RESEARCH METHODOLOGY (DJ21)

(M.A. JOURNALISM AND MASS COMMUNICATION)

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Unit I : Lesson I : Introduction To Research Methods

1. Objective of the Lesson:

The objective of the lesson is to help you in :

- **Understanding mass communication research**
- **Understanding the meaning of research**
- **Gaining an understanding of steps in research Identification and formulation of problem in research**

2. Structure of the Lesson:

- Introduction to mass communication research
- The meaning of research
- Methods and cause: a preliminary statement
- Stages of methodologies
- Steps in research identification and formulation of problem in research

3. Expansion of the Structure:

Introduction to Mass Communication Research

Mass communication is the term used to describe the academic study of various means by which individuals and entities relay information to large segments of the population all at once through Mass media.

Mass communication research includes media institutions and processes, such as diffusion of information, and media effects, such as persuasion or manipulation of public opinion.

With the Internet's increased role in delivering news and information, mass communication studies -- and media organizations -- have increasingly focused on the convergence of publishing, broadcasting and digital communication.

The academic mass communication discipline historically differs from media studies and communications studies programs with roots in departments of theatre, film or speech, and with more interest in "qualitative," interpretive theory, critical or cultural approaches to communication study. In contrast, many mass communication programs historically lean toward empirical analysis and quantitative research -- from statistical content analysis of media messages to survey research, public opinion polling, and experimental research.

Interest in "New Media" and "Computer Mediated Communication" is growing much faster than educational institutions can assimilate it. So far, traditional classes and degree programs have not been able to accommodate new paradigm shifts in communication technologies. Although national standards for the study of interactive media have been in place since the mid-nineties, course work in these areas tends to vary significantly from university to university.

Graduates of Mass Communication programs work in a variety of fields in traditional news media and publishing, advertising, public relations and research institutes.

As New Technology for communicating proliferates, we could end up communicating less. With the burgeoning of our technical ability to send messages - to saturate large audiences over a wide geographic area, or to zero in on one or more persons in a finite target area - comes a second phenomenon: the fragmentation of publics. No longer can we as communicators aim at a relatively few large targets based on the traditional demographic groups. We can't depend on the conventional mass media as our primary vehicle for informing, persuading and activating our publics.

With the winding down of the second millennium, we appear also to be nearing the end of a figurative millennium the golden age of mass communication. We are moving into the age of multiple mini-communication and fractionated publics/audiences/markets.

As communicators play catch-up with today's communication technology, we fantasize about tomorrow's and strive for the appearance of being aucourant by dropping references to exotic forms of communication into our conversation with colleagues and potential clients. The jargon includes fascinating terms like teleports, video windows, fiber optics, voice-text synthesis, ISDN (integrated services digital network). Actually, all of these have potential value to PR practitioners, but we will have to learn about them, or hire someone who does.

It is safe to say that many PR practitioners have not grasped that today's communication technology, not to mention what is to come, is both a curse - overloading the average person (public, audience, consumer) with sound, picture and printed word - and at the same time a blessing - providing an infinite number of avenues for transmitting messages. Nor, unfortunately, have we fully grasped the extent of fragmentation of our PR publics.

Problems Confronting Communicators

There are several changes confronting today's public relations practitioners. First is the loss of credibility of the traditional media, accompanied by the fact that "communication offers so many alternatives."

We have become skeptical. The question now in the average person's mind is: "How much faith can I put in any particular information source"" He sees conflicts the field of communication. We get conflicting information; we are given alternatives. Therefore, it is difficult for any one medium, or medium organization, to be the authority, to be as influential as it once was.

As for communication technology, we are becoming an aural society. We take in information through our ears rather than reading. We can listen, or watch, while doing something else, and no longer have to concentrate on what's coming at us. The marketing department is putting out one message, the advertising agency another, the PR people another, and the sales department joins in with another pitch. So communicators are going here : communicating selective messages to selective publics via selective communication mediums. The selection of the message and the medium depends, more than ever now on detailed, and sometimes painstaking, research into the public at which we aim. No longer can we do as we have done, send out the same basic news release with some rewrite and localizing, to all of the mass media in a geographic area. Now, we must deal with micro-media directed to mini-publics.

As publics fragment from larger publics into splinter publics, as they coalesce and fall apart, and as our interests as consumers of information and ideas wax and wane, those who wish to reach us with their messages must do more and more audience research.

Public opinion researchers and analysts are finding more and more ways to identify individuals as members of focus-publics, and multiple publics. The expanding use of bar scanner code technology in supermarkets to do more than just tote up prices at checkout counters is an example. As customers are willing to trade in a little of their privacy and divulge certain information about themselves, we can determine exactly who is buying what. The next step beyond this could be identification of lifestyles of each purchaser, a factor communicators are including in their public persuasion equations.

Confronted by competition from cable television, the traditional broadcast media-network and local-are going to "niche" programming. Based on continuing audience surveys, they are directing advertisers to the time of day and type of program that offers maximum impact on specific audiences; e.g.

married women between 26 and 40 with two children. This projected narrow-casting is based on consumer market profiles. Public relations practitioners can use the same research in planning institutional image or advocacy advertising.

Newspapers continue to fragment their daily print package into multiple specially labeled sections and pages aimed at specific reader interests. Special zone editions for specific geographic areas have replaced the now outmoded city, metro and downstate editions. Special sections abound. Typical is The Oregonian (Portland) which announced 34 special sections for 1990, with editorial (publicity giveaway) themes ranging from winter sports, to jazz, to health and fitness, to personal finance.

Magazines have taken dramatic steps to provide a print product that meets the need of today's "fractionating" publics. Through the use of inkjet imaging and selective binding, magazines - following the lead of catalogs - are into personal publishing. Selective binding, through computer control, uses an automated assembly line on which each copy of a magazine can be assembled with a different mix of ads and articles. You could receive your own personalized copy of a nationally distributed magazine-or any publication prepared by a public relations practitioner.

Information-service companies have computer lists of millions of names with individual personal information on each which has been researched from vehicle license registrations, and other public records, such as census data and change-of-address requests.

It is interesting that a farm publication, the Farm Journal, which has over a million readers, was the leader in personalized publishing. In an interview with the Hartford Courant, F-J executive Roger Randall said, "Each individual subscriber's magazine is manufactured separately ... Based on known information about the reader, you're building a magazine that hopefully is more interesting to the reader." Aimed at an agricultural readership that varies widely by crop, geography and acreage, the Farm Journal each year sends out more than a thousand different versions of each of its 14 issues.

The Time magazine group (Time, Sports Illustrated and People), garnered headlines with its highly publicized January 1990, PR ploy; each of the group's 9 million subscribers opened his or her magazine to find an Isuzu advertisement with her or his own name imprinted, plus that of the nearest Isuzu dealer.

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As an example, futurist Jay Ogilvy in the same book writes: "What gets me is how utterly inappropriate our basic economic categories are. We need to recast the concept of property, for one thing, because in Marx's terms property is by definition alienable: that is, unlike your elbow, which is you and not yours, property must be transfer. able to another aha equals other). I sell you the cow. You got the cow. I don't have the cow anymore. I send you information. You got the information. I still have the information."

This changing trend in communication in today’s world has warranted the need for research into communication that primarily focuses on :

- The access to media by people
- The use of media by people
- The effects of the media
- Other unintended results

The Meaning of Research

In Methods of communication research, we study several "quantitative" and "qualitative" methods--or, in my preferred terminology, more or less structured research designs for collecting data. We will deal with empirical research, i.e., tangible data which is assessed using the evidence of our senses. While these kinds of data collection methods are not the only way in which we "know" things, they have particular utility for testing research hunches and hypotheses in a variety of fields.

Research Methods are most often used for two major purposes:

(1) To establish "facts" or recurring regularities in the environment. Examples of facts include:

The incidence of violence on high school campuses.
The percentage of adult Koreans with access to the Internet at least once a week.
How many American adults over 18 engage in physical exercise.

(2) To test (and, more surreptitiously, establish) causal explanations for established facts. Most theories address explanations for factual material. Explanations typically assert causal relationships among variables of interest. For example:

Students who engage in explosive violence on high school campus have been bullied at that school.

Science or technology professionals have greater access to the Internet at work than other workers do.
Men more often engage in physical exercise than women.

Establishing facts is hard enough! The measures we use may be contaminated by response bias (e.g., many people tend to agree with any general statement. As a result, you may not know whether your scale measures the desired construct--or "agreement response set.") The population you studied may be relatively small and harbor unique characteristics that are not typical of your true population of interest. For example, it is risky to generalize from studies of college undergraduates to corporate workers. You may have measured the wrong dimensions or omitted key facets of your topic (example: you thought you were measuring positive attitudes toward performance--but instead you measured emotions about competition).

METHODS AND CAUSE: A PRELIMINARY STATEMENT

As soon as we try to establish causal precedence, things become even more difficult. For every pair of factors that we see locked in a causal relationship:

We could mistake the direction of causality. For example, recent work on parents who physically discipline (spank!) their children found that nearly 19 out of every 20 parents use some form of physical discipline. The rare children whose parents never spanked them were found to have exemplary behavior. The assumption was that parental discipline patterns influenced children's behavior. BUT, isn't it possible that "exemplary children" never even tempted their parents to use physical discipline in the first place? That is, the true causal variable here was the behavior of CHILDREN, rather than parents.

Any apparent causal relationship occurs because a third factor caused both the orginal "cause" and also the "effect." In other words, the relationship is "spurious," and not a "true" or "real" causal relationship. For example, several decades ago, researchers found that American high school students who smoked cigarettes had lower grades. Their conclusion was that something about smoking caused lower grades. Leaving aside the reversed causal possibility (your grades were so awful, you began smoking to relieve the stress), later scholars found that the "true cause" was parental social class. High school students who came from poorer backgrounds were both more likely to smoke cigarettes and also had lower grades. Once parental background was controlled, student cigarette smoking no longer predicted grade point average. Spurious relationships appear in experimental studies too; for example, your results may be due to anxiety aroused by being in a testing situation or an artifact of a particular treatment manipulation.

A very recent example of misapplied causal inference is that of Hormone Replacement Therapy (HRT) in postmenopausal women. Early studies reported that women taking estrogen/progesterone hormone supplements had lower rates of heart attacks and lower odds of osteoporosis. The data appeared so impressive that many doctors did not wait for more conclusive experimental results in their recommendations, so that by early 2002, over SIXTEEN MILLION U.S. WOMEN were on HRT. However, a few years ago, a massive experimental study was begun. Half the U.S. women received HRT and the other half received a sugar pill placebo. The women were followed longitudinally. To the researchers' shock, the experimental data indicated that women on HRT, in fact, had HIGHER rates of heart attacks and strokes. Although the incidence was still low, the data were convincing enough the experiment was immediately terminated and millions of postmenopausal women are now uncertain of what medication course to follow.

How could this happen? Women who took very good care of themselves: (A) were more likely to see their doctors and thus receive HRT in the observational studies and (B) women who take good care of themselves have a lower incidence of heart attacks in general. The TRUE causal factor, apparently, is the level of responsibility that individual women take for their physical well-being. Although the data are still far from all in, it appears that this is one case where incorrect causal inferences in observational data were literally lethal.

Your results were caused by alternative causal variables, leaving your original causal explanation suspect. For example, I recently found that the level of basic science knowledge in American adults was somewhat higher among men than among women. People who have read this material conclude that women are just less knowledgeable about science. HOWEVER, I later discovered that much of the difference occurred not only because women gave more incorrect answers than men, but also because women gave more "I don't know" responses than men did. Issues such as self-efficacy become more important in giving "I don't know" responses than incorrect ones.

A considerable amount of scholarship consists of formulating and testing alternative causal explanations for "factual material," that is, teasing out how and why regularities occur. Methodology is critical in the research enterprise. Some alternative explanationsare methodological artifacts: for example, a limited population; an unrepresentative sample; biased questionnaire items or tests; or incomplete experimental treatments. Others are conceptual issues that can only be tested using thorough methods of data collection.

STAGES OF METHODOLOGIES

All research designs share some common similarities and a well-planned sequence of activities. Some basic ones are mentioned below:

- Being able to develop a research problem
- Deciding on the unit of analysis (individual? group? organizations?) and taking measures that are consistent with that unit of analysis
- Deciding how to sample one's chosen units
- Deciding how to measure one's concepts via choice of method (experiment? survey questionnaire, including "tests"? archival search? etc.)
- Once a method has been chosen, deciding on actual measures and procedures, such as questionnaire items or experimental treatments
- Pilot testing one's measures and double-checking the results
- Moving "into the field" to collect data
- Making contact with subjects and respondents, including Institutional Review Boards (Human Subjects Committees) and any organizational representatives.
- Training field staff
- Supervising or conducting data collection
- Reducing the collected data to manageable size by selecting coding categories and coding the data
- Analyzing the data
- Reporting the results

Steps in research Identification and formulation of problem in research

Most of us, when we begin to write up professional research, like to start writing our papers like storytellers. We discuss an interesting recent research finding. We describe a compelling social problem. Very often, the "meat" of our study does not even emerge until the fifth typewritten page. Besides making it very difficult for your reader, who must scrutinize your vivid prose for several pages to learn what it is that you will even study and the topic of your research, this written procrastination serves as a signal that the researcher is not really sure what the research is about!

Some things to be noted down are :

What the project is about. Anxiety and testing results? Hormone fluxuations and sports participation? Motivation tools and sports team performance?

Why this project is important. Why it is a subject worthy of study. Will it cure a social problem? Will it diagnose a learning disability? Will it help individuals achieve a higher performance? Will it extend scholarship in the discipline?

What specifically will be done in this study. An examination of how gender and educational type and level influence science knowledge in survey data? An experiment with social identity threat and pain tolerance? An observational study of group dynamics on football teams?

