysing the transcripts, grouping together comments on similar themes and attempting to interpret them and draw conclusions.

We deal with data that can be analysed statistically (quantitative data and some types of qualitative data) in the section called quantitative data analysis. We cover data that cannot, or is very difficult, to analyse statistically in the section called qualitative data analysis.

Qualitative Data Analysis

Qualitative data is subjective, rich, and in-depth information normally presented in the form of words. In undergraduate dissertations, the most common form of qualitative data is derived from semi-structured or unstructured interviews, although other sources can include observations, life histories and journals and documents of all kinds including newspapers.

Qualitative data from interviews can be analysed for content (content analysis) or for the language used (discourse analysis). Qualitative data is difficult to analyse and often opportunities to achieve high marks are lost because the data is treated casually and without rigour. Here we concentrate on the content analysis of data from interviews.

Theory

When using a quantitative methodology, you are normally testing theory through the testing of a hypothesis. In qualitative research, you are either exploring the application of a theory or model in a different context or are hoping for a theory or a model to emerge from the data. In other words, although you may have some ideas about your topic, you are also looking for ideas, concepts and attitudes often from experts or practitioners in the field.

Collecting and Organising Data

The means of collecting and recording data through interviews and the possible pitfalls are well documented elsewhere but in terms of subsequent analysis, it is essential that you have a complete and accurate record of what was said. Do not rely on your memory (it can be very selective!) and either tape record the conversation (preferably) or take copious notes. If you are taking notes, write them up straight after the interview so that you can elaborate and clarify. If you are using a tape recorder, transcribe the exact words onto paper.

However you record the data, you should end up with a hard copy of either exactly what was said (transcript of tape recording) or nearly exactly what was said (comprehensive notes). It may be that parts of the interview are irrelevent or are more in the nature of background material, in which case you need not put these into your transcript but do make sure that they are indeed unnecessary. You should indicate omissions in the text with short statements.

You should transcribe exactly what is said, with grammatical errors and so on. It does not look very authentic if all your respondents speak with perfect grammar and BBC English! You may also want to indicate other things that happen such as laughter.

Each transcript or set of notes should be clearly marked with the name of the interviewee, the date and place and any other relevant details and, where appropriate, cross-referenced to clearly labelled tapes. These transcripts and notes

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are not normally required to be included in your dissertation but they should be available to show your supervisor and the second marker if required.

You may wonder why you should go to all the bother of transcribing your audiotapes. It is certainly a time-consuming business, although much easier if you can get access to a transcription machine that enables you to start and stop the tape with your feet while carrying on typing. It is even easier if you have access to an audio-typist who will do this labour intensive part for you. The advantage of having the interviews etc. in hard copy is that you can refer to them very quickly, make notes in the margins, re-organise them for analysis, make coding notations in the margins and so on. It is much slower in the long run to have to continually listen to the tapes. You can read much faster than the tape will play! It also has the advantage, especially if you do the transcription yourself, of ensuring that you are very familiar with the material.

Content Analysis

Analysis of qualitative data is not simple, and although it does not require complicated statistical techniques of quantitative analysis, it is nonetheless difficult to handle the usually large amounts of data in a thorough, systematic and relevant manner. Marshall and Rossman offer this graphic description:

> "Data analysis is the process of bringing order, structure and meaning to the mass of collected data. It is a messy, ambiguous, time-consuming, creative, and fascinating process. It does not proceed in a linear fashion; it is not neat. Qualitative data analysis is a search for general statements about relationships among categories of data."— Marshall and Rossman,

Hitchcock and Hughes take this one step further:

> "...the ways in which the researcher moves from a description of what is the case to an explanation of why what is the case is the case."

Content analysis consists of reading and re-reading the transcripts looking for similarities and differences in order to find themes and to develop categories. Having the full transcript is essential to make sure that you do not leave out anything of importance by only selecting material that fits your own ideas. There are various ways that you can mark the text:

Coding paragraphs – This is where you mark each paragraph with a topic/theme/category with an appropriate word in the margin.

Highlighting paragraphs/sentences/phrases – This is where you use highlighter pens of different colours or different coloured pens to mark bits about the different themes. Using the example above, you could mark the bits relating to childcare and those relating to pay in a different colour, and so on. The use of coloured pens will help you find the relevant bits you need when you are writing up.

With both the above methods you may find that your categories change and develop as you do the analysis. What is important is that you can see that by analysing the text in such a way, you pick up all the references to a given topic and don't leave anything out. This increases the objectivity and reduces the risk of you only selecting bits that conform to your own preconceptions.

You then need to arrange the data so that all the pieces on one theme are together. There are several ways of doing this:

Cut and put in folders approach

Make several copies of each transcript (keeping the master safe) and cut up each one according to what is being discussed (your themes or categories). Then sort them into folders, one for each category, so that you have all together what each interviewee said about a given theme. You can then compare and look for similarities/differences/conclusions etc. Do not forget to mark each slip of paper with the respondent's name, initials or some sort of code or you won't be able to remember who said what. Several copies may be needed in case one paragraph contains more than one theme or category. This is time consuming and messy at first, but easier in the long run especially if you have a lot of data and categories.

Card index system

Each transcript must be marked with line numbers for cross-referencing purposes. You have a card for each theme or category and cross-reference each card with each transcript so that you can find what everyone has said about a certain topic. This is quicker initially but involves a lot of referring back to the original transcripts when you write up your results and is usually only suitable for small amounts of data.

Computer analysis

If you have access to a computer package that analyses qualitative data (e.g. NUDIST) then you can use this. These vary in the way they work but these are some of the basic common principles. You can upload your transcripts created in a compatible word-processing package and then the software allows you to mark different sections with various headings/themes. It will then sort all those sections marked with a particular heading and print them off together. This is the electronic version of the folders approach! It is also possible to use a word-processing package to cut and paste comments and to search for particular words.

There is a great danger of subjective interpretation. You must accurately reflect the views of the interviewees and be thorough and methodical. You need to become familiar with your data. You may find this a daunting and stressful task or you may really enjoy it sometimes so much that you can delay getting down to the next stage which is interpreting and writing up!

Presenting qualitative data in your dissertation

This would normally follow the topics, themes and categories that you have developed in the analysis and these, in turn, are likely to have been themes that came out in the literature and may have formed the basis for your interview questions. It is usually a mistake to go through each interviewee in turn and what they said on each topic. This is cumbersome and does not give the scope to compare and contrast their ideas with the ideas of others.

Do not analyse the data on a question-by-question basis. You should summarise the key themes that emerge from the data and may give selected quotes if these are particularly appropriate.

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By presenting we mean a factual description/summary of what you found. The discussion element is your interpretation of what these findings mean and how they confirm or contradict what you wrote about in your literature section.

If you are trying to test a model then this will have been explored in your literature review and your methodology section will explain how you intend to test it. Your methodology should include who was interviewed with a clear rationale for your choices to explain how this fits into your research questions, how you ensured that the data was unbiased and as accurate as possible, and how the data was analysed. If you have been able to present an adapted model appropriate to your particular context then this should come towards the end of your findings section.

It may be desirable to put a small number of transcripts in the appendices but discuss this with your supervisor. Remember you have to present accurately what was said and what you think it means.

In order to write up your methodology section, you are strongly recommended to do some reading in research textbooks on interview techniques and the analysis of qualitative data. There are some suggested texts in the Further Reading section at the end of this pack.

Quantitative Data Analysis

Here we are concerned with the basics of statistical analysis. However, we do not cover the techniques in detail but provide a brief overview. If you are unsure of these or have forgotten them, you should refer to your notes from previous studies or consult introductory statistics textbooks. We begin by looking at some basic ideas about analysis and presentation of data. These are 'variables' and the related idea of 'scales of measurement'.

Variables

Constant reference is made in statistics textbooks to the term variable. A variable is a characteristic of interest that varies from one item to another and may take any one of a specified set of values or attributes. Variables are usually classified as quantitative or qualitative. For example, consider a study of guests at a hotel. We may be interested in the age of a guest, their spend and length of stay. Each characteristic is a quantitative variable because the data that each generates is numerical – for instance, a guest may be 34 years of age, spend £500 and stay for seven days. Quantitative variables generate quantitative data.

On the other hand, qualitative variables generate non-numerical or qualitative data. For instance, 'nationality of hotel guest' is a qualitative variable because nationality can be classified as British, American, French, etc.

Scales of measurement

Many people are confused about what type of analysis to use on a set of data and the relevant forms of pictorial presentation or data display. The decision is based on the scale of measurement of the data. These scales are nominal, ordinal and numerical. (Strictly numerical can be sub-divided into interval and ratio – however, we do not draw that distinction here.)

Nominal scale

A nominal scale is where:

- the data can be classified into a non-numerical or named categories, and
- the order in which these categories can be written or asked is arbitrary.

Ordinal scale

An ordinal scale is where:

- the data can be classified into non-numerical or named categories
- an inherent order exists among the response categories.

Ordinal scales are seen in questions that call for ratings of quality (for example, very good, good, fair, poor, very poor) and agreement (for example, strongly agree, agree, disagree, strongly disagree).

Numerical scale

A numerical scale is:

- where numbers represent the possible response categories
- there is a natural ranking of the categories
- zero on the scale has meaning
- there is a quantifiable difference within categories and between consecutive categories.

Organising the data

Once you have collected the raw data, you need to organise it. This is a two-stage process:

1. The first step is to tabulate all the responses to each question for each respondent in a data sheet using the coded values. It is advisable to construct this on a spreadsheet.
2. The second step is to construct a summary sheet.

This summary sheet will be an amended version of the original question sheet (either questionnaire or interview schedule) and contains:

- a brief overview of the data collection process, including:
  - data collection method
  - sample size and sampling method
  - number of responses
  - geographical coverage
  - time frame for data collection
- a count for each response alongside each question
- the percentage equivalents.

3.2 Classification, Tabulation and Graphical Representation of Data

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Data refers to information or facts usually collected as the result of experience, observation or experiment or premises. Data may consist of numbers, words, or images, particularly as measurements or observations of a set of variables. Data are often viewed as a lowest level of abstraction from which information and knowledge are derived.

You might be reading a newspaper regularly. Almost every newspaper gives the minimum and the maximum temperatures recorded in the city on the previous day. It also indicates the rainfall recorded, and the time of sunrise and sunset. In your school, you regularly take attendance of children and record it in a register. For a patient, the doctor advises recording of the body temperature of the patient at regular intervals.

If you record the minimum and maximum temperature, or rainfall, or the time of sunrise and sunset, or attendance of children, or the body temperature of the patient, over a period of time, what you are recording is known as data. Here, you are recording the data of minimum and maximum temperature of the city, data of rainfall, data for the time of sunrise and sunset, and the data pertaining to the attendance of children.

As an example, the class-wise attendance of students, in a school, is as recorded in *Table 3.1*.

Table 3.1 Class-wise Attendance of Students

Class	No. of Students Present
VI	42
VII	40
VIII	41
IX	35
X	36
XI	32
XI1	30
Total	256

Table 3.1 gives the data for class-wise attendance of students. Here the data comprise 7 observations in all. These observations are, attendance for class VI, VII, and so on. So, data refers to the set of observations, values, elements or objects hder consideration.

The complete set of all possible elements or objects is called a population. Each of the elements is called a piece of data. Data also refers to the known facts or things used as basis for inference or reckoning facts, information, material to be processed or stored.