This combination of elements constitutes your research problem statement: the general area of your research, why it is important, and what specifically you will study.

The research problem statement will also address:

The key conceptual variables and definitions of these variables.

Postulated causal relationships among these variables (or, conceptual hypotheses).

Writing a research problem statement will be THE MOST DIFFICULT ASSIGNMENT you will have all semester, and you will rewrite it a few times over the next several weeks.

HOW TO GET STARTED

If you are having trouble conceptualizing a research problem, you are not alone. This is typically the most difficult stage of conducting research. Further, in less structured research, you may be constantly revising the research problem as you gather data, and you may do so in any kind of research if you encounter surprising and unanticipated results. Nevertheless, here are several "tried and true" ways to begin.

CONCEPTUAL AND DEDUCTIVE APPROACH.

You are thoroughly familiar with the literature in your area (say, self-regulated learning) and you are aware of gaps where theory has not yet been tested, or where theoretical predictions contradict one another, or you derive your research problem from some basic theoretical assumptions. For example, perhaps you compare the reading assessment scores of elementary school children taught via "whole learning" versus "phonetics".

CURIOSITY.

Intrigued by regularly occurring "fact," you wish to know more about why and how that fact occurs. You may be dissatisfied with previous explanations. For example, why does educational level affect basic science knowledge? Is it the type of college major? Stimulating an interest in science? "Weeding out" the less intelligent? Holding a scientific or technical job?

You may encounter a surprising, unanticipated "serendipitous" finding that begs for an explanation. Your guesses about why this anomalous result occurred become the basis of defining your research problem. Example, several decades ago, researchers on achievement motivation discarded women subjects because their results did not "fit" the researchers' paradigm. Encountering this unexplained quirk in a footnote in my textbook, I have been examining issues in gender ever since.

Your major professor or your client defines the research problem and you conduct the study. In my experience, working for a client can be the most difficult way to begin because the client often has a very fuzzy idea at best of what they want to know or do. You often end up defining, or at the least, clarifying and refining the research problem for the client.

To develop a strong research question from your ideas, you should ask yourself these things:

- Do I know the field and its literature well?
- What are the important research questions in my field?
- What areas need further exploration?
- Could my study fill a gap? Lead to greater understanding?
- Has a great deal of research already been conducted in this topic area?
- Has this study been done before? If so, is there room for improvement?
- Is the timing right for this question to be answered? Is it a hot topic, or is it becoming obsolete?
- Would funding sources be interested?
- If you are proposing a service program, is the target community interested?
- Most importantly, will my study have a significant impact on the field?

A strong research idea should pass the “so what” test. Think about the potential impact of the research you are proposing. What is the benefit of answering your research question? Who will it help (and how)? If you cannot make a definitive statement about the purpose of your research, it is unlikely to be funded.

A research focus should be narrow, not broad-based. For example, “What can be done to prevent substance abuse?” is too large a question to answer. It would be better to begin with a more focused question such as“ What is the relationship between specific early childhood experiences and subsequent substance-abusing behaviors?”

A well-thought-out and focused research question leads directly into your hypotheses. What predictions would you make about the phenomenon you are examining? This will be the foundation of your application.

Hypotheses are more specific predictions about the nature and direction of the relationship between two variables. For example, “Those researchers who utilize an online grant writing tutorial will have higher priority scores on their next grant application than those who do not.”

Strong hypotheses:

Give insight into a research question;
Are testable and measurable by the proposed experiments;
Spring logically from the experience of the staff;

Normally, no more than three primary hypotheses should be proposed for a research study. A proposal that is hypothesis-driven is more likely to be funded than a “fishing expedition” or a primarily descriptive study.

Make sure you:

Provide a rationale for your hypotheses—where did they come from, and why are they strong?
Provide alternative possibilities for the hypotheses that could be tested—why did you choose the ones you did over others?

If you have good hypotheses, they will lead into your Specific Aims. Specific aims are the steps you are going to take to test your hypotheses and what you want to accomplish in the course of the grant period. Make sure:

Your objectives are measurable and highly focused;

Each hypothesis is matched with a specific aim.
The aims are feasible, given the time and money you are requesting in the grant.

An example of a specific aim would be “Conduct a rigorous empirical evaluation of the online grant writing tutorial, comparing outcome and process measures from two groups—those with exposure to the tutorial and those without.”

Long-Term Goals:

- Why are you doing this research?
- What are the long-term implications?
- What will happen after the grant?
- What other avenues are open to explore?
- What is the ultimate application or use of the research?

These questions all relate to the long-term goal of your research, which should be an important undercurrent of the proposal. Again, they should be a logical extension of the research question, hypotheses, and specific aims.

It is also helpful to have a long-term plan for your own career development. Where would you like to see your career go in the next 5 years? How does the research you are proposing relate to that plan?

4. Summary:

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(2) To test (and, more surreptitiously, establish) causal explanations for established facts. Most theories address explanations for factual material. Explanations typically assert causal relationships among variables of interest.

All research designs share some common similarities and a well-planned sequence of activities. They are being able to develop a research problem, deciding on the unit of analysis (individual? group? organizations?) and taking measures that are consistent with that unit of analysis, deciding how to sample one's chosen units, deciding how to measure one's concepts via choice of method, once a method has been chosen, deciding on actual measures and procedures, such as questionnaire items or experimental treatments, pilot testing one's measures and double-checking the results, moving "into the field" to collect data, making contact with subjects and respondents, including Institutional Review Boards (Human Subjects Committees) and any organizational representatives, training field staff, supervising or conducting data collection, reducing the collected data to manageable size by selecting coding categories and coding the data, analyzing the data and reporting the results.

5. Model Questions

1. Mention the current trends in mass communication research.
2. Mention some important steps in research.
3. Discuss the different stages of methodologies.
4. Mention the steps in research identification and formulation of problem in research.

6. Reference Books:

1. Anderson, J.A (1987) Communication Research : Issues and Methods. New York : McGraw Hill.
2. Babbie, E.R. (2001) The practice of social research, Belmont, CA : Wadsworth.
3. Bowers, J.W. and Courtwright, J.A. (1984) Communication Research methods, Glenview, IL : Scott, Foresman.
4. Sharp, N.W. (1988) Communication research : the Challenge of the information age. Syracuse, NY, Syracuse University Press.
5. Williams, F (1988) Research methods and the new media, New York, Free Press.

Unit I : Lesson II : The scientific method

1. Objective of the Lesson:

The objective of the lesson is to:

- **Introduce you to the scientific method**
- **Help you understand the characteristics of scientific method.**
- **Help you understand the steps in scientific method**

2. Structure of the Lesson:

- Introduction to the Scientific Method
- Why use the Scientific Method?
- Characteristics of the scientific method
- Characteristics of science
- Steps in scientific method

3. Expansion of the Structure:

The Scientific Method

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.

Why use the Scientific Method?

Our personal and cultural beliefs can influence our perceptions and our interpretations of phenomena.

The scientific method minimizes the influence of experimenter bias or prejudices.

The scientific method enables researchers, collectively and over time, to construct a reliable, consistent, and non-arbitrary representation of the world.

Characteristics of the scientific method

- ***It's public***
- ***It's objective***
- ***It's empirical***
  - operational definitions
  - constitutive definitions
- ***It's systematic and cumulative***
- ***It's predictive***

Characteristics of Science:

1. It is guided by natural law

– The pursuit of scientific knowledge must be guided by the physical and chemical laws that govern the universe (state of existence).

2. It has to be explained by referencing these natural laws.

– Scientific knowledge must explain what is observed by reference in nature. We cannot invoke the explanations based on supernatural deities (ghosts, angels, gremlins, fairies, etc.) miracles, or magic.

– Science must only rely on observable, testable evidence which must either support or not support hypotheses. Extraordinary claims require extraordinary evidence.

3. Science is testable against the observable world.

– We must be able to make observations in the real world, directly or indirectly, ask questions, or form and test hypotheses = a tentative, causal explanation/answer for an observation or phenomenon.

_ We use observations and/or tests to answer questions about the natural world.

– Science relies on observable, testable evidence, which must either support or not support hypotheses.

4. Its conclusions are tentative, that is, are not necessarily the final word.

_ If we draw a conclusion based on some observation or test on some event, we must be ready always to discard or to modify our conclusion, if further observations falsify it.

_ Can't be scientific if you start with a conclusion and refuse to change it regardless of the evidence developed during the course of the investigation.

5. It is falsifiable.

You must be able to disprove any statement. If there is no possibility that the statement cannot be correct, then it isn't science. What this means is that science will seek out errors and correct them. Unlike other philosophies, it's a self-correcting system. We add to and take away information on a daily basis depending on new discoveries and new evidence.

6. It relies on evidence that is testable (from observations and experimentations). If we cannot make repeated observations or experiments to gather information, then it is outside the realm of science (e.g. UFO's, haunted houses, etc.).

7. One cannot ever prove things true or false in science. Probability plays a role, as do critical values.

8. Correlation does not imply Causation. Just because the price of beans in China goes up when the Dalllas Cowboys football team loses does NOT mean the loss caused the bean prices to go up.

I. 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.

Therefore the Steps in the scientific method are:

- Observation and description of a phenomenon or group of related phenomena
- Formulation of a hypothesis to explain the phenomena
- Predict the existence of other phenomena
- Using the hypothesis
- Conduct experimental tests of the predictions

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.

II. 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 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? This is discussed in more detail in the appendix on *Error Analysis* and in Statistics Lab 1.

III. Common Mistakes in Applying the Scientific Method

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.

IV. Hypotheses, 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.

V. 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.

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.

4. Summary

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. The scientific method is

•public

•objective

•empirical

•It's systematic and cumulative

•It's predictive

The scientific method is guided by natural law. It has to be explained by referencing these natural laws. Science is testable against the observable world. Its conclusions are tentative, that is, are not necessarily the final word. It is falsifiable. **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.

5. Model Questions

1. Explain the scientific method of investigation.
2. Mention the characteristics of the scientific method.
3. What are the steps in the scientific method ?

6. Reference Books

1. Wilson, E. Bright. An Introduction to Scientific Research (McGraw-Hill, 1952).

2. Kuhn, Thomas. The Structure of Scientific Revolutions (Univ. of Chicago Press, 1962).

3. Barrow, John. Theories of Everything (Oxford Univ. Press, 1991).

Unit 2 : Lesson 1 : Basic Elements of Research – Concepts, definitions, Variables, Hypothesis and Causation

1. Objective of the Lesson:

The objective of the lesson is to:

- **Introduce you to the basic elements of research**
- **Help you understand concepts, definitions and variables**
- **Help you understand hypothesis and causation**

2. Structure of the Lesson:

- **Concepts**
- **Definition**
- **Variables**
- **Types of Variables**
- **Hypothesis**
- **Types of Hypothesis**
- **Causation**

3. Expansion of the Structure:

Concepts

A concept is a term that expresses an abstract idea formed by generalizing from particulars and summarizing related observations. For eg. The researcher might observe that a public speaker becomes restless, starts to perspire, and continuously fidgets with a pencil before giving a speech. The researcher may summaries these observations of behavior and label them as "speech anxiety". On a more ordinary level, the word table is a concept that represents a wide variety of observable objects , ranging from a plank supported by concrete blocks to a piece of furniture commonly found in dining rooms. Typical concepts in mass communication research includes terms like advertising effectiveness, message length, media usage, and readability.

As the term is used in mainstream cognitive science, a concept is an abstract idea or a mental symbol, typically associated with a corresponding representation in and language or symbology.

A vast array of accounts attempt to explain the nature of concepts. According to classical accounts, a concept denotes all of the entities, phenomena, and/or relations in a given category or class by using definitions. Concepts are abstract in that they omit the differences of the things in their extension, treating the members of the extension as if they were identical. Classical concepts are universal in that they apply equally to every thing in their extension. Concepts are also the basic elements of propositions, much the same way a word is the basic semantic element of a sentence. Unlike perceptions, which are particular images of individual objects, concepts cannot be visualized. Because they are not themselves individual perceptions, concepts are discursive and result from reason.

Concepts are expected to be useful in dealing with reality. Generally speaking, concepts are taken to be (a) acquired dispositions to recognize perceived objects as being of this kind or of that ontological kind, and at the same time (b) to understand what this kind or that kind of object is like, and consequently (c) to perceive a number of perceived particulars as being the same in kind and to discriminate between them and other sensible particulars that are different in kind. In addition, concepts are acquired dispositions to understand what certain kinds of objects are like both (a) when the objects, though perceptible, are not actually perceived, and (b) also when they are not perceptible at all, as is the case with all the conceptual constructs we employ in physics, mathematics, and metaphysics. The impetus to have a theory of concepts that is ontologically useful has been so strong that it has pushed forward accounts that understand a concept to have a deep connection with reality.

On some accounts, there may be agents (perhaps some animals) which don't think about, but rather use relatively basic concepts (such as demonstrative and perceptual concepts for things in their perceptual field), even though it is generally assumed that they do not think in symbols.[citation needed]. On other accounts, mastery of symbolic thought (in particular, language) is a prerequisite for conceptual thought.

Concepts are bearers of meaning, as opposed to agents of meaning. A single concept can be expressed by any number of languages. The concept of DOG can be expressed as dog in English, Hund in German, as chien in French, and perro in Spanish. The fact that concepts are in some sense independent of language makes translation possible - words in various languages have identical meaning, because they express one and the same concept.

A term labels or designates concepts. Several partly or fully distinct concepts may share the same term. These different concepts are easily confused by mistakenly being used interchangeably, which is a fallacy. Also, the concepts of term and concept are often confused, although the two are not the same.

The acquisition of concepts is studied in machine learning as supervised classification and unsupervised classification, and in psychology and cognitive science as concept learning and category formation. In the philosophy of Kant, any purely empirical theory dealing with the acquisition of concepts is referred to as a noogony.

Definition

A definition is a thorough description of the meaning of a lexical unit.

The parts of a definition:

- Synthetic component consisting of the following:

    Analytic definition

Supplemental information

- Translation equivalents (in bilingual definitions) or near synonyms (in monolingual definitions)

Variables

A ***variable*** is *any entity that can take on different values*. OK, so what does that mean? Anything that can vary can be considered a variable. For instance, *age* can be considered a variable because age can take different values for different people or for the same person at different times. Similarly, *country* can be considered a variable because a person's country can be assigned a value.

Variables aren't always 'quantitative' or numerical. The variable 'gender' consists of two text values: 'male' and 'female'. We can, if it is useful, assign quantitative values instead of (or in place of) the text values, but we don't have to assign numbers in order for something to be a variable. It's also important to realize that variables aren't only things that we measure in the traditional sense. For instance, in much social research and in program evaluation, we consider the treatment or program to be made up of one or more variables (i.e., the 'cause' can be considered a variable). An educational program can have varying amounts of 'time on task', 'classroom settings', 'student-teacher ratios', and so on. So even the program can be considered a variable (which can be made up of a number of sub-variables).

An ***attribute*** is a specific value on a variable. For instance, the variable *sex* or *gender* has two attributes: *male* and *female*. Or, the variable *agreement* might be defined as having five attributes:

- 1 = strongly disagree
- 2 = disagree
- 3 = neutral
- 4 = agree
- 5 = strongly agree

Another important distinction having to do with the term 'variable' is the distinction between an ***independent*** and ***dependent*** variable. This distinction is particularly relevant when you are investigating cause-effect relationships. It took me the longest time to learn this distinction. (Of course, I'm someone who gets confused about the signs for 'arrivals' and 'departures' at airports -- do I go to arrivals because I'm arriving at the airport or does the person I'm picking up go to arrivals because they're arriving on the plane!). I originally thought that an independent variable was one that would be free to vary or respond to some program or treatment, and that a dependent variable must be one that *depends* on my efforts (that is, it's the *treatment*). But this is entirely backwards! In fact ***the independent variable is what you (or nature) manipulates*** -- a treatment or program or cause. The ***dependent variable is what is affected by the independent variable*** -- your effects or outcomes. For example, if you are studying the effects of a new educational program on student achievement, the program is the independent variable and your measures of achievement are the dependent ones.

Finally, there are two traits of variables that should always be achieved. Each variable should be ***exhaustive***, it should include all possible answerable responses. For instance, if the variable is "religion" and the only options are "Protestant", "Jewish", and "Muslim", there are quite a few religions I can think of that haven't been included. The list does not exhaust all possibilities. On the other hand, if you exhaust all the possibilities with some variables -- religion being one of them -- you would simply have too many responses. The way to deal with this is to explicitly list the most common attributes and then use a general category like "Other" to account for all remaining ones. In addition to being exhaustive, the attributes of a variable should be ***mutually exclusive***, no respondent should be able to have two attributes simultaneously. While this might seem obvious, it is often rather tricky in practice. For instance, you might be tempted to represent the variable "Employment Status" with the two attributes "employed" and "unemployed." But these attributes are not necessarily mutually exclusive -- a person who is looking for a second job while employed would be able to check both attributes! But don't we often use questions on surveys that ask the respondent to "check all that apply" and then list a series of categories? Yes, we do, but technically speaking, each of the categories in a question like that is its own variable and is treated dichotomously as either "checked" or "unchecked", attributes that *are* mutually exclusive.

Types of Variables

We can distinguish between two types of variables according to the level of measurement:

1. Continuous or Quantitative Variables.
2. Discrete or Qualitative Variables.

A quantitative variable is one in which the variates differ in magnitude, *e.g.* income, age, GNP, etc. A qualitative variable is one in which the variates differ in kind rather than in magnitude, *e.g.* marital status, gender, nationality, etc.

Continuous or Quantitative Variables

Continuous variables can be classified into three categories:

- *Interval - scale Variables*:

  Interval scale data has order and equal intervals. Interval scale variables are measured on a linear scale, and can take on positive or negative values. It is assumed that the intervals keep the same importance throughout the scale. They allow us not only to rank order the items that are measured but also to quantify and compare the magnitudes of differences between them. We can say that the temperature of 40°C is higher than 30°C, and an increase from 20°C to 40°C is twice as much as the increase from 30°C to 40°C. Counts are interval scale measurements, such as counts of publications or citations, years of education, etc.

- *Continuous Ordinal Variables*

  They occur when the measurements are continuous, but one is not certain whether they are on a linear scale, the only trustworthy information being the rank order of the observations. For example, if a scale is transformed by an exponential, logarithmic or any other nonlinear monotonic transformation, it loses its interval - scale property. Here, it would be expedient to replace the observations by their ranks.

- *Ratio - scale Variables*

  These are continuous positive measurements on a nonlinear scale. A typical example is the growth of bacterial population (say, with a growth function Ae^{Bt}.). In this model, equal time intervals multiply the population by the same ratio. (Hence, the name ratio - scale).

  Ratio data are also interval data, but they are not measured on a linear scale. . With interval data, one can perform logical operations, add, and subtract, but one cannot multiply or divide. For instance, if a liquid is at 40 degrees and we add 10 degrees, it will be 50 degrees. However, a liquid at 40 degrees does not have twice the temperature of a liquid at 20 degrees because 0 degrees does not represent "no temperature" -- to multiply or divide in this way we would have to use the Kelvin temperature scale, with a true zero point (0 degrees Kelvin = -273.15 degrees Celsius). In social sciences, the issue of "true zero" rarely arises, but one should be aware of the statistical issues involved.

There are three different ways to handle the ratio-scaled variables.

- Simply as interval scale variables. However this procedure should be avoided as it can distort the results.
- As continuous ordinal scale.
- By transforming the data (for example, logarithmic transformation) and then treating the results as interval scale variables.

Qualitative or Discrete Variables

Discrete variables are also called categorical variables. A discrete variable, *X*, can take on a finite number of numerical values, categories or codes. Discrete variables can be classified into the following categories:

1. Nominal variables
2. Ordinal variables
3. Dummy variables from quantitative variables
4. Preference variables
5. Multiple response variables

1. *Nominal Variables*

Nominal variables allow for only qualitative classification. That is, they can be measured only in terms of whether the individual items belong to certain distinct categories, but we cannot quantify or even rank order the categories: Nominal data has no order, and the assignment of numbers to categories is purely arbitrary. Because of lack of order or equal intervals, one cannot perform arithmetic (+, -, /, *) or logical operations (>, <, =) on the nominal data. Typical examples of such variables are:

Gender:	1.Male 2. Female
Marital Status:	1. Unmarried 2. Married 3. Divorcee 4. Widower

2. *Ordinal Variables*

A discrete ordinal variable is a nominal variable, but its different states are ordered in a meaningful sequence. Ordinal data has order, but the intervals between scale points may be uneven. Because of lack of equal distances, arithmetic operations are impossible, but logical operations can be performed on the ordinal data. A typical example of an ordinal variable is the socio-economic status of families. We know 'upper middle' is higher than 'middle' but we cannot say 'how much higher'. Ordinal variables are quite useful for subjective assessment of 'quality; importance or relevance'. Ordinal scale data are very frequently used in social and behavioral research. Almost all opinion surveys today request answers on three-, five-, or seven-point scales. Such data are not appropriate for analysis by classical techniques, because the numbers are comparable only in terms of relative magnitude, not actual magnitude.

Consider for example a questionnaire item on the time involvement of scientists in the 'perception and identification of research problems'. The respondents were asked to indicate their involvement by selecting one of the following codes:

1 = Very low or nil
2 = Low
3 = Medium
4 = Great
5 = Very great

Here, the variable 'Time Involvement' is an ordinal variable with 5 states.

Ordinal variables often cause confusion in data analysis. Some statisticians treat them as nominal variables. Other statisticians treat them as interval scale variables, assuming that the underlying scale is continuous, but because of the lack of a sophisticated instrument, they could not be measured on an interval scale.

3. *Dummy Variables from Quantitative Variables*

A quantitative variable can be transformed into a categorical variable, called a dummy variable by recoding the values. Consider the following example: the quantitative variable *Age* can be classified into five intervals. The values of the associated categorical variable, called dummy variables, are 1, 2,3,4,5:

[Up to 25]	1
[25, 40]	2
[40, 50]	3
[50, 60]	4

[Above 60]	5

4. *Preference Variables*

Preference variables are specific discrete variables, whose values are either in a decreasing or increasing order. For example, in a survey, a respondent may be asked to indicate the importance of the following nine sources of information in his research and development work, by using the code [1] for the most important source and [9] for the least important source:

1. Literature published in the country
2. Literature published abroad
3. Scientific abstracts
4. Unpublished reports, material, etc.
5. Discussions with colleagues within the research unit
6. Discussions with colleagues outside the research unit but within institution
7. Discussions with colleagues outside the institution
8. Scientific meetings in the country
9. Scientific meetings abroad

Note that preference data are also ordinal. The interval distance from the first preference to the second preference is not the same as, for example, from the sixth to the seventh preference.

1. *Multiple Response Variables*

Multiple response variables are those, which can assume more than one value. A typical example is a survey questionnaire about the use of computers in research. The respondents were asked to indicate the purpose(s) for which they use computers in their research work. The respondents could score more than one category.

1. Statistical analysis
2. Lab automation/ process control

3. Data base management, storage and retrieval
4. Modeling and simulation
5. Scientific and engineering calculations
6. Computer aided design (CAD)
7. Communication and networking
8. Graphics

Hypothesis

A hypothesis consists either of a suggested explanation for a phenomenon or of a reasoned proposal suggesting a possible correlation between 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.

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 needs 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. To meet this additional criterion, it must at least in principle be possible to make an observation that would disprove the proposition as false, even if one has not actually (yet) made that observation. A falsifiable hypothesis can greatly simplify the process of testing to determine whether the hypothesis has instances in which it is false. The scientific method involves experimentation on the basis of falsifiable hypotheses in order to answer questions and explore observations.

In framing a hypothesis, the investigator must not currently know the outcome of a potentially falsifying 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.

In the United States of America, teachers of science in primary schools have often simplified the meaning of the term "hypothesis" by describing a hypothesis as "an educated guess". Overemphasizing this aspect fails to convey the explanatory or predictive quality of scientific hypotheses. To define a hypothesis as "an educated guess" resembles describing a tricycle is a "vehicle with three". The definition omits the concept's most important and characteristic feature: the purpose of hypotheses. People generate hypotheses as early attempts to explain patterns observed in nature or to predict the outcomes of experiments. For example, in science, one could correctly call the following statement a hypothesis: identical twins can have different personalities because the environment influences personality. In contrast, although one might have informed one's self about the qualifications of various political candidates, making an educated guess about the outcome of an election would not qualify as a scientific hypothesis: the guess lacks an underpinning generic explanation.

Types of hypothesis

A proposition may take the form of asserting a causal relationship (such as "A causes B"). A proposition often (but not necessarily) involves an assertion of causation. For example, if a particular independent variable changes, then a certain dependent variable also changes. This formulation, also known as an "If and Then" statement, applies whether or not a proposition asserts a direct cause-and-effect relationship.

A hypothesis about possible correlation does not stipulate the cause and effect per se, only stating that "A is related to B". Investigators may have more difficulty in verifying causal relationships than other correlations, because quite commonly intervening variables also become involved, possibly giving rise to the appearance of a possibly direct cause-and-effect relationship, but which (upon further investigation) turn out to have some other, more direct causal factor not mentioned in the proposition. Also, a mere observation of a change in one variable, when correlated with a change in another variable, can actually mistake the effect for the cause, and vice-versa (i.e., potentially get the hypothesized cause and effect backwards).

Empirical hypotheses that experimenters have repeatedly verified may become sufficiently dependable that, at some point in time, they become considered as "proven". Some people may succumb to the temptation to term such hypotheses "laws", but they would do so mistakenly, since by definition a hypothesis explains and a law describes (for example, a law can state: "Matter can neither be created or destroyed, only changed in form"). More accurately, one could refer to repeatedly verified hypotheses simply as "adequately verified", or as "dependable".

Statistics features a rather more general concept of a hypothesis: this involves making assertions about the probability distributions or likelihoods of events.

Statisticians use two kinds of hypothesis: first, the null hypothesis or H0; secondly, the alternative hypothesis or H1. To give the simplest non-trivial example, one might formulate two hypotheses about tossing a coin:

H0: coin-tossing operates "fairly" (equally likely to fall "Heads" or "Tails")
H1: coin-tossing operates in a biased manner to give a 90% probability of falling "Heads"

No finite sequence of results could utterly falsify either hypothesis. However, various statistical approaches (such as Bayesian statistics and classical statistics (i.e. t-tests)) can quantify the strong intuition that H1 appears much less likely than H0 if, in 1,000 tosses, 495 came out "Heads" — and much more likely if 895 came out "Heads". In more complex sciences, researchers generally evaluate experiments statistically rather than as simple verifications or falsifications.

Evaluating hypotheses

The hypothetico-deductive method demands falsifiable hypotheses, framed in such a manner that the scientific community can prove them false (usually by observation). (Note that confirming (or failing to falsify) a hypothesis does not necessarily prove that hypothesis: the hypothesis remains provisional.)

For example: someone who enters a new country and observes only white sheep might form the hypothesis that all sheep in that country are white. It can be considered a hypothesis, as it is falsifiable. Anyone could falsify the hypothesis by observing a single black sheep. Provided that the experimental uncertainties remain small (for example, provided that one can fairly reliably distinguish the observed black sheep from (say) a goat), and provided that the experimenter has correctly interpreted the statement of the hypothesis (for example, does the meaning of "sheep" include rams?), finding a black sheep falsifies the "white sheep only" hypothesis. However, one cannot consider failure to find non-white sheep as proof that no non-white sheep exist.