Nature of Data

For understanding the nature of data, it becomes necessary to study about the various forms of data, as shown below :

- Qualitative and Quantitative Data
- Continuous and Discrete Data
- Primary and Secondary Data

Qualitative and Quantitative Data

Let us consider a set of data given in *Table 3.2.*

Table 3.2 Management-wise Number of Schools

Management	No. of Schools
Government	4
Local Body	8
Private Aided	10
Private Unaided	2
Total	24

In *Table 3.2,* number of schools have been shown according to the management of schools. So the schools have been classified into 4 categories, namely, Government Schools, Local Body Schools, Private Aided Schools and Private Unaided Schools. A given school belongs to any one of the four categories. Such data is shown as Categorical or Qualitative Data. Here the category or the quality referred to is management. Thus categorical or qualitative data result from information which has been classified into categories. Such categories are listed alphabetically or in order of decreasing frequencies or in some other conventional way. Each piece of data clearly belongs to one classification or category.

We frequently come across categorical or qualitative data in the form of schools categorised according to Boys, Girls and Co-educational; Students' Enrolment categorised according to SC, ST, OBC and 'Others'; number of persons employed in various categories of occupations, and so on.

Let us consider another set of data given in *Table 3.3.*

Table 3.3 Number of Schools according to Enrolment

Enrolment	No. of Schools
Upto 50	6
51 - 100	15
101 - 200	12
201 - 300	8
Above 300	4
Total	45

In *Table 3.3,* number of schools have been shown according to the enrolment of students in the school. Schools with enrolment varying in a specified range are grouped together, e.g. there are 15 schools where the students enrolled are any number between 51 and 100. As the grouping is based on numbers, such data are called Numerical or Quantitative Data. Thus, numerical or quantitative data result from counting or measuring. We frequently come across numerical data in newspapers, advertisements etc. related to the temperature of the cities, cricket averages, incomes, expenditures and so on.

Continuous and Discrete Data

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Numerical or quantitative data may be continuous or discrete depending on the nature of the elements or objects being observed.

Let us consider the *Table 3.4* depicting the heights of students of a class.

Table 3.4 Heights of Students of a Class

Height	No. of Students
4'8"- 4' 10"	2
4'10" - 5'0"	2
5'0" - 5'2"	5
5'2" - 5'4"	8
5'4" - 5'6"	12
5'6" - 5'8"	10
5'8"- 5'10"	2
Total	41

Table 3.4 gives the data pertaining to the heights of students of a class. Here the element under observation is the height of the students. The height varies from 4' 8" to 5' 10". The height of an individual may be anywhere from 4' 8" to 5'10". Two students may vary by almost zero inch height. Even if we take two adjacent points, say 4' 8.00" and 4' 8.01" there may be several values between the two points. Such data are called Continuous Data, as the height is continuous. Continuous Data arise from the measurement of continuous attributes or variables, in which individual may differ by amounts just approaching zero. Weights and heights of children; temperature of a body; intelligence and achievement level of students, etc. are the examples of continuous data.

Let us consider *Table* 3.3 showing the number of students enrolled and the number of schools according to enrolment. Let us, consider the enrolment of 2 schools as 60 and 61. Now in between 60 and 61, there cannot be any number, as the enrolment will always be in whole numbers. Thus there is a gap of one unit from 60 to 61. Such data, where the elements being observed have gaps are called Discrete Data.

Discrete Data are characterised by, gaps in the scale, for which no real values may ever be found. Such data are usually expressed in whole numbers. The size of a family, enrolment of children, number of books etc. are the examples of discrete data. Generally data arising from measurement are continuous, while data arising from counting or arbitrary classification are discrete.

The achievement scores of students, though presented in discrete form may be considered to constitute continuous data, since a score of 24 represents any point between 23.5 and 24.5. Actually achievement is a continuous attribute or variable.

All measurements of continuous attributes are approximate in character and as such do not provide a basis for distinguishing between continuous and discrete data. The distinction is made on the basis of variable being measured. 'Height' is a continuous variable but number of children would give discrete data.

Primary and Secondary Data

The data collected by or on behalf of the person or people who are going to make use of the data refers to primary data. For example, the attendance of children, the result of examinations conducted by you are primary data. If you contact the parents of the children and ask about their educational qualifications to relate them to the performance of the children, this also gives primary data. Actually, when an individual personally collects data or information pertaining to an event, a definite plan or design, it refers to primary data.

Sometimes an investigator may use the data already collected by you, such as the school attendance of children, or performance of students in various subjects. etc, for his/her study, then the data are secondary data. The data used by a person or people other than the people by whom or for whom the data were collected refers to secondary data. For many reasons we may have to use secondary data, which should be used carefully, since the data could have beeb collected with a purpose different from that of the investigator and may lose some detail or may not be fully relevant. For using secondary data, it is always useful to know :

(a) how the data have been collected and processed;

(b) the accuracy of data;

(c) how far the data have been summarised;

(d) how comparable the data are with other tabulations; and

(e) how to interpret the data, especially when figures collected for one purpose are used for another purpose.

Secondary Data

In research, Secondary data is collecting and possibly processing data by people other than the researcher in question. Common sources of secondary data for social science include censuses, large surveys, and organizational records. In sociology primary data is data you have collected yourself and secondary data is data you have gathered from primary sources to create new research. In terms of historical research, these two terms have different meanings. A primary source is a book or set of archival records. A secondary source is a summary of a book or set of records.

Advantages to the secondary data collection method are— (1) it saves time that would otherwise be spent collecting data, (2) provides a larger database (usually) than what would be possible to collect on ones own However there are disadvantages to the fact that the researcher cannot personally check the data so it's reliability may be questioned.

Secondary data analysis

There are two different types of sources that need to be established in order to conduct a good analysis. The first type is a primary source which is the initial material that is collected during the research process. Primary data is the data that the researcher is collecting themselves using methods such as surveys,direct observations, interviews, as well as logs(objective data sources). Primary data is a reliable way to collect data because the researcher will know where it came from and how it was collected and analyzed since they did it themselves. Secondary sources on the other hand are sources that are based upon the data that was collected from the primary source. Secondary sources take the role of analyzing, explaining, and combining the information from the primary source with additional information.

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Secondary data analysis is commonly known as second-hand analysis. It is simply the analysis of preexisting data in a different way or to answer a different question than originally intended. Secondary data analysis utilizes the data that was collected by someone else in order to further a study that you are interested in completing.

In contrast to secondary data, primary data comes from observations made by the researchers themselves. This often creates credibility issues that do not arise with secondary data.

Tabulation and Presentation of Data

The collected data must be arranged, tabulated, and presented to permit ready and meaningful analysis and interpretation. To study and interpret the examination-grade distribution in a class of 30 pupils, for instance, the grades are arranged in ascending order: 30, 35, 43, 52, 61, 65, 65, 65, 68, 70, 72, 72, 73, 75, 75, 76, 77, 78, 78, 80, 83, 85, 88, 88, 90, 91, 96, 97, 100, 100. This progression shows at a glance that the maximum is 100, the minimum 30, and the range, or difference, between the maximum and minimum is 70.

In a cumulative-frequency graph, such as *Fig. 1*, the grades are marked on the horizontal axis and double marked on the vertical axis with the cumulative number of the grades on the left and the corresponding percentage of the total number on the right. Each dot represents the accumulated number of students who have attained a particular grade or less. For example, the dot A corresponds to the second 72; reading on the vertical axis, it is evident that there are 12, or 40 percent, of the grades equal to or less than 72.

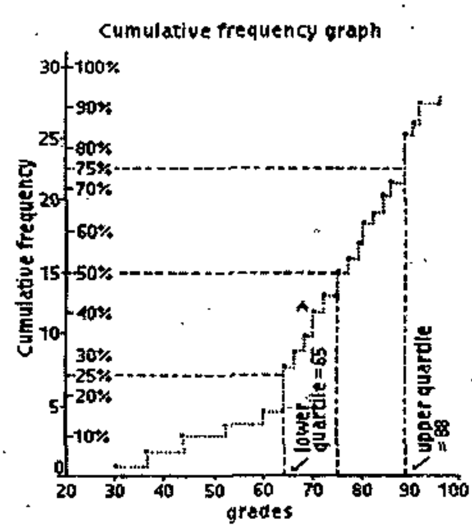

Figure 1

In analyzing the grades received by 10 sections of 30 pupils each on four examinations, a total of 1200 grades, the amount of data is too large to be exhibited

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conveniently as in *Fig. 1*. The statistician separates the data into suitably chosen groups, or intervals. For example, ten intervals might be used to tabulate the 1200 grades, as in column (a) of the accompanying frequency-distribution table; the actual number in an interval, called the frequency of the interval, is entered in column (c). The numbers that define the interval range are called the interval boundaries. It is convenient to choose the interval boundaries so that the interval ranges are equal to each other; the interval midpoints, half the sum of the interval boundaries, are simple numbers, because they are used in many calculations. A grade such as 87 will be tallied in the 80-90 interval; a boundary grade such as 90 may be tallied uniformly throughout the groups in either the lower or upper intervals. The relative frequency, column (d), is the ratio of the frequency of an interval to the total count; the relative frequency is multiplied by 100 to obtain the percent relative frequency. The cumulative frequency, column (e), represents the number of students receiving grades equal to or less than the range in each succeeding interval; thus, the number of students with grades of 30 or less is obtained by adding the frequencies in column (c) for the first three intervals, which total 53. The cumulative relative frequency, column (f), is the ratio of the cumulative frequency to the total number of grades.

Frequency histogram for grades listed in frequency-distribution table.

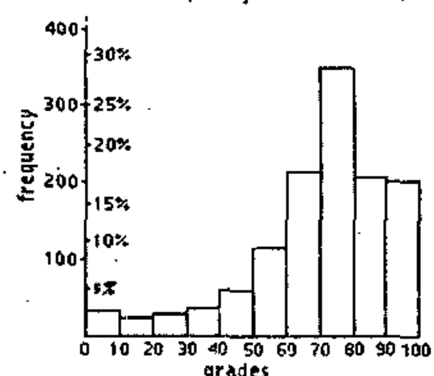

Figure 2

Cumulative frequency polygon for grades listed in frequency-distribution table.

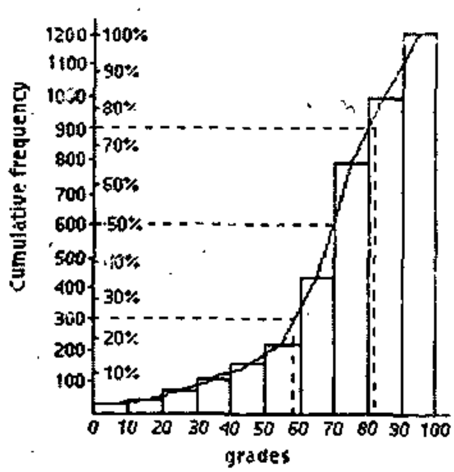

Figure 3

The data of a frequency-distribution table can be presented graphically in a frequency histogram, as in *Fig. 2*, or a cumulative frequency polygon, as in *Fig. 3*. The histogram is a series of rectangles with bases equal to the interval ranges and areas proportional to the frequencies. The polygon in *Fig. 3* is drawn by connecting with straight lines the interval midpoints of a cumulative frequency histogram.

Newspapers and other printed media frequently present statistical data pictorially by using different lengths or sizes of various symbols to indicate different values.