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
- Simplicity
- 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 recognised knowledge-systems

Causation

Causality or causation denotes the relationship between one event (called cause) and another event (called effect) which is the consequence (result) of the first.

What is Causation?

When changes in one variable (X) affect changes in another variable (Y), we say that X causes Y. Examples: Sun Rises Rooster Crows (unidirectional)
Education Higher wages (bidirectional?)

This informal understanding suffices in everyday usage, however the philosophical analysis of causality or causation has proved exceedingly difficult. The work of philosophers to understand causality and how best to characterize it extends over millennia. In the western philosophical tradition explicit discussion stretches back at least as far as Aristotle, and the topic remains a staple in contemporary philosophy journals. Though cause and effect are most often held to relate events, other candidates include processes, properties, variables, facts, and states of affairs; which of these comprise the correct causal relata, and how best to characterize the nature of the relationship between them, has as yet no universally accepted answer, and remains under discussion.

Causation is a relation between facts or events. In English we use the verb "cause" to denote this relation; but there are plenty of other transitive English verbs that are causal in the sense of implying a causal relation: "burn", "scrape", "kill", "push" and arguably "mean", "see", "know" and "think of". This appears to illustrate the centrality of the notion of causation in our everyday thought. But I shall not be discussing the extent to which causation really is involved in distinguishing, e.g., true belief from knowledge, or veridical from hallucinatory perception.

The most important contribution to the subject is of course Hume's Treatise and his discussion is important in understanding the concept. It is necessary to be aware of the framework in which Hume operates. He by and large adhered to the empiricist doctrine that there is no idea without a preceding impression (though he does admit certain exceptions e.g. the missing shade of blue). What this means is that one can only have causal thoughts if the causal relation has suitably impinged upon one's experience. And this raises the question (which is interesting whether or not you accept this empiricism): how does causation impinge upon experience? "Let us therefore cast our eye on any two objects, which we call cause and effect, and turn them on all sides, in order to find that impression, which produces an idea of such prodigious consequence". He starts by pointing out, what is anyway obvious, that causation cannot consist in any manifest property of an "object". There is no "mark" of an object or event, considered by itself, by which we denominate it a "cause" in general. What tells us that A causes B must therefore be some relation between A and B (though he will end up making the same point about an object considered by itself).

The first relation that he regards as necessary for causation is spatiotemporal contiguity: "nothing can operate in a time or place, which is ever so little removed from those of its existence." This point was familiar from Locke. But is it plausible that a cause must always adjoin its effect?

It is clearly true e.g. in the case of a match's being struck causing the lighting of the match. But what about "action at a distance"? We may take the example that so perplexed Newton, that of gravitation. It looks as if the mass of the Sun, which is millions of miles away, causes the Earth to move in a certain way. But how can that be? The sun is millions of miles away. For all the Earth "knows", there is nothing in the place occupied by the sun. The discomfort is even more acute when we try to imagine a failure of temporal contiguity. It is an interesting question why Hume's requirement strikes us plausible. The reason, according to Russell, was as follows: the idea of cause is ultimately modelled on the operation of volition to produce actions. But volitions always appear "contiguous" with the actions they produce; therefore we assume causes do as well. ("On the Notion of Cause" in his Mysticism and Logic). Therefore there are relations between A and B considered by themselves as he has just made about an object considered by itself.

The first relation that he regards as n accounts of causation (e.g. Lewis') that seem to extract a substantial conceptual core from our everyday usage without entailing that causes are always spatiotemporally contiguous with their effects.

The second relation that Hume mentions is temporal priority. This means proper precedence: a cause can be neither later than nor simultaneous with its effect. And he gives an argument for saying that causes cannot be simultaneous with their effects. The idea is this. Suppose that a state of affairs A causes B. Now the only time-slice of A that can cause B is the last one that could have done so; for the passage of time by itself has no causal efficacy. But if the last possible time-slice of A that can cause B is the one that occurs simultaneously with B, then only what is simultaneous with B can cause it. But then this applies to A as well; and so we reach the conclusion that if any causes are simultaneous with their effects then they all must be, and so everything would happen at once. Again, it is not clear why the passage of time can have no causal efficacy. And again, it is arguable that our presumption that this is so derives from the idea that the concept of causation is modelled on our experience of volition.

As for the fact that a cause cannot be later than its effect: this Hume simply builds in to his definition of causation: there is no question of why this must be so. It is a very easy way of avoiding the question "Why must all causes be later than their effects?" to say "That is just part of the definition of cause". But it is doesn't really help. We could invent a concept, call it cause, which is just like causation except without the requirement that if A causes B then A temporally precedes B; and then we can raise the equally puzzling question "Why must all causes precede their effects?"—for it seems that they do.

Yet again, it may be argued that this feature of causation is a reflection of the experience of agency on which the concept is modelled. There is nothing more that he can find in two objects, considered by themselves, to show them to be related as cause and effect. It is clear that contiguity and priority are not sufficient for causation. There are plenty of events so related, neither of which causes the other (for example, a bomb might hit the ground and immediately explode, but the bomb was on a timer, and so the striking of the ground did not cause the explosion). What more then is there to causation?
The answer, of course, is supposed to be necessary connection. A cause is supposed to make its effect necessary.

4. Summary :

A concept is a term that expresses an abstract idea formed by generalizing from particulars and summarizing related observations. Typical concepts in mass communication research includes terms like advertising effectiveness, message length, media usage, and readability.

As the term is used in mainstream cognitive science, a concept is an abstract idea or a mental symbol, typically associated with a corresponding representation in and language or symbology.

Concepts are useful in dealing with reality. Generally speaking, concepts are taken to be (a) acquired dispositions to recognize perceived objects as being of this kind or of that ontological kind, and at the same time (b) to understand what this kind or that kind of object is like, and consequently (c) to perceive a number of perceived particulars as being the same in kind and to discriminate between them and other sensible particulars that are different in kind. In addition, concepts are acquired dispositions to understand what certain kinds of objects are like both (a) when the objects, though perceptible, are not actually perceived, and (b) also when they are not perceptible at all, as is the case with all the conceptual constructs we employ in physics, mathematics, and metaphysics.

A ***definition*** is a thorough description of the meaning of a lexical unit.

A ***variable*** is *any entity that can take on different values*. Anything that can vary can be considered a variable. For instance, *age* can be considered a variable because age can take different values for different people or for the same person at different times.

We can distinguish between two types of variables according to the level of measurement:

3. Continuous or Quantitative Variables.
4. Discrete or Qualitative Variables.

A quantitative variable is one in which the variates differ in magnitude, *e.g.* income, age, GNP, etc. A qualitative variable is one in which the variates differ in kind rather than in magnitude*, e.g.* marital status, gender, nationality, etc.

Continuous or Quantitative Variables

Continuous variables can be classified into three categories:

Interval - scale Variables : Interval scale data has order and equal intervals.

Continuous Ordinal Variables : They occur when the measurements are continuous, but one is not certain whether they are on a linear scale, the only trustworthy information being the rank order of the observations.

Ratio - scale Variables : These are continuous positive measurements on a nonlinear scale.

Discrete variables are also called categorical variables. A discrete variable, X, can take on a finite number of numerical values, categories or codes. Discrete variables can be classified into the following categories:

6. Nominal variables
7. Ordinal variables
8. Dummy variables from quantitative variables
9. Preference variables
10. Multiple response variables

Nominal Variables : Nominal variables allow for only qualitative classification. That is, they can be measured only in terms of whether the individual items belong to certain distinct categories, but we cannot quantify or even rank order the categories:

Ordinal Variables : A discrete ordinal variable is a nominal variable, but its different states are ordered in a meaningful sequence. Ordinal data has order, but the intervals between scale points may be uneven.

Preference Variables : Preference variables are specific discrete variables, whose values are either in a decreasing or increasing order.

Multiple Response Variables : Multiple response variables are those, which can assume more than one value.

A hypothesis consists either of a suggested explanation for a phenomenon or of a reasoned proposal suggesting a possible correlation between multiple phenomena. Scientists generally base such hypotheses on previous observations or on extensions of scientific theories.

In framing a hypothesis, the investigator must not currently know the outcome of a potentially falsifying 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.

Statisticians use two kinds of hypothesis: first, the null hypothesis or H0; secondly, the alternative hypothesis or H1. To give the simplest non-trivial example, one might formulate two hypotheses about tossing a coin:

Causality or causation denotes the relationship between one event (called cause) and another event (called effect) which is the consequence (result) of the first.

When changes in one variable (X) affect changes in another variable (Y), we say that X causes Y. Examples: Sun Rises Rooster Crows (unidirectional)
Causation is a relation between facts or events.

5. Model Questions:

1. What is a concept ? Give examples.
2. Define variables. Mention the different types of variables.
3. What is a hypothsis ? Mentiion the types of hypothesis.
4. Discuss causation.
5. What is a definition ?

6. Reference Books:

1. Hsia, H.J (1988) Mass Communicatin research methods – a step by step approach, Hillsdale, NJ, Lawrence Erlbaum.
2. Mason, E.J and Bramble, W.J (1989) Understading and conducting research (2^{nd} ed) New York, McGraw Hill.
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Unit 2 : Lesson 2 : Survey Method and Content Analysis, Historical Methods and Field Experiments

1. Objective of the Lesson:

The objective of the lesson is to:

- **Introduce you to the Survey method of research**
- **Introduce you to the Content Analysis method of research**
- **Introduce you to the historical method of research**
- **Help you understand field experiments**

2. Structure of the Lesson:

- **Survey**
- **Types of Surveys**
- **Questionnaires and Interviews**
- **Advantages and Disadvantages of Survey Methods**
- **Content Analysis**
- **Uses and Process of Content Analysis**

- **Steps to Follow in the Historical Method**
- **Advantages**
- **Field Experiments**
- **Merits and demerits**

3. Expansion of the Structure:

Survey

Survey research is one of the most important areas of measurement in applied social research. The broad area of survey research encompasses any measurement procedures that involve asking questions of respondents. A "survey" can be anything form a short paper-and-pencil feedback form to an intensive one-on-one in-depth interview.

The different types of surveys are roughly divided into two broad areas: Questionnaires and Interviews.

Types of Surveys

Data are usually collected through the use of questionnaires, although sometimes researchers directly interview subjects. Surveys can use qualitative (e.g. ask open-ended questions) or quantitative (e.g. use forced-choice questions) measures. There are two basic types of surveys: cross-sectional surveys and longitudinal surveys.

Cross-Sectional Surveys

Cross-sectional surveys are used to gather information on a population at a single point in time. An example of a cross sectional survey would be a questionaire that collects data on how parents feel about Internet filtering, as of March of 1999. A different cross-sectional survey questionnaire might try to determine the relationship between two factors, like religiousness of parents and views on Internet filtering.

Longitudinal Surveys

Longitudinal surveys gather data over a period of time. The researcher may then analyze changes in the population and attempt to describe and/or explain them. The three main types of longitudinal surveys are trend studies, cohort studies, and panel studies.

Trend Studies

Trend studies focus on a particular population, which is sampled and scrutinized repeatedly. While samples are of the same population, they are typically not composed of the same people. Trend studies, since they may be conducted over a long period of time, do not have to be conducted by just one researcher or research project. A researcher may combine data from several studies of the same population in order to show a trend. An example of a trend study would be a yearly survey of librarians asking about the percentage of reference questions answered using the Internet.

Cohort Studies

Cohort studies also focus on a particular population, sampled and studied more than once. But cohort studies have a different focus. For example, a sample of 1999 graduates of GSLIS at the University of Texas could be questioned regarding their attitudes toward paraprofessionals in libraries. Five years later, the researcher could question another sample of 1999 graduates, and study any changes in attitude. A cohort study would sample the same class, every time. If the researcher studied the class of 2004 five years later, it would be a trend study, not a cohort study.

Panel Studies

Panel studies allow the researcher to find out why changes in the population are occurring, since they use the same sample of people every time. That sample is called a panel. A researcher could, for example, select a sample of UT graduate students, and ask them questions on their library usage. Every year thereafter, the researcher would contact the same people, and ask them similar questions, and ask them the reasons for any changes in their habits. Panel studies, while they can yield extremely specific and useful explanations, can be difficult to conduct. They tend to be expensive, they take a lot of time, and they suffer from high attrition rates. *Attrition* is what occurs when people drop out of the study.

Surveys can also be divided into two broad categories: the questionnaire and the interview. Questionnaires are usually paper-and-pencil instruments that the respondent completes. Interviews are completed by the interviewer based on the respondent says. Sometimes, it's hard to tell the difference between a questionnaire and an interview. For instance, some people think that questionnaires always ask short closed-ended questions while interviews always ask broad open-ended ones. But you will see questionnaires with open-ended questions (although they do tend to be shorter than in interviews) and there will often be a series of closed-ended questions asked in an interview.

Questionnaires

When most people think of questionnaires, they think of the mail survey. All of us have, at one time or another, received a questionnaire in the mail. There are many advantages to mail surveys. They are relatively inexpensive to administer. You can send the exact same instrument to a wide number of people. They allow the respondent to fill it out at their own convenience. But there are some disadvantages as well. Response rates from mail surveys are often very low. And, mail questionnaires are not the best vehicles for asking for detailed written responses.

A second type is the group administered questionnaire. A sample of respondents is brought together and asked to respond to a structured sequence of questions. Traditionally, questionnaires were administered in group settings for convenience. The researcher could give the questionnaire to those who were present and be fairly sure that there would be a high response rate. If the respondents were unclear about the meaning of a question they could ask for clarification. And, there were often organizational settings where it was relatively easy to assemble the group (in a company or business, for instance).