Graphical Representation

Most people show lack of interest or have no time to go through facts and figures given in a daily newspaper or a magazine. But if these figures are graphically presented, they become easier to grasp and catch the eye and have a more lasting effect on the reader's mind. The graphical representation of data makes the reading more interesting, less time-consuming and easily understandable. The disadvantage of graphical presentation is that it lacks details and is less accurate. In our study, we have the following graphs:

1. Bar Graphs
2. Pie Charts
3. Frequency Polygon
4. Histogram

Bar Graphs

This is the simplest type of graphical presentation of data. The following types of bar graphs are possible:— (a) Simple bar graph (b) Double bar graph (c) Divided bar graph.

Pie Charts

Sometimes a circle is used to represent a given data. The various parts of it are proportionally represented by sectors of the circle. Then the graph is called a Pie Graph or Pie Chart.

Frequency Polygon

In a frequency distribution, the mid-value of each class is obtained. Then on the graph paper, the frequency is plotted against the corresponding mid-value. These points are joined by straight lines. These straight lines may be extended in both directions to meet the X-axis to form a polygon.

Histogram

A two dimensional frequency density diagram is called a histogram. A histogram is a diagram which represents the class interval and frequency in the form of a rectangle.

3.3 Statistical Technique

Statistical methods can be used to summarize or describe a collection of data; this is called descriptive statistics. In addition, patterns in the data may be modeled in a way that accounts for randomness and uncertainty in the

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observations, and are then used to draw inferences about the process or population being studied; this is called inferential statistics. Descriptive, and inferential statistics (predictive statistics) comprise applied statistics.

There is also a discipline called mathematical statistics, which is concerned with the theoretical basis of the subject. Moreover, there is a branch of statistics called exact statistics that is based on exact probability statements.

In applying statistics to a scientific, industrial, or societal problem, it is necessary to begin with a process or population to be studied. This might be a population of people in a country, of crystal grains in a rock, or of goods manufactured by a particular factory during a given period. It may instead be a process observed at various times; data collected about this kind of "population" constitute what is called a time series.

For practical reasons, rather than compiling data about an entire population, a chosen subset of the population, called a sample, is studied. Data are collected about the sample in an observational or experimental setting. The data are then subjected to statistical analysis, which serves two related purposes: description and inference.

- *Descriptive statistics can be used to summarize the data, either numerically* or graphically, to describe the sample. Examples of numerical descriptors include the mean and standard deviation for continuous data, such as height, and frequency and percentage for categorical data, such as race.
- Inferential statistics is used to model patterns in the data, accounting for randomness and drawing inferences about the larger population. These *inferences may take the form of answers to yes/no questions (hypothesis* testing), estimates of numerical characteristics (estimation), descriptions of association (correlation), or modeling of relationships (regression). Other modeling techniques include ANOVA, time series, and data mining.

Some well known statistical tests and procedures are:

- Analysis of variance (ANOVA)
- Chi-square test
- Correlation
- Factor Analysis
- Mann-Whitney U
- Mean Square Weighted Deviation MSWD
- Pearson product-moment correlation coefficient
- Regression analysis
- Spearman's rank correlation coefficient
- Student's t-test
- Time Series Analysis

Chi-square Test

"Chi-square test" is often shorthand for Pearson's chi-square test.

A chi-square test (also chi-squared or χ^2 test) is any statistical hypothesis test in which the test statistic has a chi-square distribution when the null hypothesis is true, or any in which the probability distribution of the test statistic

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(assuming the null hypothesis is true) can be made to approximate a chi-square distribution as closely as desired by making the sample size large enough.

Some examples of chi-squared tests where the chi-square distribution is only approximately valid:

- Pearson's chi-square test, also known as the chi-square goodness-of-fit test or chi-square test for independence, When mentioned without any modifiers or without other precluding context, this test is usually understood.
- Yates' chi-square test, also known as Yates' correction for continuity.
- Mantel-Haenszel chi-square test.
- Linear-by-linear association chi-square test.
- The portmanteau test in time-series analysis, testing for the presence of autocorrelation
- Likelihood-ratio tests in general statistical modelling, for testing whether there is evidence of the need to move from a simple model to a more complicated one (where the simple model is nested within the complicated one).

One case where the distribution of the test statistic is an exact chi-square distribution is the test that the variance of a normally-distributed population has a given value based on a sample variance. Such a test is uncommon in practice because values of variances to test against are seldom known exactly.

If a sample of size n is taken from a population having a normal distribution, then there is a well-known result (see distribution of the sample variance) which allows a test to be made of whether the variance of the population has a pre-determined value. For example, a manufacturing process might have been in stable condition for a long period, allowing a value for the variance to be determined essentially without error. Suppose that a variant of the process is being tested, giving rise to a small sample of product items whose variation is to be tested. The test statistic T in this instance could be set to be the sum of squares about the sample mean, divided by the nominal value for the variance (ie. the value to be tested as holding). Then T has a chi-square distribution with *n–1 degrees of freedom*. For example if the sample size is 21, the acceptance region for T for a significance level of 5% is the interval 9.59 to 34.17.

T-test

A *t-test* is any statistical hypothesis test in which the test statistic has a Student's *t-distribution* if the null hypothesis is true. It is applied when the population is assumed to be normally distributed but the sample sizes are small enough that the statistic on which inference is based is not normally distributed because it relies on an uncertain estimate of standard deviation rather than on a precisely known value.

History

The *t-statistic* was introduced in 1908 by William Sealy Gosset, a statistician working for the Guinness brewery in Dublin, Ireland ("Student" was his pen name). Gosset had been hired due to Claude Guinness's innovative policy of recruiting the best graduates from Oxford and Cambridge to apply biochemistry and statistics to Guinness' industrial processes. Gosset devised the *t-test* as a way to cheaply monitor the quality of stout. He published the test in Biometrika in 1908, but was forced to use a pen name by his employer, who regarded the fact that they were using statistics as a trade secret. In fact, Gosset's identity was known to fellow statisticians.

Today, the *t-test* is more generally applied to the confidence that can be placed in judgments made from small samples.

Uses

Among the most frequently used *t-tests* are:

- A test of whether the mean of a normally distributed population has a value specified in a null hypothesis.
- A test of the null hypothesis that the means of two normally distributed populations are equal. Given two data sets, each characterized by its mean, standard—deviation and number of data points, we can use some kind of *t-test* to determine whether the means are distinct, provided that the underlying distributions can be assumed to be normal. All such tests are usually called Student's t tests, though strictly speaking that name should only be used if the variances of the two populations are also assumed to be equal; the form of the test used when this assumption is dropped is sometimes called Welch's t test. There are different versions of the *t-test* depending on whether the two samples are
  - o unpaired, independent of each other (e.g., individuals randomly assigned into two groups, measured after an intervention and compared with the other group), or
  - o paired, so that each member of one sample has a unique relationship with a particular member of the other sample (e.g., the same people measured before and after an intervention).

If the calculated *p-value* is below the threshold chosen for statistical significance (usually the 0.10, the 0.05, or 0.01 level), then the null hypothesis which usually states that the two groups do not differ is rejected in favor of an alternative hypothesis, which typically states that the groups do differ.

- A test of whether the slope of a regression line differs significantly from 0.

Once a *t-value* is determined, a *p-value* can be found using a table of values from Student's *t-distribution*.

Assumptions

- Normal distribution of data (which can be tested by using a normality test, such as the *Shapiro-Wilk and Kolmogorov-Smirnov tests*).
- Equality of variances (which can be tested by using the F test, the more robust Levene's test, Bartlett's test, or the Brown-Forsythe test).

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- Samples may be independent or dependent, depending on the hypothesis and the type of samples:
  - o Independent samples are usually two randomly selected groups
  - o Dependent samples are either two groups matched on some variable (for example, age) or are the same people being tested twice (called repeated measures)

Since all calculations are done subject to the null hypothesis, it may be very difficult to come up with a reasonable null hypothesis that accounts for equal means in the presence of unequal variances. In the usual case, the null hypothesis is that the different treatments have no effect — this makes unequal variances untenable. In this case, one should forgo the ease of using this variant afforded by the statistical packages. See also Behrens–Fisher problem.

One scenario in which it would be plausible to have equal means but unequal variances is when the 'samples' represent repeated measurements of a single quantity, taken using two different methods. If systematic error is negligible (e.g. due to appropriate calibration) the effective population means for the two measurement methods are equal, but they may still have different levels of precision and hence different variances.

Determining type

For novices, the most difficult issue is often whether the samples are independent or dependent. Independent samples typically consist of two groups with no relationship. Dependent samples typically consist of a matched sample (or a "paired" sample) or one group that has been tested twice (repeated measures).

Dependent *t-tests* are also used for matched-paired samples, where two groups are matched on a particular variable. For example, if we examined the heights of men and women in a relationship, the two groups are matched on relationship status. This would call for a dependent *t-test* because it is a paired sample (one man paired with one woman). Alternatively, we might recruit 100 men and 100 women, with no relationship between any particular man and any particular woman; in this case we would use an independent samples test.

Another example of a matched sample would be to take two groups of students, match each student in one group with a student in the other group based on an achievement test result, then examine how much each student reads. An example pair might be two students that score 90 and 91 or two students that scored 45 and 40 on the same test. The hypothesis would be that students that did well on the test may or may not read more. Alternatively, we might recruit students with low scores and students with high scores in two groups and assess their reading amounts independently.

An example of a repeated measures t-test would be if one group were pre- and post-tested. (This example occurs in education quite frequently.) If a teacher wanted to examine the effect of a new set of textbooks on student achievement, (s)he could test the class at the beginning of the year (pretest) and at the end of the year (posttest). A dependent *t-test* would be used, treating the pretest and posttest as matched variables (matched by student).

Measurement of Central Tendency and Variability

Central tendency is defined as the central point around which data revolve. There are three measures of central tendency and each one plays a different role in determining where the center of the distribution or the average score lies. First, the mean is often referred to as the statistical average. To determine the mean of a distribution, all of the scores are added together and the sum is then divided by the number of scores. The mean is the preferred measure of central tendency because it is used more frequently in advanced statistical procedures, however, it is also the most susceptible to extreme scores. For example, if the scores '8' '9' and '10' were added together and divided by '3', the mean would equal '9'. If the 10 was changed to 100, making it an extreme score, the mean would change drastically. The new mean of '8' '9' and '100' would be '39.'

The median is another method for determining central tendency and is the preferred method for highly skewed distributions. The media is simply the middle most occurring score. For an even number of scores there will be two middle numbers and these are simply added together and divided by two in order to determine the median. Using the same distribution as above, the scores '8' '9' and '10' would have a median of 9. By changing the '10' to a score of '100' you'll notice that the median of this new positively skewed distribution does not change. The median remains equal to '9.' Finally, the mode is the least used measure of central tendency. The mode is simply the most frequently occurring score. For distributions that have several peaks, the mode may be the preferred measure. There is no limit to the number of modes in a distribution. If two scores tie as the most frequently occurring score, the distribution would be considered bimodal. Three would be trimodal, and all distributions with two or more modes would be considered multimodal distributions.

Measures of Central Tendency—

$\bar{X} = \epsilon X / N$

M_d= *Middle score*

M_o= *Most frequent score*

1+3+8+8+10=30

Mean= 30/5=6

Median= 8

Mode= 8

Interestingly, in a perfectly normal distribution, the mean, median, and mode are exactly the same. As the skew of the distribution increases, the mean and median begin to get pulled toward the extreme scores. The mean gets pulled the most which is why it becomes less valid the more skewed the distribution. The median gets pulled a little and the mode typically remains the same. You can often tell how skewed a distribution is by the distance between these three measures of central tendency.

NOTES

Measures of Variability

Variability refers to how spread apart the scores of the distribution are or how much the scores vary from each other. There are four major measures of variability, including the range, interquartile range, variance, and standard deviation. The range represents the difference between the highest and lowest score in a distribution. It is rarely used because it considers only the two extreme scores. The interquartile range, on the other hand, measures the difference between the outermost scores in only the middle fifty percent of the scores. In other words, to determine the interquartile range, the score at the 25th percentile is subtracted from the score at the 75th percentile, representing the range of the middle 50 percent of scores.

The variance is the average of the squared differences of each score from the mean. To calculate the variance, the difference between each score and the mean is squared and then added together. This sum is then divided by the number of scores minus one. When the square root is taken of the variance we call this new statistic the standard deviation. Since the variance represents the squared differences, the standard deviation represents the true differences and is therefore easier to interpret and much more commonly used. Since the standard deviation relies on the mean of the distribution, however, it is also affected by extreme scores in a skewed distribution.

Statistical Estimation

Given the distribution of a variable in a population, we obtain the results about the distributions of various quantities, such as the mean and variance, calculated from sample observations. Such a quantity is called a statistic. These results are of direct interest in the planning of sampling enquires, as they enable the investigator to estimate the precision attainable with a sample of a given size, and hence help him to decide how large a sample should be taken.

When the sample has been taken , what sort of inferences can be drawn about the population, on the basis of the sample? We donot know the characteristics of the population. We have taken one random sample and wish to use our knowledge of sampling theory to make whatever inference can be made about the population.

One fundamental difficulty usually arises. The expressions of sampling variation given by the various formulae for standard errors or variances usually involve some parameters of the population. For instance, the standard error of the sample mean is /n. If we are attempting to make an inference about a normal distribution on the basis of one random sample, we shall know the sample size, n, but not the population standard deviation, . We cannot, therefore, calculate the standard error exactly.

Testing hypotheses is actually making a decision between two hypotheses H_0 and H_1. In decision making, we can calculate two kinds of errors in decision: accept H_1 when H_0 is correct, or accept H_0 when H_1 is correct. From this, we can draw the following table.

NOTES

Select	True H_0	H_1
H_0	OK	β
H_1	p or α	OK

Here p or is probability to make error to select H_1 when H_0 is correct, and β is probability make error to select H_0 when H_1 is correct. We are mainly interested in *p*.

Example 1

A researcher claim that the mean of the *IQ for students is 110* and the expected value for all population is *100*, with the standard deviation of *10*. Here we can test the nullhypotheses

$$H_0: \mu_0 = 100$$

against the alternative hypotheses

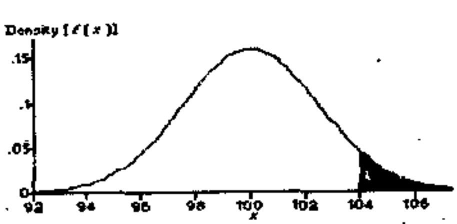
$$H_1: \mu_1 = 110.$$

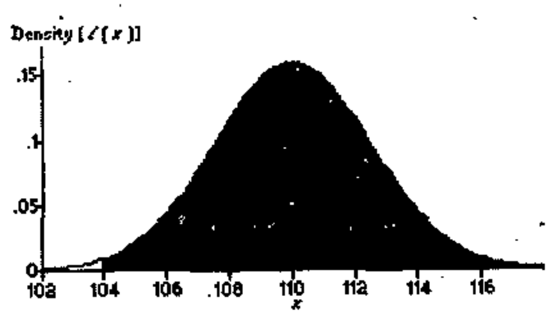
If the nullhypotheses is correct, the *IQ* is $N(100, 10^2)$-distributed. If the alternative hypothese is correct, the *IQ* is $N(110, 10^2)$-distributed. The sample distribution of the mean in sample size $n = 16$ *for* H_0 is $N(100, 10^2/16)$ and for H_1 $N(110, 10^2/16)$.

If we make the conclusion with $p < 0.05$, we can calculate the cut point *c*. If the mean from the sample is greater the *c*, we reject H_0. If the mean is smaller than c, we accept H_0. Because the continuos distribution has no probabilities for the exact values, we can calculate *c* from following formulas:

$$For\ H_0: P(\bar{X}_n > c) = 0.05 \Leftrightarrow \Phi\left(\frac{c-100}{10/\sqrt{16}}\right) = 0.95 \Rightarrow \frac{c-100}{10/\sqrt{16}} = 1.645 \Rightarrow c \approx 104$$

$$For\ H_1: \beta = p(\bar{X}_1 < 104) = \Phi\left(\frac{104-110}{10/\sqrt{16}}\right) = 1-\Phi(2.4) \approx 0.009$$





NOTES

Here p (or α) is the significance (probability) that the sample mean is from the population, where $\mu = 100$. It is understood also as a probability to make a wrong conclusion, when we reject the nullhypotheses. The β is the risk (probability) that we take to make a wrong conclusion, when we accept the nullhypotheses. Instead of β is $1-\beta$ often used, and it is called as the power of the test (here 0.991).The probabilities can be seen in the *fig 4*:

From the previous formulas, we can see the effect of the sample size. When sample size increases, the standard error of the mean decreases and we get smaller p-values and larger power for the test. We can also calculate the required number of cases *(n)*, if we know the clinically relevant difference $(\mu_0 - \mu_1)$, the standard deviation of the variable (σ), the significance level $(p = 0.05)$ and the power of the test ($1-\beta$), that will be required. That is not very practical way to define the sample size, but it shows the dependency between significance, test power, sample size, required difference and deviation.

Interval Estimation

In statistics, interval estimation is the use of sample data to calculate an interval of possible (or probable) values of an unknown population parameter, in contrast to point estimation, which is a single number. Neyman (1937) identified interval estimation ("estimation by interval") as distinct from point estimation ("estimation by unique estimate"). In doing so, he recognised that then-recent work quoting results in the form of an estimate plus-or-minus a standard deviation indicated that interval estimation was actually the problem statisticians really had in mind.

The most prevalent forms of interval estimation are:

- confidence intervals (a frequentist method); and
- credible intervals (a Bayesian method).

Other common approaches to interval estimation, which are encompassed by statistical theory, are:

- Tolerance intervals
- Prediction intervals - used mainly in Regression Analysis

There is a third approach to statistical inference, namely fiducial inference, that also considers interval estimation. Non-statistical methods that can lead to interval estimates include fuzzy logic.

An interval estimate is one type of outcome of a statistical analysis. Some other types of outcome are point estimates and decisions.

Discussion

The scientific problems associated with interval estimation may be summarised as follows:

- When interval estimates are reported, they should have a commonly-held interpretation in the scientific community and more widely. In this regard, credible intervals are held to be most readily understood by the general public. Interval estimates derived from fuzzy logic have much more application-specific meanings.

- For commonly occurring situations there should be sets of standard procedures that can be used, subject to the checking and validity of any required assumptions. This applies for both confidence intervals and credible intervals.
- For more novel situations there should be guidance on how interval estimates can be formulated. In this regard confidence intervals and credible intervals have a similar standing but there are differences:
- credible intervals can readily deal with prior information, while confidence intervals cannot.
- confidence intervals are more flexible and can be used practically in more situations than credible intervals: one area where credible intervals suffer in comparison is in dealing with non-parametric models.
- There should be ways of testing the performance of interval estimation procedures. This arises because many such procedures involve approximations of various kinds and there is a need to check that the actual performance of a procedure is close to what is claimed. The use of stochastic simulations makes this is straightforward in the case of confidence intervals, but it is somewhat more problematic for credible intervals where prior information needs to taken properly into account. Checking of credible intervals can be done for situations representing no-prior-information but the check involves checking the long-run frequency properties of the procedures.

Point estimation

In statistics, point estimation involves the use of sample data to calculate a single value (known as a statistic) which is to serve as a "best guess" for an unknown (fixed or random) population parameter.

More formally, it is the application of a point estimator to the data.

In general, point estimation should be contrasted with interval estimation.

Point estimation should be contrasted with general Bayesian methods of estimation, where the goal is usually to compute (perhaps to an approximation) the posterior distributions of parameters and other quantities of interest. The contrast here is between estimating a single point (point estimation), versus estimating a weighted set of points (a probability density function). However, where appropriate, Bayesian methodology can include the calculation of point estimates, either as the expectation or median of the posterior distribution or as the mode of this distribution.

In a purely frequentist context (as opposed to Bayesian), point estimation should be contrasted with the specific interval estimation calculation of confidence intervals.

Linear Programming

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In mathematics, linear programming *(LP)* is a technique for optimization of a linear objective function, subject to linear equality and linear inequality constraints. Informally, linear programming determines the way to achieve the best outcome (such as maximum profit or lowest cost) in a given mathematical model and given some list of requirements represented as linear equations.

More formally, given a polytope (for example, a polygon or a polyhedron), and a real-valued affine function

$$f(x_1, x_2, \ldots\ldots, x_n) = c_1x_1 + c_2x_2 + \ldots\ldots + c_nx_n + d$$

defined on this polytope, a linear programming method will find a point in the polytope where this function has the smallest (or largest) value. Such points may not exist, but if they do, searching through the polytope vertices is guaranteed to find at least one of them.

Linear programs are problems that can be expressed in canonical form:

Maximize $c^T X$

Subject to $AX \le b$.

X represents the vector of variables (to be determined), while c and b are vectors of (known) coefficients and A is a (known) matrix of coefficients. The expression to be maximized or minimized is called the objective function ($c^T X$ in this case). The equations $AX \le b$ are the constraints which specify a convex polyhedron over which the objective function is to be optimized.

Linear programming can be applied to various fields of study. Most extensively it is used in business and economic situations, but can also be utilized for some engineering problems. Some industries that use linear programming models include transportation, energy, telecommunications, and manufacturing. It has proved useful in modeling diverse types of problems in planning, routing, scheduling, assignment, and design.

History of linear programming

The problem of solving a system of linear inequalities dates back at least as far as Fourier, after whom the method of Fourier-Motzkin elimination is named. Linear programming arose as a mathematical model developed during the second world war to plan expenditures and returns in order to reduce costs to the army and increase losses to the enemy. It was kept secret until 1947. Postwar, many industries found its use in their daily planning.

The founders of the subject are Leonid Kantorovich, a Russian mathematician who developed linear programming problems in 1939, George B. Dantzig, who published the simplex method in 1947, John von Neumann, who developed the theory of the duality in the same year. The linear programming problem was first shown to be solvable in polynomial time by Leonid Khachiyan in 1979, but a larger theoretical and practical breakthrough in the field came in 1984 when Narendra Karmarkar introduced a new interior point method for solving linear programming problems.

Dantzig's original example of finding the best assignment of 70 people to 70 jobs exemplifies the usefulness of linear programming. The computing power required to test all the permutations to select the best assignment is vast; the number of possible configurations exceeds the number of particles in the universe. However, it takes only a moment to find the optimum solution by posing the problem as a linear program and applying the Simplex algorithm. The theory behind linear programming drastically reduces the number of possible optimal solutions that must be checked.