Interviews

Interviews are a far more personal form of research than questionnaires. In the personal interview, the interviewer works directly with the respondent. Unlike with mail surveys, the interviewer has the opportunity to probe or ask follow-up questions. And, interviews are generally easier for the respondent, especially if what is sought is opinions or impressions. Interviews can be very time consuming and they are resource intensive. The interviewer is considered a part of the measurement instrument and interviewers have to be well trained in how to respond to any contingency.

Almost everyone is familiar with the telephone interview. Telephone interviews enable a researcher to gather information rapidly. Most of the major public opinion polls that are reported were based on telephone interviews. Like personal interviews, they allow for some personal contact between the interviewer and the respondent. And, they allow the interviewer to ask follow-up questions. But they also have some major disadvantages. Many people don't have publicly-listed telephone numbers. Some don't have telephones. People often don't like the intrusion of a call to their homes. And, telephone interviews have to be relatively short or people will feel imposed upon.

Sampling Issues

The sample is the actual group you will have to contact in some way. There are several important sampling issues you need to consider when doing survey research.

Who is the respondent?

Who is the respondent in your study? Let's say you draw a sample of households in a small city. A household is not a respondent. Do you want to interview a specific individual? Do you want to talk only to the "head of household" (and how is that person defined)? Are you willing to talk to any member of the household? Do you state that you will speak to the first adult member of the household who opens the door? What if that person is unwilling to be interviewed but someone else in the house is willing? How do you deal with multi-family households? Similar problems arise when you sample groups, agencies, or companies. Can you survey any member of the organization? Or, do you only want to speak to the Director of Human Resources? What if the person you would like to interview is unwilling or unable to participate? Do you use another member of the organization?

Constructing the Survey

Constructing a survey instrument is an art in itself. There are numerous small decisions that must be made -- about content, wording, format, placement -- that can have important consequences for your entire study. While there's no one perfect way to accomplish this job, we do have lots of advice to offer that might increase your chances of developing a better final product.

First of all you'll learn about the two major types of surveys that exist, the questionnaire and the interview and the different varieties of each. Then you'll see how to write questions for surveys. There are three areas involved in writing a question:

- determining the question content, scope and purpose
- choosing the response format that you use for collecting information from the respondent
- figuring out how to word the question to get at the issue of interest

Finally, once you have your questions written, there is the issue of how best to place them in your survey.

Advantages and Disadvantages of Survey Methods

It's hard to compare the advantages and disadvantages of the major different survey types. Even though each type has some general advantages and disadvantages, there are exceptions to almost every rule. The following table presents some of the advantages and disadvantages of survey method.

Issue	Questionnaire			Interview	
	Group	Mail	Drop-Off	Personal	Phone
Are Visual Presentations Possible?	Yes	Yes	Yes	Yes	No
Are Long Response Categories Possible?	Yes	Yes	Yes	???	No
Is Privacy A Feature?	No	Yes	No	Yes	???
Is the	No	No	No	Yes	Yes

Method Flexible?					
Are Open-ended Questions Feasible?	No	No	No	Yes	Yes
Is Reading & Writing Needed?	???	Yes	Yes	No	No
Can You Judge Quality of Response?	Yes	No	???	Yes	???
Are High Response Rates Likely?	Yes	No	Yes	Yes	No
Can You Explain Study in Person?	Yes	No	Yes	Yes	???
Is It Low Cost?	Yes	Yes	No	No	No
Are Staff & Facilities Needs Low?	Yes	Yes	No	No	No
Does It Give Access to Dispersed Samples?	No	Yes	No	No	No
Does	No	Yes	Yes	No	No

Respondent Have Time to Formulate Answers?					
Is There Personal Contact?	Yes	No	Yes	Yes	No
Is A Long Survey Feasible?	No	No	No	Yes	No
Is There Quick Turnaround?	No	Yes	No	No	Yes

Content Analysis

Content analysis is a research tool used to determine the presence of certain words or concepts within texts or sets of texts. Researchers quantify and analyze the presence, meanings and relationships of such words and concepts, then make inferences about the messages within the texts, the writer(s), the audience, and even the culture and time of which these are a part. Texts can be defined broadly as books, book chapters, essays, interviews, discussions, newspaper headlines and articles, historical documents, speeches, conversations, advertising, theater, informal conversation, or really any occurrence of communicative language.

Perhaps due to the fact that it can be applied to examine any piece of writing or occurrence of recorded communication, content analysis is currently used in a dizzying array of fields, ranging from marketing and media studies, to literature and rhetoric, ethnography and cultural studies, gender and age issues, sociology and political science, psychology and cognitive science, and many other fields of inquiry. Additionally, content analysis reflects a close relationship with socio- and psycholinguistics, and is playing an integral role in the development of artificial intelligence. The following list (adapted from Berelson, 1952) offers more possibilities for the uses of content analysis:

- Reveal international differences in communication content
- Detect the existence of propaganda
- Identify the intentions, focus or communication trends of an individual, group or institution
- Describe attitudinal and behavioral responses to communications
- Determine psychological or emotional state of persons or groups

Since the 1980s, content analysis has become an increasingly important tool in the measurement of success in public relations (notably media relations) programs and the assessment of media profiles. In these circumstances, content analysis is an element of media evaluation or media analysis. In analyses of this type, data from content analysis is usually combined with media data (circulation, readership, number of viewers and listeners, frequency of publication). It has also been used by futurists to identify trends. In 1982, John Naisbitt published his popular Megatrends, based on content analysis in the US media.

The creation of coding frames is intrinsically related to a creative approach to variables that exert an influence over textual content. In political analysis, these variables could be political scandals, the impact of public opinion polls, sudden events in external politics, inflation etc. Mimetic Convergence, created by F. Lampreia Carvalho for the comparative analysis of electoral proclamations on free-to-air television is an example of creative articulation of variables in content analysis. The methodology describes the construction of party identities during long-term party competitions on TV, from a dynamic perspective, governed by the logic of the contingent. This method aims to capture the contingent logic observed in electoral campaigns by focusing on the repetition and innovation of themes sustained in party broadcasts. According to such post-structuralist perspective from which electoral competition is analysed, the party identities, 'the real' cannot speak without mediations because there is not a natural centre fixing the meaning of a party structure, it rather depends on ad-hoc articulations. There is no empirical reality outside articulations of meaning. Reality is an outcome of power struggles that unify ideas of social structure as a result of contingent interventions. In Brazil, these contingent interventions have proven to be mimetic and convergent rather than divergent and polarised, being integral to the repetition of dichotomised worldviews.

Content analysis has been criticised for being a positivist methodology, yet here is an example of a methodology used to organise a content analysis which is able to capture the logic of the contingent dominating the political field, enabling an analysis of the constitution of party identities from the theoretical perspective of deconstruction and theory of hegemony.

As an evaluation approach, content analysis is considered to be quasi-evaluation because content analysis judgments need not be based on value statements. Instead, they can be based on knowledge. Such content analyses are not evaluations. On the other hand, when content analysis judgments are based on values, such studies are evaluations (Frisbie, 1986).

Uses of content analysis

Ole Holsti (1969) groups 15 uses of content analysis into three basic categories:

- make inferences about the antecedents of a communication
- describe and make inferences about characteristics of a communication
- make inferences about the effects of a communication.
- He also places these uses into the context of the basic communication paradigm.

The following table shows fifteen uses of content analysis in terms of their general purpose, element of the communication paradigm to which they apply, and the general question they are intended to answer.

Uses of Content Analysis by Purpose, Communication Element, and Question			
Purpose	**Element**	**Question**	**Use**
Make inferences about the antecedents of communications	Source	Who?	Answer questions of disputed authorship
	Encoding process	Why?	• Secure political & military intelligence • Analyze traits of individuals • Infer cultural aspects & change Provide legal & evaluative evidence
Describe & make inferences about the characteristics of communications	Channel	How?	• Analyze techniques of persuasion Analyze style
	Message	What?	• Describe trends in communication content • Relate known characteristics of sources to messages they produce Compare communication content to standards
	Recipient	To whom?	• Relate known characteristics of audiences to messages produced for them Describe patterns of communication
Make inferences about the consequences of communications	Decoding process	With what effect?	• Measure readability • Analyze the flow of information Assess responses to communications

Source : Purpose, communication element, & question from Holsti (1969). Uses primarily from Berelson (1952) as adapted by Holsti (1969).

Qualitatively, content analysis can involve any kind of analysis where communication content (speech, written text, interviews, images ...) is categorized and classified. In its beginnings, using the first newspapers at the end of 19th century, analysis was done manually by measuring the number of lines and amount of space given a subject. With the rise of common computing facilities like PCs, computer-based methods of analysis are growing in popularity. Answers to open ended questions, newspaper articles, political party manifestoes, medical records or systematic observations in experiments can all be subject to systematic analysis of textual data. By having contents of communication available in form of machine readable texts, the input is analysed for frequencies and coded into categories for building up inferences. Robert Philip Weber (1990) notes: "To make valid inferences from the text, it is important that the classification procedure be reliable in the sense of being consistent: Different people should code the same text in the same way" (p. 12). The validity, inter-coder reliability and intra-coder reliability are subject to intense methodological research efforts over long years (Krippendorf, 2004).

A further step in analysis is the distinction between dictionary-based (quantitative) approaches and qualitative approaches. Dictionary-based approaches set up a list of categories derived from the frequency list of words and control the distribution of words and their respective categories over the texts. While methods in quantitative content analysis in this way transform observations of found categories into quantitative statistical data, the qualitative content analysis focuses more on the intentionality and its implications.

Historical Method of Research

The historical method comprises the techniques and guidelines by which historians use primary sources and other evidence to research and then to write history. The question of the nature, and indeed the possibility, of sound historical method is raised in the philosophy of history, as a question of epistemology. The following summarizes the history guidelines commonly used by historians in their work, under the headings of external criticism, internal criticism, and synthesis.

Once the decision is made to conduct historical research, there are steps that should be followed to achieve a reliable result. Charles Busha and Stephen Harter detail six steps for conducting historical research (91):

- the recognition of a historical problem or the identification of a need for certain historical knowledge.
- the gathering of as much relevant information about the problem or topic as possible.
- if appropriate, the forming of hypothesis that tentatively explain relationships between historical factors.
- The rigorous collection and organization of evidence, and the verification of the authenticity and veracity of information and its sources.
- The selection, organization, and analysis of the most pertinent collected evidence, and the drawing of conclusions; and
- the recording of conclusions in a meaningful narrative. External criticism: authenticity and provenance

Steps to Follow in the Historical Method

1. Isolate the problem
2. Collect source materials, including primary and secondary sources
3. Evaluate source material
4. Formulate hypotheses
5. Report and interpret findings

Primary Sources of Information - Direct outcomes of events or the records of eyewitnesses

1. Original documents
2. Relics
3. Remains
4. Artifacts

Secondary Sources of Information - Information provided by a person who did not directly observe the event, object, or condition

1. Textbooks
2. Encyclopedias
3. Newspapers
4. Periodicals
5. Review of research and other references

External Criticism - Asks if the evidence under consideration is authentic. The researcher checks the genuineness or validity of the source. Is it what it appears or claims to be? Is it admissible as evidence?

Internal Criticism - After the source is authenticated, it asks if the source is accurate, was the writer or creator competent, honest, and unbiased? How long after the event happened until it was reported? Does the witness agree with other witnesses?

Establishing the Genuineness of a Document of Relic

- Does the language and writing style conform to the period in question and is it typical of other work done by the author?
- Is there evidence that the author exhibits ignorance of things or events that man of his training and time should have known?

- Did he report about things, events, or places that could not have been known during that period?
- Has the original manuscript been altered either intentionally or unintentionally by copying?
- Is the document an original draft or a copy? If it is a copy, was it reproduced in the exact words of the original?
- If manuscript is undated or the author unknown, are there any clues internally as to its origin?

Checking the Content of a Source of Information

- What was meant by the author by each word and statement?
- How much credibility can the author's statements be given?

Evaluation

- Statement of hypotheses
- External and internal criticism of sources
- Observation and experimentation
- Technical terminology
- Generalization and prediction

Advantages

- The research is not physically involved in the situation under study.
- No danger of experimenter-subject interaction.
- Documents are located by the researcher, data is gathered, and conclusions are drawn out of sight.

Field Experiments

A field experiment applies the scientific method to experimentally examine an intervention in the real world (or as many experimental economists like to say, naturally-occurring environments) rather than in the laboratory. Field experiments, like lab experiments, generally randomize subjects (or other sampling units) into treatment and control groups and compare outcomes between these groups. Clinical trials of pharmaceuticals are one example of field experiments. Economists have used field experiments to analyze discrimination, health care programs, charitable fundraising, education, information aggregation in markets, and microfinance programs.

Merits and Demerits of Field Experiments

Studies which are carried out in the natural environment, be that a hospital, a school, or the street, are known as field studies, or if experimental in nature, field experiments. In field experiments the researcher is testing hypotheses in a similar way to the way it would be done in the laboratory. The main difference is that many of the extraneous variables the researcher would be able to control in the laboratory, are not able to be controlled in the field.

One obvious advantage of the field study is that it is able to overcome the criticism that findings from laboratory settings are not generalisable to the "real world". Field studies take place in this real world, so generalisation is therefore not a problem - field studies are said to have high external, or ecological validity.

Laboratory studies are very artificial and are perceived as such by the participants. This may influence the way they respond, which may not be typical if the way they might respond in the real world. Participants in field studies may not always be aware that they are taking part in a study. In a health related study they may simply feel that they are receiving their usual treatment when in fact that treatment may be being manipulated by the experimenter. Nowadays, medical ethics committees tend to frown upon research in which the participants are not fully informed about the nature of the investigation, so most participants would have had to agree and sign a consent form before taking part, though they may not know all the details of the study.

From a methodological perspective, the greatest problem with field studies is due to the lack of control over certain elements of the study. For example in a drug trial, the researcher has little or no control over other medicines the participants may be taking, and even though participants may be advised to avoid certain medicines, there is no guarantee that they will conform. Similarly compliance problems may interfere with the study, the researcher has little control over exactly when participants take the prescribed drug, or even if they do!