Uses

Linear programming is a considerable field of optimization for several reasons. Many practical problems in operations research can be expressed as linear programming problems. Certain special cases of linear programming, such as network flow problems and multicommodity flow problems are considered important enough to have generated much research on specialized algorithms *for their solution. A number of algorithms for other types of optimization problems* work by solving LP problems as sub-problems. Historically, ideas from linear programming have inspired many of the central concepts of optimization theory, such as duality, decomposition, and the importance of convexity and its generalizations. Likewise, linear programming is heavily used in microeconomics and company management, such as planning, production, transportation, technology and other issues. Although the modern management issues are ever-changing, most companies would like to maximize profits or minimize costs with limited resources. Therefore, many issues can boil down to linear programming problems.

Standard form

Standard form is the usual and most intuitive form of describing a linear programming problem. It consists of the following three parts:

- A linear function to be maximized

  e.g. maximize $c_1x_1 + c_2x_2$

- Problem constraints of the following form

  e.g. $a_{11}x_1 + a_{12}x_2 \le b_1$

  $a_{21}x_1 + a_{22}x_2 \le b_2$

  $a_{31}x_1 + a_{32}x_2 \le b_3$

- Non-negative variables

  e.g. $x_1 \ge 0$

  $x_2 \ge 0$

The problem is usually expressed in matrix form, and then becomes:

maximize $c^T X$

subject to $AX \le b$, $x \ge 0$

Other forms, such as minimization problems, problems with constraints on alternative forms, as well as problems involving negative variables can always be rewritten into an equivalent problem in standard form.

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3.4 Analysis of Variance

In statistics, analysis of variance (ANOVA) is a collection of statistical models, and their associated procedures, in which the observed variance is partitioned into components due to different explanatory variables. The initial techniques of the analysis of variance were developed by the statistician and geneticist R. A. Fisher in the 1920s and 1930s, and is sometimes known as Fisher's ANOVA or Fisher's analysis of variance, due to the use of Fisher's F-distribution as part of the test of statistical significance.

There are three conceptual classes of such models:

1. Fixed-effects models assumes that the data came from normal populations which may differ only in their means. (Model 1)

2. Random effects models assume that the data describe a hierarchy of different populations whose differences are constrained by the hierarchy. (Model 2)

3. Mixed-effect models describe situations where both fixed and random effects are present. (Model 3)

In practice, there are several types of ANOVA depending on the number of treatments and the way they are applied to the subjects in the experiment:

- One-way ANOVA is used to test for differences among two or more independent groups. Typically, however, the one-way ANOVA is used to test for differences among at least three groups, since the two-group case can be covered by a *T-test* (Gossett, 1908). When there are only two means to compare, the *T-test* and the *F-test* are equivalent; the relation between ANOVA and t is given by $F = t^2$.

- One-way ANOVA for repeated measures is used when the subjects are subjected to repeated measures; this means that the same subjects are used for each treatment. Note that this method can be subject to carryover effects.

- Factorial ANOVA is used when the experimenter wants to study the effects of two or more treatment variables. The most commonly used type of factorial ANOVA is the 2×2 (read as "two by two", as you would a matrix) design, where there are two independent variables and each variable has two levels or distinct values. Factorial ANOVA can also be multi-level such as 3×3, etc. or higher order such as 2×2×2, etc. but analyses with higher numbers of factors are rarely done by hand because the calculations are lengthy. However, since the introduction of data analytic software, the utilization of higher order designs and analyses has become quite common.

- When one wishes to test two or more independent groups subjecting the subjects to repeated measures, one may perform a factorial mixed-design ANOVA, in which one factor is a between-subjects variable and the other is within-subjects variable. This is a type of mixed-effect model.
- Multivariate analysis of variance (MANOVA) is used when there is more than one dependent variable.

Models

Fixed-effects models

The fixed-effects model of analysis of variance applies to situations in which the experimenter applies several treatments to the subjects of the experiment to see if the response variable values change. This allows the experimenter to estimate the ranges of response variable values that the treatment would generate in the population as a whole.

Random-effects models

Random effects models are used when the treatments are not fixed. This occurs when the various treatments (also known as factor levels) are sampled from a larger population. Because the treatments themselves are random variables, some assumptions and the method of contrasting the treatments differ from ANOVA model 1.

Most random-effects or mixed-effects models are not concerned with making inferences concerning the particular sampled factors. For example, consider a large manufacturing plant in which many machines produce the same product. The statistician studying this plant would have very little interest in comparing the three particular machines to each other. Rather, inferences that can be made for all machines are of interest, such as their variability and the overall mean.

Assumptions

- *Independence of cases-* this is a requirement of the design.
- *Normality-* the distributions in each of the groups are normal.
- *Equality (or "homogeneity") of variances, called homoscedasticity—* the variance of data in groups should be the same.

Levene's test for homogeneity of variances is typically used to confirm homoscedasticity. The Kolmogorov-Smirnov or the Shapiro-Wilk test may be used to confirm normality. Some authors claim that the F-test is unreliable if there are deviations from normality (Lindman, 1974) while others claim that the F-test is robust. The Kruskal-Wallis test is a nonparametric alternative which does not rely on an assumption of normality.

These together form the common assumption that the errors are independently, identically, and normally distributed for fixed effects models, or:

$$\varepsilon \sim N(0, \sigma^2).$$

Examples—

Group *A* is given vodka, Group *B* is given gin, and Group *C* is given a placebo. All groups are then tested with a memory task. A one-way ANOVA can be used to assess the effect of the various treatments (that is, the vodka, gin, and placebo).

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Group A is given vodka and tested on a memory task. The same group is allowed a rest period of five days and then the experiment is repeated with gin. The procedure is repeated using a placebo. A one-way ANOVA with repeated measures can be used to assess the effect of the vodka versus the impact of the placebo.

In an experiment testing the effects of expectations, subjects are randomly assigned to four groups:

1. expect vodka—receive vodka
2. expect vodka—receive placebo
3. expect placebo—receive vodka
4. expect placebo—receive placebo (the last group is used as the control group)

Each group is then tested on a memory task. The advantage of this design is that multiple variables can be tested at the same time instead of running two different experiments. Also, the experiment can determine whether one variable affects the other variable (known as interaction effects). A factorial ANOVA (2×2) can be used to assess the effect of expecting vodka or the placebo and the actual reception of either.

3.5 Factor Analysis

Factor analysis is a statistical method used to describe variability among observed variables in terms of fewer unobserved variables called factors. The observed variables are modeled as linear combinations of the factors, plus "error" terms. The information gained about the interdependencies can be used later to reduce the set of variables in a dataset. Factor analysis originated in psychometrics, and is used in behavioral sciences, social sciences, marketing, product management, operations research, and other applied sciences that deal with large quantities of data.

Factor analysis is often confused with principal component analysis. The two methods are related, but distinct, though factor analysis becomes essentially equivalent to principal component analysis if the "errors" in the factor analysis model (see below) are assumed to all have the same variance.

Example

The following example is a simplification for expository purposes, and should not be taken to be realistic. Suppose a psychologist proposes a theory that there are two kinds of intelligence, "verbal intelligence" and "mathematical intelligence", neither of which is directly observed. Evidence for the theory is sought in the examination scores from each of 10 different academic fields of 1000 students. If each student is chosen randomly from a large population, then each student's 10 scores are random variables. The psychologist's theory may say that for each of the 10 academic fields, the score averaged over the group of all students who share some common pair of values for verbal and mathematical "intelligences" is some constant times their level of verbal intelligence plus another constant times their level of mathematical intelligence, i.e., it is a linear combination of those two "factors". The numbers for a particular subject, by which the two kinds of intelligence are multiplied to obtain the expected score, are posited by the theory to be the same for all intelligence level pairs, and are called "factor loadings" for this subject. For example, the theory may hold that the average student's aptitude in the field of amphibiology is

{10 × the student's verbal intelligence} + {6 × the student's mathematical intelligence}.

The numbers 10 and 6 are the factor loadings associated with amphibiology. Other academic subjects may have different factor loadings.

Two students having identical degrees of verbal intelligence and identical degrees of mathematical intelligence may have different aptitudes in amphibiology because individual aptitudes differ from average aptitudes. That difference is called the "error" — a statistical term that means the amount by which an individual differs from what is average for his or her levels of intelligence.

The observable data that go into factor analysis would be 10 scores of each of the 1000 students, a total of 10,000 numbers. The factor loadings and levels of the two kinds of intelligence of each student must be inferred from the data.

Factor analysis in psychometrics

History

Charles Spearman spearheaded the use of factor analysis in the field of psychology and is sometimes credited with the invention of factor analysis. He discovered that school children's scores on a wide variety of seemingly unrelated subjects were positively correlated, which led him to postulate that a general mental ability, or g, underlies and shapes human cognitive performance. His postulate now enjoys broad support in the field of intelligence research, where it is known as the g theory.

Raymond Cattell expanded on Spearman's idea of a two-factor theory of intelligence after performing his own tests and factor analysis. He used a multi-factor theory to explain intelligence. Cattell's theory addressed alternate factors in intellectual development, including motivation and psychology. Cattell also developed several mathematical methods for adjusting psychometric graphs, such as his "scree" test and similarity coefficients. His research led to the development of his theory of fluid and crystallized intelligence, as well as his 16 Personality Factors theory of personality. Cattell was a strong advocate of factor analysis and psychometrics. He believed that all theory should be derived from research, which supports the continued use of empirical observation and objective testing to study human intelligence.

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Applications in psychology

Factor analysis is used to identify "factors" that explain a variety of results on different tests. For example, intelligence research found that people who get a high score on a test of verbal ability are also good on other tests that require verbal abilities. Researchers explained this by using factor analysis to isolate one factor, often called crystallized intelligence or verbal intelligence, that represents the degree to which someone is able to solve problems involving verbal skills.

Factor analysis in psychology is most often associated with intelligence research. However, it also has been used to find factors in a broad range of domains such as personality, attitudes, beliefs, etc. It is linked to psychometrics, as it can assess the validity of an instrument by finding if the instrument indeed measures the postulated factors.

Advantages

- Reduction of number of variables, by combining two or more variables into a single factor. For example, performance at running, ball throwing, batting, jumping and weight lifting could be combined into a single factor such as general athletic ability. Usually, in an item by people matrix, factors are selected by grouping related items. In the Q factor analysis technique, the matrix is transposed and factors are created by grouping related people: For example, liberals, libertarians, conservatives and socialists, could form separate groups.

- Identification of groups of inter-related variables, to see how they are related to each other. For example, Carroll used factor analysis to build his Three Stratum Theory. He found that a factor called "broad visual perception" relates to how good an individual is at visual tasks. He also found a "broad auditory perception" factor, relating to auditory task capability. Furthermore, he found a global factor, called "g" or general intelligence, that relates to both "broad visual perception" and "broad auditory perception". This means someone with a high "g" is likely to have both a high "visual perception" capability and a high "auditory perception" capability, and that "g" therefore explains a good part of why someone is good or bad in both of those domains.

Disadvantages

- "..each orientation is equally acceptable mathematically. But different factorial theories proved to differ as much in terms of the orientations of factorial axes for a given solution as in terms of anything else, so that model fitting did not prove to be useful in distinguishing among theories."

(Sternberg, 1977). This means all rotations represent different underlying processes, but all rotations are equally valid outcomes of standard factor analysis optimization. Therefore, it is impossible to pick the proper rotation using factor analysis alone.

- Factor analysis can be only as good as the data allows. In psychology, where researchers have to rely on more or less valid and reliable measures such as self-reports, this can be problematic.
- Interpreting factor analysis is based on using a "heuristic", which is a solution that is "convenient even if not absolutely true" (Richard B. Darlington). More than one interpretation can be made of the same data factored the same way, and factor analysis cannot identify causality.

Factor analysis in marketing

The basic steps are:

- Identify the salient attributes consumers use to evaluate products in this category.
- Use quantitative marketing research techniques (such as surveys) to collect data from a sample of potential customers concerning their ratings of all the product attributes.
- Input the data into a statistical program and run the factor analysis procedure. The computer will yield a set of underlying attributes (or factors).
- Use these factors to construct perceptual maps and other product positioning devices.

Information collection

The data collection stage is usually done by marketing research professionals. Survey questions ask the respondent to rate a product sample or descriptions of product concepts on a range of attributes. Anywhere from five to twenty attributes are chosen. They could include things like: ease of use, weight, accuracy, durability, colourfulness, price, or size. The attributes chosen will vary depending on the product being studied. The same question is asked about all the products in the study. The data for multiple products is coded and input into a statistical program such as R, SPSS, SAS, Stata, and SYSTAT.

Analysis

The analysis will isolate the underlying factors that explain the data. Factor analysis is an interdependence technique. The complete set of interdependent relationships are examined. There is no specification of either dependent variables, independent variables, or causality. Factor analysis assumes that all the rating data on different attributes can be reduced down to a few important dimensions.

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This reduction is possible because the attributes are related. The rating given to any one attribute is partially the result of the influence of other attributes. The statistical algorithm deconstructs the rating (called a raw score) into its various components, and reconstructs the partial scores into underlying factor scores. The degree of correlation between the initial raw score and the final factor score is called a factor loading. There are two approaches to factor analysis: "principal component analysis" (the total variance in the data is considered); and "common factor analysis" (the common variance is considered).

Note that principal component analysis and common factor analysis differ in terms of their conceptual underpinnings. The factors produced by principal component analysis are conceptualized as being linear combinations of the variables whereas the factors produced by common factor analysis are conceptualized as being latent variables. Computationally, the only difference is that the diagonal of the relationships matrix is replaced with communalities (the variance accounted for by more than one variable) in common factor analysis. This has the result of making the factor scores indeterminate and thus differ depending on the method used to compute them whereas those produced by principal component analysis are not dependent on the method of computation. Although there have been heated debates over the merits of the two methods, a number of leading statisticians have concluded that in practice there is little difference (Velicer and Jackson, 1990) which makes sense since the computations are quite similar despite the differing conceptual bases, especially for datasets where communalities are high and/or there are many variables, reducing the influence of the diagonal of the relationship matrix on the final result (Gorsuch, 1983).

The use of principal components in a semantic space can vary somewhat because the components may only "predict" but not "map" to the vector space. This produces a statistical principal component use where the most salient words or themes represent the preferred basis.

Advantages

- Both objective and subjective attributes can be used
- Factor Analysis can be used to identify the hidden dimensions or constructs which may or may not be apparent from direct analysis.
- It is not extremely difficult to do, inexpensive, and accurate
- There is flexibility in naming and using dimensions

Disadvantages

- Usefulness depends on the researchers' ability to develop a complete and accurate set of product attributes - If important attributes are missed the value of the procedure is reduced accordingly.

- Naming of the factors can be difficult - multiple attributes can be highly correlated with no apparent reason.
- If the observed variables are completely unrelated, factor analysis is unable to produce a meaningful pattern (though the eigenvalues will highlight this: suggesting that each variable should be given a factor in its own right).
- If sets of observed variables are highly similar to each other but distinct from other items, Factor analysis will assign a factor to them, even though this factor will essentially capture true variance of a single item. In other words, it is not possible to know what the 'factors' actually represent; only theory can help inform the researcher on this.

Factor analysis in physical sciences

Factor analysis has also been widely used in physical sciences such as geochemistry, ecology, and hydrochemistry.

In groundwater quality management, it is important to relate the spatial distribution of different chemical parameters to different possible sources, which have different chemical signatures. For example, a sulfide mine is likely to be associated with high levels of acidity, dissolved sulfates and transition metals. These signatures can be identified as factors through R-mode factor analysis, and the location of possible sources can be suggested by contouring the factor scores.

In geochemistry, different factors can correspond to different mineral associations, and thus to mineralisation.

3.6 Regression Analysis

In statistics, regression analysis refers to techniques for the modeling and analysis of numerical data consisting of values of a dependent variable (also called response variable or measurement) and of one or more independent variables (also known as explanatory variables or predictors). The dependent variable in the regression equation is modeled as a function of the independent variables, corresponding parameters ("constants"), and an error term. The error term is treated as a random variable.

It represents unexplained variation in the dependent variable. The parameters are estimated so as to give a "best fit" of the data. Most commonly the best fit is evaluated by using the least squares method, but other criteria have also been used.

Regression can be used for prediction (including forecasting of time-series data), inference, hypothesis testing, and modeling of causal relationships. These uses of regression rely heavily on the underlying assumptions being satisfied. Regression analysis has been criticized as being misused for these purposes in many cases where the appropriate assumptions cannot be verified to hold. One factor contributing to the misuse of regression is that it can take considerably more skill to critique a model than to fit a model.

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History of regression analysis

The earliest form of regression was the method of least squares, which was published by Legendre in 1805, and by Gauss in 1809. The term "least squares" is from Legendre's term, moindres carrés. However, Gauss claimed that he had known the method since 1795.

Legendre and Gauss both applied the method to the problem of determining, from astronomical observations, the orbits of bodies about the Sun. Euler had worked on the same problem (1748) without success. Gauss published a further development of the theory of least squares in 1821, including a version of the Gauss–Markov theorem.

The term "regression" was coined by Francis Galton, a cousin of Charles Darwin, in the nineteenth century to describe a biological phenomenon. The phenomenon was that the heights of descendants of tall ancestors tend to regress down towards a normal average. For Galton, regression had only this biological meaning, but his work was later extended by Udny Yule and Karl Pearson to a more general statistical context. At the present time, the term "regression" is often synonymous with "least-squares curve fitting".

Underlying assumptions

Classical assumptions for regression analysis include:

- The sample must be representative of the population for the inference prediction.
- The error is assumed to be a random variable with a mean of zero conditional on the explanatory variables.
- The independent variables are error-free. If this is not so, modeling may be done using errors-in-variables model techniques.
- The predictors must be linearly independent, i.e. it must not be possible to express any predictor as a linear combination of the others.
- The errors are uncorrelated, that is, the variance-covariance matrix of the errors is diagonal and each non-zero element is the variance of the error.
- The variance of the error is constant across observations (homoscedasticity). If not, weighted least squares or other methods might be used.

These are sufficient (but not all necessary) conditions for the least-squares estimator to possess desirable properties, in particular, these assumptions imply that the parameter estimates will be unbiased, consistent, and efficient in the class of linear unbiased estimators. Many of these assumptions may be relaxed in more advanced treatments.

Assumptions include the geometrical support of the variables (Cressie, 1996). Independent and dependant variables often refer to values measured at point locations. There may be spatial trends and spatial autocorrelation in the variables that violates statistical assumptions of regression. Geographic weighted regression is one technique to deal with such data (Fotheringham et al., 2002). Also, variables may include values aggregated by areas. With aggregated data the Modifiable Areal Unit Problem can cause extreme variation in regression parameters (Fotheringham and Wong, 1991). When analyzing data aggregated by political boundaries, postal codes or census areas results may be very different with a different choice of units.

Regression equation

It is convenient to assume an environment in which an experiment is performed: the dependent variable is then outcome of a measurement.

The regression equation deals with the following variables:

- The unknown parameters denoted as β. This may be a scalar or a vector of length *k*.
- The independent variables, X.
- The dependent variable, Y.

Regression equation is a function of variables X and β.

$$Y = f(X, \beta)$$

The user of regression analysis must make an *intelligent guess about this function.* Sometimes the form of this function is known, sometimes he must apply a trial and error process.

Assume now that the vector of unknown parameters, β is of length *k*. In order to perform a regression analysis the user must provide information about the dependent variable *Y*:

- If the user performs the measurement N times, where N < k, regression analysis cannot be performed: there is not provided enough information to do so.
- If the user performs *N* independent measurements, where *N* = *k*, then the *problem reduces to solving a set of N equations with N unknowns* β.
- If, on the other hand, the user provides results of *N* independent measurements, where *N* > *k*, regression analysis can be performed. Such a system is also called an overdetermined system;

In the last case the regression analysis provides the tools for:

1. finding a solution for unknown parameters β that will, for example, minimize the distance between the measured and predicted values of the dependent variable *Y* (also known as method of least squares).

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2. under certain statistical assumptions the regression analysis uses the surplus of information to provide statistical information about the unknown parameters β and predicted values of the dependent variable Y.

Independent measurements

Quantitatively, this is explained by the following example: Consider a regression model with, say, three unknown parameters β_0, β_1 and β_2. An experimenter performed 10 repeated measurements at exactly the same value of independent variables X. In this case regression analysis fails to give a unique value for the three unknown parameters: the experimenter did not provide enough information. The best one can do is to calculate the average value of the dependent variable Y and its standard deviation.

If the experimenter had performed five measurements at X_1, four at X_2 and one at X_3, where X_1, X_2 and X_3 are different values of the independent variable X then regression analysis would provide a unique solution to unknown parameters β.

In the case of general linear regression (see below) the above statement is equivalent to the requirement that matrix X^TX is regular (that is: it has an inverse matrix).

Statistical assumptions

When the number of measurements, *N*, is larger than the number of unknown parameters, *k*, and the measurement errors ϵ_i are normally distributed then the excess of information contained in *(N - k)* measurements is used to make the following statistical predictions about the unknown parameters:

- confidence intervals of unknown parameters.

3.7 Data Analysis using Software Packages

Many statisticians use several of the statistical packages at the same time. The core statistical capabilities exist in each of the packages. Each of the packages has its own strengths and ease of use features for the different types of analysis. We used some of the most popular statistical packages, which were available to us.

SAS

Some features of SAS:

(a) A very complete package for statistical analysis.

(b) Can link to Access Database via ODBC.

(c) Data can be put in several different locations including mainframes.

(d) Can be run on several different platforms i.e. large mainframe computers down to PC's.

(e) SAS programming is used as a means to access the data for several other purposes besides statistical analysis. SAS is an integrated suite of software tools used for purposes such as data warehousing, executive information systems, data visualization, application development, etc. besides statistical analysis.

(f) We have a staff of highly experienced, dedicated SAS programmers around the world.

(g) There is a long term commitment to dedicate staff to the SAS environment. There is probably nothing, which cannot be done with SAS but getting it done is always very difficult. There is so much literature in it that manuals take up entire shelf! May be that's why there are a lot of jobs out there for SAS programmers!

(h) It is expensive (unless you get an academic discount). SAS has this trick. They sell you base SAS, which is quite limited. Then, they sell you SAS/STAT, and other modules. These prices add up.

(i) SAS requires a lot of support, by someone who knows computers very well and knows SAS very well. It is a pain to learn. This is partially mitigated by the fact that SAS is very modular. Basically, there is the data step, where SAS data sets are made, manipulated and saved. Then there is a long list of procedures (called PROC's), which can be learned one at a time, for the most part.

(j) The graphics in SAS are horrible. They came out with SAS/GRAPH, which has (theoretically) vast capability, but is almost impossible to use.

However, SAS appears to be more appropriate for an enterprise solution, where the data may reside in many different formats and SAS is the tool used to get at the data and perform Statistical analysis. Where we are looking only for a single user PC somewhat limited use solution the other packages appear more appropriate.