A further problem with field studies is that they tend to be more time consuming, and therefore more expensive, compared with laboratory studies. The skills required of the researcher in persuading and cajoling participants, maintaining motivation levels over what may be a long period of time, are different from those skills usually recognised as important in a researcher, and indeed the laboratory based researcher may need further training or additional help before field studies can be undertaken successfully.

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4. Summary

Survey research is one of the most important areas of measurement in applied social research. The broad area of survey research encompasses any measurement procedures that involve asking questions of respondents. A "survey" can be anything form a short paper-and-pencil feedback form to an intensive one-on-one in-depth interview.

The different types of surveys are roughly divided into two broad areas: Questionnaires and Interviews.

Data are usually collected through the use of questionnaires, although sometimes researchers directly interview subjects. Surveys can use qualitative (e.g. ask open-ended questions) or quantitative (e.g. use forced-choice questions) measures. There are two basic types of surveys: cross-sectional surveys and longitudinal surveys.
Cross-sectional surveys are used to gather information on a population at a single point in time. An example of a cross sectional survey would be a questionaire that collects data on how parents feel about Internet filtering.
Longitudinal surveys gather data over a period of time. The researcher may then analyze changes in the population and attempt to describe and/or explain them. The three main types of longitudinal surveys are trend studies, cohort studies, and panel studies.
Trend studies focus on a particular population, which is sampled and scrutinized repeatedly. While samples are of the same population, they are typically not composed of the same people.
Cohort studies also focus on a particular population, sampled and studied more than once.

Surveys can also be divided into two broad categories: the questionnaire and the interview. Questionnaires are usually paper-and-pencil instruments that the respondent completes. Interviews are completed by the interviewer based on the respondent says.

Content analysis is a research tool used to determine the presence of certain words or concepts within texts or sets of texts.

The historical method comprises the techniques and guidelines by which historians use primary sources and other evidence to research and then to write history. The question of the nature, and indeed the possibility, of sound historical method is raised in the philosophy of history, as a question of epistemology.

A field experiment applies the scientific method to experimentally examine an intervention in the real world (or as many experimental economists like to say, naturally-occurring environments) rather than in the laboratory. Field experiments, like lab experiments, generally randomize subjects (or other sampling units) into treatment and control groups and compare outcomes between these groups. Clinical trials of pharmaceuticals are one example of field experiments. Economists have used field experiments to analyze discrimination, health care programs, charitable fundraising, education, information aggregation in markets, and microfinance programs.

5. Model Questions:

1. Discuss the historical method of research. What are its advantages and disadvantages?
2. Discuss Field experiments. What are its advantages and disadvantages?
3. Mention the steps in historical method of research.
4. Mention the steps in Field experiments.
5. Discuss the survey method of research. Enumerate its advantages and disadvantages.
6. What are the tools used in data collection in the survey method ? Discuss.

7. What is content analysis ? What are the steps in content analysis ?

6. Reference Books

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Unit 3 : Lesson 1 : Sampling in Research and Questionnaire method of data collection

1. Objective of the Lesson:

The objective of the lesson is to:

- **Introduce you to sampling methods**
- **Help you understand the applications and limitations of sampling methods**
- **Introduce you to the methods of data collection**
- **Help you understand how to construct a questionnaire**
- **Help you understand the advantages and disadvantages of questionnaires**

2. Structure of the Lesson:

- Sampling
- Population definition
- Sampling frame
- Types of Sampling
- Sampling size
- Questionnaire
- Questionnaire Design

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. Results from probability theory and statistical theory are employed to guide practice.

The sampling process consists of 7 simple stages:

- Definition of population of concern
- Specification of a sampling frame, a set of items or events that it is possible to measure
- Specification of sampling method for selecting items or events from the frame
- Determine the sample size
- Implement the sampling plan
- Sampling and data collecting
- Review of sampling process

Population definition

Successful statistical practice is based on focused problem definition. Typically, we seek to take action on some population, for example when a batch of material from production must be released to the customer or sentenced for scrap or rework.

Alternatively, we seek knowledge about the cause system of which the population is an outcome, for example when a researcher performs an experiment on rats with the intention of gaining insights into biochemistry that can be applied for the benefit of humans. In the latter case, the population of concern can be difficult to specify, as it is in the case of measuring some physical characteristic such as the electrical conductivity of copper.

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. For example, in an opinion poll, possible sampling frames include:

Sampling methods

Within any of the types of frame identified above, a variety of sampling methods can be employed, individually or in combination.

Probability Sampling

A **probability sampling** method is any method of sampling that utilizes some form of *random selection*. In order to have a random selection method, you must set up some process or procedure that assures that the different units in your population have equal probabilities of being chosen. Humans have long practiced various forms of random selection, such as picking a name out of a hat, or choosing the short straw. These days, we tend to use computers as the mechanism for generating random numbers as the basis for random selection.

Some Definitions

Before we learn the various probability methods we have to define some basic terms.
These are:

- **N** = the number of cases in the sampling frame

- **n** = the number of cases in the sample
- $_{N}C_{n}$ = the number of combinations (subsets) of n from N
- **f** = n/N = the sampling fraction

With those terms defined we can begin to define the different probability sampling methods.

Simple Random Sampling

The simplest form of random sampling is called **simple random sampling**.

First, we have to get the sampling frame organized. To accomplish this, we'll go through agency records to identify every client over the past 12 months. If we're lucky, the agency has good accurate computerized records and can quickly produce such a list. Then, we have to actually draw the sample. Decide on the number of clients you would like to have in the final sample. For the sake of the example, let's say you want to select 100 clients to survey and that there were 1000 clients over the past 12 months. Then, the sampling fraction is f = n/N = 100/1000 = .10 or 10%.

Now, to actually draw the sample, you have several options. You could print off the list of 1000 clients, tear then into separate strips, put the strips in a hat, mix them up real good, close your eyes and pull out the first 100. But this mechanical procedure would be tedious and the quality of the sample would depend on how thoroughly you mixed them up and how randomly you reached in. Perhaps a better procedure would be to use the kind of ball machine that is popular with many of the state lotteries.

Simple random sampling is simple to accomplish and is easy to explain to others. Because simple random sampling is a fair way to select a sample, it is reasonable to generalize the results from the sample back to the population. Simple random sampling is not the most statistically efficient method of sampling and you may, just because of the luck of the draw, not get good representation of subgroups in a population. To deal with these issues, we have to turn to other sampling methods.

Stratified Random Sampling

Stratified Random Sampling, also sometimes called *proportional* or *quota* random sampling, involves dividing your population into homogeneous subgroups and then taking a simple random sample in each subgroup.

When we use the same sampling fraction within strata we are conducting *proportionate* stratified random sampling. When we use different sampling fractions in the strata, we call this *disproportionate* stratified random sampling. Second, stratified random sampling will generally have more statistical precision than simple random sampling. This will only be true if the strata or groups are homogeneous. If they are, we expect that the variability within-groups is lower than the variability for the population as a whole. Stratified sampling capitalizes on that fact.

Systematic Random Sampling

Here are the steps you need to follow in order to achieve a **systematic random sample**:

- number the units in the population from 1 to N
- decide on the n (sample size) that you want or need
- k = N/n = the interval size
- randomly select an integer between 1 to k
- then take every kth unit

For this to work, it is essential that the units in the population are randomly ordered, at least with respect to the characteristics you are measuring. Why would you ever want to use systematic random sampling? For one thing, it is fairly easy to do. You only have to select a single random number to start things off. It may also be more precise than simple random sampling. Finally, in some situations there is simply no easier way to do random sampling.

Cluster (Area) Random Sampling

The problem with random sampling methods when we have to sample a population that's disbursed across a wide geographic region is that you will have to cover a lot of ground geographically in order to get to each of the units you sampled. Imagine taking a simple random sample of all the residents of New York State in order to conduct personal interviews. By the luck of the draw you will wind up with respondents who come from all over the state. Your interviewers are going to have a lot of traveling to do. It is for precisely this problem that **cluster or area random sampling** was invented.

In cluster sampling, we follow these steps:

- divide population into clusters (usually along geographic boundaries)
- randomly sample clusters
- measure <u>all</u> units within sampled clusters

Multi-Stage Sampling

The four methods we've covered so far -- simple, stratified, systematic and cluster -- are the simplest random sampling strategies. In most real applied social research, we would use sampling methods that are considerably more complex than these simple variations. The most important principle here is that we can combine the simple methods described earlier in a variety of useful ways that help us address our sampling needs in the most efficient and effective manner possible. When we combine sampling methods, we call this **multi-stage sampling**.

Sample size

Where the frame and population are identical, statistical theory yields exact recommendations on sample size. However, where it is not straightforward to define a frame representative of the population, it is more important to understand the cause system of which the population are outcomes and to ensure that all sources of variation are embraced in the frame. Large number of observations are of no value if major sources of variation are neglected in the study. In other words, it is taking a sample group that matches the survey category and is easy to survey. Bartlett, Kotrlik, and Higgins (2001) published a paper titled Organizational Research: Determining Appropriate Sample Size in Survey Research Information Technology, Learning, and Performance Journal that provides an explanation of Cochran's (1977) formulas. A discussion and illustration of sample size formulas, including the formula for adjusting the sample size for smaller populations, is included. A table is provided that can be used to select the sample size for a research problem based on three alpha levels and a set error rate.

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

Review of sampling process

After sampling, a review should be held of the exact process followed in sampling, rather than that intended, in order to study any effects that any divergences might have on subsequent analysis. A particular problem is that of non-responses.

Weighting of samples

In many situations the sample fraction may be varied by stratum and data will have to be weighted to correctly represent the population. Thus for example, a simple random sample of individuals in the United Kingdom might include some in remote Scottish islands who would be inordinately expensive to sample. A cheaper method would be to use a stratified sample with urban and rural strata. The rural sample could be under-represented in the sample, but weighted up appropriately in the analysis to compensate.

Data can be collected using various methods like questionnaires, interview schedules and observation, etc. The tool for data collection depends upon the type of data that is to be collected, the nature of research and the characteristics of the sample. This lesson describes the questionnaire as a method of data collection.

Questionnaire

A questionnaire is a research instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondents. Although they are often designed for statistical analysis of the responses, this is not always the case. The questionnaire was invented by Sir Francis Galton.

Questionnaires have advantages over some other types of surveys in that they are cheap, do not require as much effort from the questioner as verbal or telephone surveys, and often have standardized answers that make it simple to compile data. However, such standardized answers may frustrate users. Questionnaires are also sharply limited by the fact that respondents must be able to read the questions and respond to them. Thus, for some demographic groups conducting a survey by questionnaire may not be practical.

Questionnaire Design

Questionnaires are an inexpensive way to gather data from a potentially large number of respondents. Often they are the only feasible way to reach a number of reviewers large enough to allow statistically analysis of the results. A well-designed questionnaire that is used effectively can gather information on both the overall performance of the test system as well as information on specific components of the system. If the questionnaire includes demographic questions on the participants, they can be used to correlate performance and satisfaction with the test system among different groups of users.

It is important to remember that a questionnaire should be viewed as a multi-stage process beginning with definition of the aspects to be examined and ending with interpretation of the results. Every step needs to be designed carefully because the final results are only as good as the weakest link in the questionnaire process. Although questionnaires may be cheap to administer compared to other data collection methods, they are every bit as expensive in terms of design time and interpretation.

The steps required to design and administer a questionnaire include:

1. Defining the Objectives of the survey
2. Determining the Sampling Group
3. Writing the Questionnaire
4. Administering the Questionnaire
5. Interpretation of the Results

When to use a questionnaire?

There is no all encompassing rule for when to use a questionnaire. The choice will be made based on a variety of factors including the type of information to be gathered and the available resources for the experiment. A questionnaire should be considered in the following circumstances.

a. **When resources and money are limited.** A Questionnaire can be quite inexpensive to administer. Although preparation may be costly, any data collection scheme will have similar preparation expenses. The administration cost per person of a questionnaire can be as low as postage and a few photocopies. Time is also an important resource that questionnaires can maximize. If a questionnaire is self-administering, such as a e-mail questionnaire, potentially several thousand people could respond in a few days. It would be impossible to get a similar number of usability tests completed in the same short time.
b. **When it is necessary to protect the privacy of the participants.** Questionnaires are easy to administer confidentially. Often confidentiality is the necessary to ensure participants will respond honestly if at all. Examples of such cases would

include studies that need to ask embarrassing questions about private or personal behavior.

c. **When corroborating other findings.** In studies that have resources to pursue other data collection strategies, questionnaires can be a useful confirmation tools. More costly schemes may turn up interesting trends, but occasionally there will not be resources to run these other tests on large enough participant groups to make the results statistically significant. A follow-up large scale questionnaire may be necessary to corroborate these earlier results.

Writing the Questionnaire

At this point, we assume that we have already decided what kind of data we are to measure, formulated the objectives of the investigation, and decided on a participant group. Now we must compose our questions.

If the preceding steps have been faithfully executed, most of the questions will be on obvious topics. Most questionnaires, however, also gather demographic data on the participants. This is used to correlate response sets between different groups of people. It is important to see whether responses are consistent across groups. For example, if one group of participants is noticeably less satisfied with the test interface, it is likely that the interface was designed without fair consideration of this group's specific needs. This may signify the need for fundamental redesign of the interface. In addition, certain questions simply may only be applicable to certain kinds of users. For example, if one is asking the participants whether they find the new tutorial helpful, we do not want to include in our final tally the responses of experienced users who learned the system with an older tutorial. There is no accurate way to filter out these responses without simply asking the users when they learned the interface.