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SPSS

Some features of SPSS:

(a) SPSS is owned by the same company, which owns some other statistical package copyright such as SYSTAT; that is, this experience of statistical programming makes it more advanced and user friendly.

(b) SPSS owes a lot to the days when the manual (the plum one) was one of the best introductory books around on statistics.

(c) Non programmers find it easier to use than some other statistical packages; more menu driven versus programming

(d) Slower performance

(e) Tends to be used more in the professional field.

(f) Training available everywhere.

(g) It seems that SPSS is not the software of choice in industries that need data analyst. But SPSS has its audience too. It depends on our area of expertise.

SPSS and SAS

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SPSS is a nice program for doing social research. SAS is a wonderful tool for doing data mining. They both have their place. I can tell you that in smaller databases, such as market research, SPSS is a far better tool for some quick and painless analysis. When you need to get some numbers flying around and are doing transformations like a maniac you had better know how to do some SAS. In terms of creating easily exportable, attractive output SPSS blows SAS away. It is not even close. SAS/Graph is well, not so good. The reason SAS is more valuable is because SPSS cannot really handle large databases very well. If I need to manipulate thousands and thousands of cases, SAS has the power and reliability to get you there. It also exists in a UNIX/mainframe environment. SPSS does not.

STATA

Some features of STATA:

(a) Interactive, very fast performance. Analysis can be done iteratively or through programming (called ado files). STATA loads the entire data set into RAM (which makes it much faster than SPSS in the normal case) which means the performance degrades considerably when data set size exceeds available memory. Whether this matters depends on the exact size of the data sets, and how much RAM you have, and how effectively you can subset the data. You may find that you can extract subsets with programs like stat/transfer (cheap and very effective) and avoid the problem.

(b) Fast performance requires large memory, would need memory and possibly system upgrade. Model could be constrained by lack of memory.

(c) Offers "NetCourses"; less expensive training accomplished via E-mail.

(d) Some love the analysis tools and support, both from the STATA company and from other users on the STATALIST (many of whom are STATA employees who answer questions and take input back into the company. Even the president of the company participates in their listserv.).

(e) STATA does not play as nicely with other programs as SAS does. Also, STATA does not have many of the modules available in SAS.

(f) STATA can handle extremely large datasets, both in terms of number of cases and variables. We can take a table of results from STATA and using the Copy Table command, paste results directly into Excel, which we can then very easily format into a Word document.

(g) Updates are easy to install, and there are many very good user-written plug-ins available.

(h) STATA's documentation is superior to those available from SAS.

(i) STATA is much more competitively priced considering you get the entire package rather than getting pieces of it. They even have a deal where students can get a 160 page manual and a one year license for a negligible amount of money (Small STATA).

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STATA and SPSS

STATA has many advantages from a statistics point of view, depending on what you are doing. They have excellent support for complex samples (cluster, stratified, weighted) and offer lots of statistics you can't get from SPSS—especially for limited dependent variables. SPSS is ahead of STATA in terms of the friendly interface and we think it is easier to do data management with SPSS. If you're looking for a single program to handle big data sets and do relatively simple analyses, SPSS is certainly up to the job.

MINITAB

MINITAB is very quick to learn. Nearly 450 textbooks (up to now) and textbook supplements reference MINITAB Statistical Software, making it easy to use MINITAB in academic courses. There are a lot of macro's written for MINITAB. MINITAB Statistical Software is available for PC and Macintosh microcomputer systems. MINITAB is also available for mainframes, minicomputers, and workstations including VAX and other DEC platforms, Sun, IBM, Prime, Data General, Hewlett-Packard, and others.

MINITAB , SPSS, SAS

MINITAB is much more suited to statistical analysis than Excel, but definitely has some significant disadvantages compared to SAS or SPSS. It has a good interface and decent graphics, a reasonable macro facility, and decent support.

MATLAB

MATLAB is a (non-statistics-specific) mathematical programming language which happens to contain some statistical routines. MATLAB, of course, is wide open in terms of adding new capabilities, but requires that you have the time, energy and knowledge to construct the necessary code. MATLAB is very powerful numerical computational package. We can do the same analysis in several ways.

S-PLUS and R

S is considered a very high-level language and an environment for data analysis and graphics since its evolution in the mid-70's at Bell Labs. The evolution of the S language is characterized by four books by John Chambers and coauthors, which are also the primary references for S. There is a huge amount of user-contributed code for S.

S-PLUS is a value-added version of S sold by Insightful Corporation (previous MathSoft. Inc) since 1994 providing professional support to user-end. Based on the S language, S-PLUS provides functionality in a wide variety of areas, including robust regression, modern non-parametric regression, time series, survival analysis, multivariate analysis, classical statistical tests, quality control, and graphics drivers. Add-on modules add additional capabilities for wavelet analysis, spatial statistics, GARCH models, and design of experiments.

R is a system for statistical computation and graphics. It consists of a language plus a run-time environment with graphics, a debugger, access to certain system functions, and the ability to run programs stored inscript files. R was initially written by Ross Ihaka and Robert Gentleman at the Department of Statistics of the University of Auckland in Auckland, New Zealand. The name suggests that the authors consider R to be a pre-stage of S. In addition, a large group of individuals has contributed to R by sending code and bug reports. The reason behind this might be its free availability including source codes. The design of R has been heavily influenced by two existing languages: Becker, Chambers & Wilks' S and Sussman's Scheme. Whereas the resulting language is very similar in appearance to S, the underlying implementation and semantics are derived from Scheme.

Since almost anything we can do in R has source code that we could port to SPLUS with little effort there will never be much we can do in R that we couldn't do in SPLUS if you wanted to. However, R is considered superior to S-PLUS in context of drawing graphs since several graphics features that R has; S-PLUS does not have.

Sample Questions

1. How is qualitative data analysed?
2. Discuss the method of tabulation and data presentation.
3. How is data graphically representated?
4. Write short notes on—
   (a) Chi-square test
   (b) T-test
   (c) Central tendency
5. How is variability measured?
6. What is the significance of linear programming in research methodology?
7. How is variance analysed?
8. Write a short note on the application of factor analysis in various research fields.
9. Discuss use of two software packages in data analysis.

Unit— IV

Report Writing

NOTES

LEARNING OBJECTIVES

4.1 Introduction

A report is a very formal document that is written for a variety of purposes in the sciences, social sciences, engineering and business disciplines. Generally, findings pertaining to a given or specific task are written up into a report. It should be noted that reports are considered to be legal documents in the workplace and, thus, they need to be precise, accurate and difficult to misinterpret. A report is a systematic, well organised document which defines and analyses a subject or problem, and which may include:

- the record of a sequence of events
- interpretation of the significance of these events or facts
- evaluation of the facts or results of research presented
- discussion of the outcomes of a decision or course of action
- conclusions
- recommendations

Reports must always be:

- accurate
- concise
- clear
- well structured

How many different types of reports are there?

laboratory reports	health and safety reports
research reports	case study reports
field study reports	cost-benefit analysis reports
proposals	comparative advantage reports
progress reports	feasibility studies

technical reports	instruction manuals
financial reports	And on it goes ...

When would I be asked to write a report?

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Engineering Reports can outline a proposal for a project; report on progress of a project; present research and findings from a project; detail the technical aspects of innovations; present results from a feasibility or cost-benefit analytical study.

Education and Health Science Practicum reports are based on experiences at prac. school or hospital. Ongoing journal entries are written up into a report at the end of term. There are field and research reports.

Science and some Social Sciences Laboratory reports outline, analyse and evaluate results from experiments. Research or field reports are findings from the field and make recommendations based on this. Feasibility studies report investigations into the feasibility of something and make recommendations accordingly. Case study reports are found especially in the areas of social welfare, social work, and psychology.

Business Report writing is frequently used in business subjects. Reports can range from short memos to lengthy reports such as cost-benefit analysis reports; research and field reports; financial reports; proposals; progress reports; health and safety reports; quality reports; case study reports.

How does the structure of a report differ from the structure of an essay?

Reports are organised into separate sections according to the specific requirements of the given task. While it is important that paragraphs are structured and there is unity, coherence and logical development to the report, it is not a continuous piece of writing like an essay. Each type of report serves a very specific purpose and is aimed at a very particular audience.

Report writing may seem repetitive to us, but this is because reports are not usually read from cover-to-cover by one person. For example, a manager may read only the synopsis or abstract and act on the advice it contains while a technical officer may read only the section that explains how things work. On the other hand, a personnel officer may look at only the conclusions and recommendations that directly affect his or her working area.

Types of Report

A report is a dreadfully official document that is written to serve the range of purpose in the engineering and business disciplines; sciences and social sciences. Therefore, they need to be clear-cut and accurate. Good report writing call for—professionalism, profound knowledge of the subject, attentiveness, and outstanding writing proficiency.

Types of Report Writing –

- Research Report Writing
- Business Report Writing

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- Science Report Writing

Research Report Writing— To presents the tangible proof of the conducted research is the major intention of the academic assignment. When writing on research report, you must ponder over clarity, organization, and content. Research reports are all the more same to technical reports, lab reports, formal reports and scientific papers which comprise a quite consistent format that will facilitate you to put your information noticeably, making it crystal clear.

Business Report Writing— In business milieu, Business report writing happens to be an indispensable part of the communication process. Executive summary is written in a non-technical manner. By and large, audience for business reports will consist of upper level manager, for that reason you should take the audience needs in consideration. Go on with the introduction to articulate the problem and determine the scope of the research. To attain the desired results, don't fail to state about the precise quantitative tools.

Science Report Writing— Parallel to a business report, science report writing also corresponds with the line of investigation. To report upon an empirical investigation, these reports make use of standard scientific report format, portraying technique, fallout and conclusions. As an assignment in undergraduate papers within the scientific disciplines, it is required frequently.

The main objective of the Science report is to boast an aim, the technique which enlightens how the project has been analyzed, the outcomes which presents the findings and the conclusion. This embraces advance research suggestions and your own biased opinion on the topic which has been talked about.

When writing a science report, do not fail to remember to use heading and subheadings in order to direct a reader through your work. In the form of tables and graphs, Statistical evidence should be incorporated in appendices. Than refer to it in the body of your scientific report.

Reports are a common form of writing because of the inclusion of recommendations which are helpful in implementing the decision.

4.2 Main Components of a Research Report

The research report should contain the following components:

TITLE and COVER PAGE

SUMMARY OF STUDY DESIGN, FINDINGS AND RECOMMENDATIONS

ACKNOWLEDGEMENTS

TABLE OF CONTENTS

List of tables, figures (optional)

List of abbreviations (optional)

NOTES

1. INTRODUCTION (statement of the problem in its local context, including relevant literature)
2. OBJECTIVES
3. METHODOLOGY
4. RESEARCH FINDINGS
5. DISCUSSION
6. CONCLUSIONS AND RECOMMENDATIONS

REFERENCES

ANNEXES (data collection tools; tables)

Report Structure

- Cover page

The cover page should contain the title, the names of the authors with their titles and positions, the institution that is publishing the report, and the month and year of publication. The title could consist of a challenging statement or question, followed by an informative subtitle covering the content of the study and indicating the area where the study was implemented.

- Summary

The summary should be written only after the first or even the second draft of the report has been completed. It should contain:

— a very brief description of the problem (WHY this study was needed)— the main objectives (WHAT has been studied)

— the place of study (WHERE)

— the type of study and methods used (HOW)

— major findings and conclusions, followed by

— the major (or all) recommendations.