Typically, demographic data is collected at the beginning of the questionnaire, but such questions could be located anywhere or even scattered throughout the questionnaire. One obvious argument in favor of the beginning of the questionnaire is that normally background questions are easier to answer and can ease the respondent into the questionnaire. One does not want to put off the participant by jumping in to the most difficult questions. We are all familiar with such kinds of questions.

It is important to ask only those background questions that are necessary. Do not ask income of the respondent unless there is at least some rational for suspecting a variance across income levels. There is often only a fine line between background and personal information. You do not want to cross over in to the personal realm unless absolutely necessary. If you need to solicit personal information, phrase your questions as unobtrusively as possible to avoid ruffling your participants and causing them to answer less than truthfully.

Whether your questions are open or closed format, there are several points that must by considered when writing and interpreting questionnaires:

1. **Clarity:** This is probably the area that causes the greatest source of mistakes in questionnaires. Questions must be clear, succinct, and unambiguous. The goal is to eliminate the chance that the question will mean different things to different people. If the designers fails to do this, then essentially participants will be answering different questions.

   To this end, it is best to phrase your questions empirically if possible and to avoid the use of necessary adjectives. For example, it asking a question about frequency, rather than supplying choices that are open to interpretation such as:

   1. Very Often
   2. Often
   3. Sometimes
   4. Rarely
   5. Never

   It is better to quantify the choices, such as:

6. Every Day or More
7. 2-6 Times a Week
8. About Once a Week
9. About Once a Month
10. Never

There are other more subtle aspects to consider such as language and culture. Avoid the use of colloquial or ethnic expressions that might not be equally used by all participants. Technical terms that assume a certain background should also be avoided.

2. **Leading Questions:** A leading question is one that forces or implies a certain type of answer. It is easy to make this mistake not in the question, but in the choice of answers. A closed format question must supply answers that not only cover the whole range of responses, but that are also equally distributed throughout the range. All answers should be equally likely. An obvious, nearly comical, example would be a question that supplied these answer choices:
    1. Superb
    2. Excellent
    3. Great
    4. Good
    5. Fair
    6. Not so Great

A less blatant example would be a Yes/No question that asked:

7. Is this the best CAD interface you have every used?

In this case, even if the participant loved the interface, but had an favorite that was preferred, she would be forced to answer No. Clearly, the negative response covers too wide a range of opinions. A better way would be to ask the same question but supply the following choices:

8. Totally Agree
9. Partially Agree
10. Neither Agree or Disagree
11. Partially Disagree
12. Totally Agree

This example is also poor in the way it asks the question. It's choice of words makes it a leading question and a good example for the next section on phrasing.

3. **Phrasing:** Most adjectives, verbs, and nouns in English have either a positive or negative connotation. Two words may have equivalent meaning, yet one may be a compliment and the other an insult. Consider the two words "child-like" and "childish", which have virtually identical meaning. Child-like is an affectionate term that can be applied to both men and women, and young and old, yet no one wishes to be thought of as childish.

   In the above example of "Is this the best CAD interface you have every used?" clearly "best" has strong overtones that deny the participant an objective environment to consider the interface. The signal sent the reader is that the designers surely think it is the best interface, and so should everyone else. Though this may seem like an extreme example, this kind of superlative question is common practice.

   A more subtle, but no less troublesome, example can be made with verbs that have neither strong negative or positive overtones. Consider the following two questions:

   1. Do you agree with the Governor's plan to oppose increased development of wetlands?

2. Do you agree with the Governor's plan to support curtailed development of wetlands?

They both ask the same thing, but will likely produce different data. One asks in a positive way, and the other in a negative. It is impossible to predict how the outcomes will vary, so one method to counter this is to be aware of different ways to word questions and provide a mix in your questionnaire. If the participant pool is very large, several versions may be prepared and distributed to cancel out these effects.

4. **Embarrassing Questions:** Embarrassing questions dealing with personal or private matters should be avoided. Your data is only as good as the trust and care that your respondents give you. If you make them feel uncomfortable, you will lose their trust. Do not ask embarrassing questions.

5. **Hypothetical Questions** Hypothetical are based, at best, on conjecture and, at worst, on fantasy. I simple question such as:
   1. If you were governor, what would you do to stop crime?

   This forces the respondent to give thought to something he may have never considered. This does not produce clear and consistent data representing real opinion. Do not ask hypothetical questions.

6. **Prestige Bias:** Prestige bias is the tendency for respondents to answer in a way that make them feel better. People may not lie directly, but may try to put a better light on themselves. For example, it is not uncommon for people to respond to a political opinion poll by saying they support Samaritan social programs, such as food stamps, but then go on to vote for candidates who oppose those very programs. Data from other questions, such as those that ask how long it takes to learn an interface, must be viewed with a little skepticism. People tend to say they are faster learners than they are.

There is little that can be done to prevent prestige bias. Sometimes there just is no way to phrase a question so that all the answers are noble. The best means to deal with prestige bias is to make the questionnaire as private as possible. Telephone interviews are better than person-to-person interviews, and written questionnaires mailed to participants are even better still. The farther away the critical eye of the researcher is, the more honest the answers.

4. Summary:

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. Results from probability theory and statistical theory are employed to guide practice.

The sampling process consists of 7 simple stages:

- Definition of population of concern
- Specification of a sampling frame, a set of items or events that it is possible to measure
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- Determine the sample size
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- Sampling and data collecting
- Review of sampling process

A **probability sampling** method is any method of sampling that utilizes some form of *random selection*. In order to have a random selection method, you must set up some process or procedure that assures that the different units in your population have equal probabilities of being chosen. Humans have long practiced various forms of random selection, such as picking a name out of a hat, or choosing the short straw. These days, we tend to use computers as the mechanism for generating random numbers as the basis for random selection.

The simplest form of random sampling is called **simple random sampling**. In this method the objective is to select n units out of N such that each ${}_{N}C_{n}$ has an equal chance of being selected.

Stratified Random Sampling, also sometimes called *proportional* or *quota* random sampling, involves dividing your population into homogeneous subgroups and then taking a simple random sample in each subgroup. In more formal terms:

There are several major reasons why you might prefer stratified sampling over simple random sampling. First, it assures that you will be able to represent not only the overall population, but also key subgroups of the population, especially small minority groups. If you want to be able to talk about subgroups, this may be the only way to effectively assure you'll be able to. If the subgroup is extremely small, you can use different sampling fractions (f) within the different strata to randomly over-sample the small group (although you'll then have to weight the within-group estimates using the sampling fraction whenever you want overall population estimates).

Steps to follow in order to achieve a **systematic random sample**:

- umber the units in the population from 1 to N
- decide on the n (sample size) that you want or need
- k = N/n = the interval size
- randomly select an integer between 1 to k
- then take every kth unit

The problem with random sampling methods when we have to sample a population that's disbursed across a wide geographic region is that you will have to cover a lot of ground geographically in order to get to each of the units you sampled. Imagine taking a simple random sample of all the residents of New York State in order to conduct personal interviews. By the luck of the draw you will wind up with respondents who come from all over the state. Your interviewers are going to have a lot of traveling to do. It is for precisely this problem that **cluster or area random sampling** was invented.

In cluster sampling, we follow these steps:

- divide population into clusters (usually along geographic boundaries)
- randomly sample clusters
- measure all units within sampled clusters

When we combine sampling methods, we call this **multi-stage sampling**.

Where the frame and population are identical, statistical theory yields exact recommendations on sample size. However, where it is not straightforward to define a frame representative of the population, it is more important to understand the cause system of which the population are outcomes and to ensure that all sources of variation are embraced in the frame. Large number of observations are of no value if major sources of variation are neglected in the study. In other words, it is taking a sample group that matches the survey category and is easy to survey.

After sampling, a review should be held of the exact process followed in sampling, rather than that intended, in order to study any effects that any divergences might have on subsequent analysis. A particular problem is that of non-responses.

In survey sampling, many of the individuals identified as part of the sample may be unwilling to participate or impossible to contact. In this case, there is a risk of differences, between (say) the willing and unwilling, leading to selection bias in conclusions. This is often addressed by follow-up studies which make a repeated attempt to contact the unresponsive and to characterize their similarities and differences with the rest of the frame.

In many situations the sample fraction may be varied by stratum and data will have to be weighted to correctly represent the population. Thus for example, a simple random sample of individuals in the United Kingdom might include some in remote Scottish islands who would be inordinately expensive to sample. A cheaper method would be to use a stratified sample with urban and rural strata. The rural sample could be under-represented in the sample, but weighted up appropriately in the analysis to compensate.

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Questionnaires have advantages over some other types of surveys in that they are cheap, do not require as much effort from the questioner as verbal or telephone surveys, and often have standardized answers that make it simple to compile data. However, such standardized answers may frustrate users. Questionnaires are also sharply limited by the fact that respondents must be able to read the questions and respond to them. Thus, for some demographic groups conducting a survey by questionnaire may not be practical.

Questionnaires are an inexpensive way to gather data from a potentially large number of respondents. Often they are the only feasible way to reach a number of reviewers large enough to allow statistically analysis of the results. A well-designed questionnaire that is used effectively can gather information on both the overall performance of the test system as well as information on specific components of the system. If the questionnaire includes demographic questions on the participants, they can be used to correlate performance and satisfaction with the test system among different groups of users.

The steps required to design and administer a questionnaire include:

6. Defining the Objectives of the survey
7. Determining the Sampling Group
8. Writing the Questionnaire
9. Administering the Questionnaire

10. Interpretation of the Results

Questionnaires are quite flexible in what they can measure, however they are not equally suited to measuring all types of data. We can classify data in two ways, **Subjective vs.**

When a questionnaire is administered, the researchers control over the environment will be somewhat limited. This is why questionnaires are inexpensive to administer. In general, questionnaires are better suited to gathering reliable subjective measures, such as user satisfaction, of the system or interface in question.

In general, there are two types of questions one will ask, **open format or closed format.**

Open format questions are those that ask for unprompted opinions. In other words, there are no predetermined set of responses, and the participant is free to answer however he chooses. Open format questions are good for soliciting subjective data or when the range of responses is not tightly defined. An obvious advantage is that the variety of responses should be wider and more truly reflect the opinions of the respondents. This increases the likelihood of you receiving unexpected and insightful suggestions, for it is impossible to predict the full range of opinion. It is common for a questionnaire to end with and open format question asking the respondent for her unabashed ideas for changes or improvements.

Open format questions have several disadvantages. First, their very nature requires them to be read individually. There is no way to automatically tabulate or perform statistical analysis on them. This is obviously more costly in both time and money, and may not be practical for lower budget or time sensitive evaluations. They are also open to the influence of the reader, for no two people will interpret an answer in precisely the same way. This conflict can be eliminated by using a single reader, but a large number of responses can make this impossible. Finally, open format questions require more thought and time on the part of the respondent. Whenever more is asked of the respondent, the chance of tiring or boring the respondent increases.

Closed format questions usually take the form of a multiple-choice question. They are easy for the respondent, give

Closed format questions offer many advantages in time and money. By restricting the answer set, it is easy to calculate percentages and other hard statistical data over the whole group or over any subgroup of participants. Modern scanners and computers make it possible to administer, tabulate, and perform preliminary analysis in a matter of days. Closed format questions also make it easier to track opinion over time by administering the same questionnaire to different but similar participant groups at regular intervals. Finally closed format questions allow the researcher to filter out useless or extreme answers that might occur in an open format question.

Questions can be **Dichotomous Questions :** When a question has two possible responses, we consider it dichotomous. **Questions Based on Level of Measurement :** We can also classify questions in terms of their level of measurement. For instance, we might measure occupation using a nominal question. Here, the number next to each response has no meaning except as a placeholder for that response. **Filter or Contingency Questions :** Sometimes you have to ask the respondent one question in order to determine if they are qualified or experienced enough to answer a subsequent one. This requires using a filter or contingency question.

5. Model Questions:

1. What is sampling? Why is it important in research?
2. What are the various methods in sampling? Discuss with examples.
3. What is a questionnaire ? What are the steps in constructing a questionnaire ?
4. Discuss the various types of questions.
5. What are the advantages and disadvantages of the questionnaire method?

6. Reference Books:

1. Roger D. Wimmer and Joseph R. Dominick Mass Media Research: An Introduction. 8th ed. (Belmont, CA: Wadsworth, 2005).
2. Anderson, J.A (1987) Communication Research : Issues and Methods. New York : McGraw Hill.
3. Babbie, E.R. (2001) The practice of social research, Belmont, CA : Wadsworth.
4. Bowers, J.W. and Courtwright, J.A. (1984) Communication Research methods, Glenview, IL : Scott, Foresman.
5. Sharp, N.W. (1988) Communication research : the Challenge of the information age. Syracuse, NY, Syracuse University Press.

Unit 3 : Lesson 4 : Methods of Data Collection : Interview, Observation and Case Study

1. Objective of the Lesson:

The objective of the lesson is to:

- Introduce you to the observation method of data collection
- Help you to understand how to conduct case studies
- Introduce you to the interview method of data collection

2. Structure of the Lesson:

- Qualitative Methods
- Observation Method
- Participant Observation
- Direct Observation
- Case Study Method
- Steps in Case Study method
- Interviews
- Conducting the Interview

3. Expansion of the Structure:

There are a wide variety of methods that are common in qualitative measurement. In fact, the methods are largely limited by the imagination of the researcher.

Qualitative Methods

There are a wide variety of methods that are common in qualitative measurement. In fact, the methods are largely limited by the imagination of the researcher.

Observation Method

Participant Observation

One of the most common methods for qualitative data collection, participant observation is also one of the most demanding. It requires that the researcher become a participant in the culture or context being observed. The literature on participant observation discusses how to enter the context, the role of the researcher as a participant, the collection and storage of field notes, and the analysis of field data. Participant observation often requires months or years of intensive work because the researcher needs to become accepted as a natural part of the culture in order to assure that the observations are of the natural phenomenon.