The summary will be the first (and for busy health decision makers most likely the only) part of your study that will be read. Therefore, its writing demands thorough reflection and is time consuming. Several drafts may have to be made, each discussed by the research team as a whole.

As you will have collaborated with various groups during the drafting and implementation of your research proposal, you may consider writing different summaries for each of these groups.

NOTES

- Acknowledgements

It is good practice to thank those who supported you technically or financially in the design and implementation of your study. Also your employer who has allowed you to invest time in the study and the respondents may be acknowledged. Acknowledgements are usually placed right after the title page or at the end of the report, before the references.

- Table of contents

A table of contents is essential. It provides the reader a quick overview of the major sections of your report, with page references, so that (s)he can go through the report in a different order or skip certain sections.

- List of tables, figures

If you have many tables or figures it is helpful to list these also, in a 'table of contents' type of format with page numbers.

- List of abbreviations (optional)

If abbreviations or acronyms are used in the report, these should be stated in full in the text the first time they are mentioned. If there are many, they should be listed in alphabetical order as well. The list can be placed before the first chapter of the report.

The table of contents and lists of tables, figures, abbreviations should be prepared last, as only then can you include the page numbers of all chapters and sub-sections in the table of contents. Then you can also *finalise* the numbering of figures and tables and include all abbreviations.

Chapter 1: Introduction

The introduction is a relatively easy part of the report that can best be written after a first draft of the findings has been made. It should certainly contain some relevant (environmental/ administrative/ economic/ social) background data about the country, the health status of the population, and health service data which are related to the problem that has been studied.

You may slightly comprise or make additions to the corresponding section in your research proposal, including additional literature, and use it for your report.

Then the statement of the problem should follow, again revised from your research proposal with additional comments and relevant literature collected during the implementation of the study. It should contain a paragraph on what you hope(d) to achieve with the results of the study.

Global literature can be reviewed in the introduction to the statement of the problem if you have selected a problem of global interest. Otherwise, relevant literature from individual countries may follow as a separate literature review after the statement of the problem. You can also introduce theoretical concepts or models that you have used in the analysis of your data in a separate section after the statement of the problem.

Chapter 2: Objectives

NOTES

The general and specific objectives should be included as stated in the proposal. If necessary, you can adjust them slightly for style and sequence. However you should not change their basic nature. If you have not been able to meet some of the objectives this should be stated in the methodology section and in the discussion of the findings. The objectives form the HEART of your study. They determined the methodology you chose and will determine how you structure the reporting of your findings.

Chapter 3: Methodology

The methodology you followed for the collection of your data should be described in detail. The methodology section should include a description of:

- the study type;
- major study themes or variables (a more detailed list of variables on which data was collected may be annexed);
- the study population(s), sampling method(s) and the size of the sample(s);
- data-collection techniques used for the different study populations;
- how the data was collected and by whom;
- procedures used for data analysis, including statistical tests (if applicable).

If you have deviated from the original study design presented in your research proposal, you should explain to what extent you did so and why. The consequences of this deviation for meeting certain objectives of your study should be indicated. If the quality of some of the data is weak, resulting in possible biases, this should be described as well under the heading 'limitations of the study'.

Chapter 4: Research findings

The systematic presentation of your findings in relation to the research objectives is the crucial part of your report.

The description of findings should offer a good combination or triangulation of data from qualitative and quantitative components of the study. There are two different ways in which you can present your findings:

Chapter 5: Discussion

The findings can now be discussed by objective or by cluster of related variables or themes, which should lead to conclusions and possible recommendations. The discussion may include findings from other related studies that support or contradict your own.

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Chapter 6: Conclusions and recommendations

The conclusions and recommendations should follow logically from the discussion of the findings. Conclusions can be short, as they have already been elaborately discussed in chapter 5. As the discussion will follow the sequence in which the findings have been presented (which in turn depends on your objectives) the conclusions should logically follow the same order.

It makes easy reading for an outsider if the recommendations are again placed in roughly the same sequence as the conclusions. However, the recommendations may at the same time be summarised according to the groups towards which they are directed.

References

The references in your text can be numbered in the sequence in which they appear in the report and then listed in this order in the list of references (Vancouver system). Another possibility is the Harvard system of listing in brackets the author's name(s) in the text followed by the date of the publication and page number, for example: (Shan 2000: 84). In the list of references, the publications are then arranged in alphabetical order by the principal author's last name.

You can choose either system as long as you use it consistently throughout the report.

Annexes or Appendices

The annexes should contain any additional information needed to enable professionals to follow your research procedures and data analysis.

Information that would be useful to special categories of readers but is not of interest to the average reader can be included in annexes as well.

Examples of information that can be presented in annexes are:

- tables referred to in the text but not included in order to keep the report short;
- lists of hospitals, districts, villages etc. that participated in the study;
- questionnaires or check lists used for data collection.

Note:

Never start writing without an outline. Make sure that all sections carry the headings and numbers consistent with the outline before they are word-processed. Have the outline visible on the wall so everyone will be aware immediately of any additions or changes, and of progress made.

Prepare the first draft of your report double-spaced with large margins so that you can easily make comments and corrections in the text.

Have several copies made of the first draft, so you will have one or more copies to work on and one copy on which to insert the final changes for revision.

4.3 Style and Layout

NOTES

(1) Style of writing

Remember that your reader:

- Is short of time
- Has many other urgent matters demanding his or her interest and attention
- Is probably not knowledgeable concerning 'research jargon'

Therefore the rules are:

- Simplify. Keep to the essentials.
- Justify. Make no statement that is not based on facts and data.
- Quantify when you have the data to do so. Avoid 'large', 'small'; instead, say '50%', 'one in three'.
- Be precise and specific in your phrasing of findings.
- Inform, not impress. Avoid exaggeration.
- Use short sentences.
- Use adverbs and adjectives sparingly.
- Be consistent in the use of tenses (past or present tense). Avoid the passive voice, if possible, as it creates vagueness (e.g., 'patients were interviewed' leaves uncertainty as to who interviewed them) and repeated use makes dull reading.
- Aim to be logical and systematic in your presentation.

(2) Layout of the report

A good physical layout is important, as it will help your report:

- make a good initial impression,
- encourage the readers, and
- give them an idea of how the material has been organised so the reader can make a quick determination of what he will read first.

Particular attention should be paid to make sure there is:

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- An attractive layout for the title page and a clear table of contents.
- Consistency in margins and spacing.
- Consistency in headings and subheadings, e.g.: font size 16 or 18 bold, for headings of chapters; size 14 bold for headings of major sections; size 12 bold, for headings of sub-sections, etc.
- Good quality printing and photocopying. Correct drafts carefully with spell check as well as critical reading for clarity by other team-members, your facilitator and, if possible, outsiders.
- Numbering of figures and tables, provision of clear titles for tables, and clear headings for columns and rows, etc.
- Accuracy and consistency in quotations and references.

4.4 Common Weaknesses in Writing

Writing is always a challenging job, which requires courage. Starting is usually most difficult. Don't be afraid to make mistakes, otherwise you will never begin! However, it is good to be aware of common pitfalls, which you might try to avoid.

An almost universal weakness of beginning report writers is omitting the obvious. Hardly ever does the description of the country or area contain sufficient data to permit outsiders to follow the presentation of findings and discussion without problems. On the other hand, some data (e.g., exact geographical location on the globe) could be left out which are usually in.

Endless description without interpretation is another pitfall. Tables need conclusions, not detailed presentation of all numbers or percentages in the cells which readers can see for themselves. The chapter discussion, in particular, needs comparison of data, highlighting of unexpected results, your own or others' opinions on problems discovered, weighing of pro's and con's of possible solutions. Yet, too often the discussion is merely a dry summary of findings.

Neglect of qualitative data is also quite common. Still, quotes of informants as illustration of your findings and conclusions make your report lively. They also have scientific value in allowing the reader to draw his/her own conclusions from the data you present. (Assuming you are not biased in your presentation!)

Sometimes qualitative data (e.g., open opinion questions) are just coded and counted like quantitative data, without interpretation, whereas they may be providing interesting illustrations of reasons for the behaviour of informants or of their attitudes. This is serious maltreatment of data that needs correction.

Revising and Finalising the Text

When a first draft of the findings, discussion and conclusions has been completed, all working group members and facilitators should read it critically and make comments.

The following questions should be kept in mind when reading the draft:

- Have all important findings been included?
- Do the conclusions follow logically from the findings? If some of the findings contradict each other, has this been discussed and explained, if possible? Have weaknesses in the methodology, if any, been revealed?
- Are there any overlaps in the draft that have to be removed?
- Is it possible to condense the content? In general a text gains by shortening. Some parts less relevant for action may be included in annexes. Check if descriptive paragraphs may be shortened and introduced or finished by a concluding sentence.
- Do data in the text agree with data in the tables? Are all tables consistent (with the same number of informants per variable), are they numbered in sequence, and do they have clear titles and headings?
- Is the sequence of paragraphs and subsections logical and coherent? Is there a smooth connection between successive paragraphs and sections? Is the phrasing of findings and conclusions precise and clear?

The original authors of each section may prepare a second draft, taking into consideration all comments that have been made. However, you might consider the appointment of two editors amongst yourselves, to draft the complete version.

In the meantime, other group members may (re)write the introductory sections (INTRODUCTION, OBJECTIVES and METHODOLOGY, adjusted from your original proposal).

Now a first draft of the SUMMARY can be written.

4.5 Finalising the Research Report

It is advisable to have one of the other groups and facilitators read the second draft and judge it on the points mentioned in the previous section. Then a final version of the report should be prepared. This time you should give extra care to the presentation and layout: structure, style and consistency of spelling (use spell check!).

Use verb tenses consistently. Descriptions of the field situation may be stated in the past tense (e.g., 'Five households owned less than one acre of land.') Conclusions drawn from the data are usually in the present tense (e.g., 'Food taboos hardly have any impact on the nutritional status of young children.)

Note:— For a final check on readability you might skim through the pages and read the first sentences of each paragraph. If this gives you a clear impression of the organisation and results of your study, you may conclude that you did the best you could.

NOTES

Group Work

1. Make an outline for your report on a flipchart, after reviewing your objectives, your sources of information and the outcomes of your data analysis. Number proposed sections and subsections. Stick the outline to the wall in a visible place. Leave sufficient space between the lines for additions (more subsections, for example) and for changes.
2. Start writing, beginning with the chapter on findings. Decide with your facilitator whether you will interpret the data presenting it by variable, by objective or by study population. If you are unsure in the beginning which method of organising the presentation will work best, record your findings and interpretations by study population. In the second draft you can decide how to reorganise and shorten the presentation. Divide writing tasks among sub-groups of one or two persons.
3. Discuss your findings in relation to each other, to the objectives and to other literature, and write the chapter Discussion. Then list the major conclusions in relation to possible recommendations.
4. Develop at the same time the introductory chapters (background and statement of the problem, including new literature, objectives and methodology), adapting what you prepared for the proposal.
5. Finally, develop the summary following the outline given earlier in this module. Take at least half a day for this, working systematically.
6. Keep track of progress in writing and typing, making notes on the flipchart that has the outline of your report.
7. Go over the first draft with the group as a whole checking it for gaps, overlaps, etc. before the second draft is prepared. Have a facilitator from another group read the whole draft report before it is finalised.

Sample Questions

1. What is the meaning and significance of report in research?
2. Discuss the types of research.
3. What is the standard structure of a report?
4. How is report written?
5. What are the fundamental weaknesses of a report writing?
6. How is final touch given to a report?