Direct Observation

Direct observation is distinguished from participant observation in a number of ways. First, a direct observer doesn't typically try to become a participant in the context. However, the direct observer does strive to be as unobtrusive as possible so as not to bias the observations. Second, direct observation suggests a more detached perspective. The researcher is watching rather than taking part. Consequently, technology can be a useful part of direct observation. For instance, one can videotape the phenomenon or observe from behind one-way mirrors. Third, direct observation tends to be more focused than participant observation. The researcher is observing certain sampled situations or people rather than trying to become immersed in the entire context. Finally, direct observation tends not to take as long as participant observation. For instance, one might observe child-mother interactions under specific circumstances in a laboratory setting from behind a one-way mirror, looking especially for the nonverbal cues being used.

One of the most common methods for qualitative data collection, participant observation is also one of the most demanding. It requires that the researcher become a participant in the culture or context being observed. The literature on participant observation discusses how to enter the context, the role of the researcher as a participant, the collection and storage of field notes, and the analysis of field data. Participant observation often requires

months or years of intensive work because the researcher needs to become accepted as a natural part of the culture in order to assure that the observations are of the natural phenomenon.

We shall discuss the historical roots of participant observation, its practice, and its analysis. Finally, we shall discuss some criticisms made of this method.

Case Study Method

Introduction

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 (Yin, 1984, p. 23).

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.

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:

1. **Determine and define the research questions**
2. **Select the cases and determine data gathering and analysis techniques**
3. **Prepare to collect the data**
4. **Collect data in the field**
5. **Evaluate and analyze the data**
6. **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.

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 depth and which instruments and data gathering approaches to use. When using multiple cases, each case is treated as a single case. Each case?s 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 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.

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.

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.

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.

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 reader?s confidence that all avenues have been explored, clearly communicating the boundaries of the case, and giving special attention to conflicting propositions.

Interviews

Interviews are among the most challenging and rewarding forms of measurement. They require a personal sensitivity and adaptability as well as the ability to stay within the bounds of the designed protocol. Here, I describe the preparation you need to do for an interview study and the process of conducting the interview itself.

The Role of the Interviewer

The interviewer is really the "jack-of-all-trades" in survey research. The interviewer's role is complex and multifaceted. It includes the following tasks:

- **Locate and enlist cooperation of respondents**
- **Motivate respondents to do good job**
- **Clarify any confusion/concerns**
- **Observe quality of responses**
- **Conduct a good interview**

Conducting the Interview

So all the preparation is complete, the training done, the interviewers ready to proceed, their "kits" in hand. It's finally time to do an actual interview. Each interview is unique, like a small work of art (and sometimes the art may not be very good). Each interview has its own ebb and flow -- its own pace. To the outsider, an interview looks like a fairly standard, simple, prosaic effort. But to the interviewer, it can be filled with special nuances and interpretations that aren't often immediately apparent. Every interview includes some common components. There's the opening, where the interviewer gains entry and establishes the rapport and tone for what follows. There's the middle game, the heart of the process, that consists of the protocol of questions and the improvisations of the probe. And finally, there's the endgame, the wrap-up, where the interviewer and respondent establish a sense of closure. Whether it's a two-minute phone interview or a personal interview that spans hours, the interview is a bit of theater, a mini-drama that involves real lives in real time.

Opening Remarks

In many ways, the interviewer has the same initial problem that a salesperson has. You have to get the respondent's attention initially for a long enough period that you can sell them on the idea of participating in the study. Many of the remarks here assume an interview that is being conducted at a respondent's residence. But the analogies to other interview contexts should be straightforward.

Gaining entry

The first thing the interviewer must do is gain entry. Several factors can enhance the prospects. Probably the most important factor is your initial appearance. The interviewer needs to dress professionally and in a manner that will be comfortable to the respondent.

Introduction

If you've gotten this far without having the door slammed in your face, chances are you will be able to get an interview. Without waiting for the respondent to ask questions, you should move to introducing yourself. You should have this part of the process memorized so you can deliver the essential information in 20-30 seconds at most. State your name and the name of the organization you represent. Show your identification badge and the letter that introduces you. You want to have as legitimate an appearance as possible. If you have a three-ring binder or clipboard with the logo of your organization, you should have it out and visible. You should assume that the respondent will be interested in participating in your important study -- assume that you will be doing an interview here.

Explaining the study ; Asking quesions

At this point, you've been invited to come in. They hardly ever get asked their views about anything, and yet they know that important decisions are made all the time based on input from others.). Or, the respondent has continued to listen long enough that you need to move onto explaining the study. There are three rules to this critical explanation: 1) Keep it short; 2) Keep it short; and 3) Keep it short! The respondent doesn't have to or want to know all of the neat nuances of this study, how it came about, how you convinced your thesis committee to buy into it, and so on. You should have a one or two sentence description of the study memorized. No big words. No jargon. No detail. There will be more than enough time for that later (and you should bring some written materials you can leave at the end for that purpose). This is the "25 words or less" description. What you should spend some time on is assuring the respondent that you are interviewing them confidentially, and that their participation is voluntary.

Recording the Response

Although we have the capability to record a respondent in audio and/or video, most interview methodologists don't think it's a good idea. Respondents are often uncomfortable when they know their remarks will be recorded word-for-word. They may strain to only say things in a socially acceptable way. Although you would get a more detailed and accurate record, it is likely to be distorted by the very process of obtaining it. This may be more of a problem in some situations than in others. It is increasingly common to be told that your conversation may be recorded during a phone interview. And most focus group methodologies use unobtrusive recording equipment to capture what's being said. But, in general, personal interviews are still best when recorded by the interviewer using pen and paper.

4. Summary

One of the most common methods for qualitative data collection, participant observation is also one of the most demanding. It requires that the researcher become a participant in the culture or context being observed.

Direct observation is distinguished from participant observation in a number of ways. First, a direct observer doesn't typically try to become a participant in the context. However, the direct observer does strive to be as unobtrusive as possible so as not to bias the observations. Second, direct observation suggests a more detached perspective. The researcher is watching rather than taking part. Third, direct observation tends to be more focused than participant observation. The researcher is observing certain sampled situations or people rather than trying to become immersed in the entire context. Finally, direct observation tends not to take as long as participant observation.

One of the most common methods for qualitative data collection, participant observation is also one of the most demanding. It requires that the researcher become a participant in the culture or context being observed. The literature on participant observation discusses how to enter the context, the role of the researcher as a participant, the collection and storage of field notes, and the analysis of field data. Participant observation often requires months or years of intensive work because the researcher needs to become accepted as a natural part of the culture in order to assure that the observations are of the natural phenomenon.

On first glance, participant observation appears to be just looking, listening, generally experiencing, and writing it all down. However, it is the most personally demanding and analytically difficult method of social research to undertake. It requires researchers to spend a great deal of time in surrounding within which researchers may not be familiar (e.g., factory floor or bank office); to secure and maintain relationships with people with who, they have little personal affinity (e.g., criminals and market traders); to take a lot of notes on what appears to be everyday mundane happenings (e.g., people’s body language and speech patterns, and their arrival and departures); to possibly incurring some personal risk in their fieldwork (e.g., accidents at work); and to spend months of analysis after the fieldwork, analysing field-notes and diaries. Nevertheless, to those who are prepared and willing, it is also one of the most rewarding methods which yields fascinating insights into people's social lives and relationships (e.g., the social world of factory workers or gang members).

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.

Interviews are among the most challenging and rewarding forms of measurement. They require a personal sensitivity and adaptability as well as the ability to stay within the bounds of the designed protocol. Here, I describe the preparation you need to do for an interview study and the process of conducting the interview itself.

The interviewer has to find the respondent. In door-to-door surveys, this means being able to locate specific addresses. The interviewer has to be motivated and has to be able to communicate that motivation to the respondent. Often, this means that the interviewer has to be convinced of the importance of the research. Interviewers have to be able to think on their feet. Respondents may raise objections or concerns that were not anticipated. The interviewer has to be able to respond candidly and informatively. Whether the interview is personal or over the phone, the interviewer is in the best position to judge the quality of the information that is being received. Last, and certainly not least, the interviewer has to conduct a good interview!

One of the most important aspects of any interview study is the training of the interviewers themselves. In many ways the interviewers are your measures, and the quality of the results is totally in their hands. Interviewers need to know more than simply how to conduct the interview itself. They should learn about the background for the study, previous work that has been done, and why the study is important. Interviewers need to know who they are working for. They -- and their respondents -- have a right to know not just what agency or company is conducting the research, but also, who is paying for the research.

The first thing the interviewer must do is gain entry. Several factors can enhance the prospects. Probably the most important factor is your initial appearance. The interviewer needs to dress professionally and in a manner that will be comfortable to the respondent. In some contexts a business suit and briefcase may be appropriate. In others, it may intimidate.

The interviewer should record responses as they are being stated. This conveys the idea that you are interested enough in what the respondent is saying to write it down. You don't have to write down every single word -- you're not taking stenography. But you may want to record certain key phrases or quotes verbatim. You need to develop a system for distinguishing what the respondent says verbatim from what you are characterizing (how about quotations, for instance!).

5. Model Questions

1. Discuss the interview method of data collection.
2. Describe the steps in conducting an interview.
3. Discuss the observation method of collecting data.
4. Mention the various steps in observation method.
5. Distinguish between direct and participant observation.
6. Discuss the case study method of research. Mention its advantages disadvantages.
7. Discuss the steps in case study method of research.

6. Reference Books

1. Bright, E.. An Introduction to Scientific Research (McGraw-Hill, 1952).
2. Gilbert J. Garraghan, A Guide to Historical Method, Fordham University Press: New York (1946). ISBN 0-8371-7132-6.
3. R. J. Shafer, A Guide to Historical Method, The Dorsey Press: Illinois (1974). ISBN 0-534-10825-3.

Unit 4 : Lesson 1 : Use of Statistics in Research : Measures of Central Tendency

1. Objective of the Lesson:

The objective of the lesson is to:

- Introduce you to the use of statistics in research
- Help you to understand measures of central tendency : mean, median and mode

2. Structure of the Lesson:

- Measures of central tendency
- Arithmetic Mean
- Geometric Mean
- Harmonic Mean
- Median
- Computation of median
- Sampling distribution of median
- Mode

Measures of central tendency

Measures of central tendency are measures of the location of the middle or the center of a distribution. The definition of "middle" or "center" is purposely left somewhat vague so that the term "central tendency" can refer to a wide variety of measures.

Measures of central tendency, or "location", attempt to quantify what we mean when we think of as the "typical" or "average" score in a data set. The concept is extremely important and we encounter it frequently in daily life. For example, we often want to know before purchasing a car its average distance per litre of petrol. Or before accepting a job, you might want to know what a typical salary is for people in that position so you will know whether or not you are going to be paid what you are worth. Or, if you are a smoker, you might often think about how many cigarettes you smoke "on average" per day. Statistics geared toward measuring central tendency all focus on this concept of "typical" or "average." As we will see, we often ask questions in psychological science revolving around how groups differ from each other "on average". Answers to such a question tell us a lot about the phenomenon or process we are studying.

Arithmetic Mean

The arithmetic mean is what is commonly called the average: When the word "mean" is used without a modifier, it can be assumed that it refers to the arithmetic mean. The mean is the sum of all the scores divided by the number of scores. The formula in summation notation is:

$\mu = \Sigma X/N$

where μ is the population mean and N is the number of scores.

If the scores are from a sample, then the symbol M refers to the mean and N refers to the sample size. The formula for M is the same as the formula for
μ.

$M = \Sigma X/N$

The mean is a good measure of central tendency for roughly symmetric distributions but can be misleading in skewed distributions since it can be greatly influenced by scores in the tail. Therefore, other statistics such as the median may be more informative for distributions such as reaction time or family income that are frequently very skewed

The sum of squared deviations of scores from their mean is lower than their squared deviations from any other number.

For normal distributions, the mean is the most efficient and therefore the least subject to sample fluctuations of all measures of central tendency.

The formal definition of the arithmetic mean is μ = E[X] where μ is the population mean of the variable X and E[X] is the expected value of X.

Geometric Mean

The geometric mean is the nth root of the product of the scores. Thus, the geometric mean of the scores: 1, 2, 3, and 10 is the fourth root of 1 x 2 x 3 x 10 which is the fourth root of 60 which equals 2.78. The formula can be written as:

Geometric mean = $\left(\prod X\right)^{\frac{1}{N}}$

where ΠX means to take the product of all the values of X. The geometric mean can also be computed by:

1. taking the logarithm of each number
2. computing the arithmetic mean of the logarithms
3. raising the base used to take the logarithms to the arithmetic mean.

X	Ln(X)
1	0
2	0.693147
3	1.098612

10	2.302585
Geometric mean = 2.78	Arithmetic mean = 1.024. EXP[1.024] = 2.78

The base of natural logarithms is 2.718. The expression: EXP[1.024] means that 2.718 is raised to the 1.024th power. Ln(X) is the natural log of X.

Naturally, you get the same result using logs base 10 as shown below.

X	Log(X)
1	0.0000
2	0.30103
3	0.47712
10	1.00000
Geometric mean = 2.78	Arithmetic mean = 0.44454. $10^{0.44454}$ = 2.78

If any one of the scores is zero then the geometric mean is zero. The geometric mean does not make sense if any scores are less than zero.

The geometric mean is less affected by extreme values than is the arithmetic mean and is useful as a measure of central tendency for some positively skewed distributions.

The geometric mean is an appropriate measure to use for averaging rates. For example, consider a stock portfolio that began with a value of $1,000 and had annual returns of 13%, 22%, 12%, -5%, and -13%.The table below shows the value after each of the five years.

Year	Return	Value
1	13%	1,130
2	22%	1,379
3	12%	1,544
4	-5%	1,467
5	-13%	1,276

The question is how to compute annual rate of return? The answer is to compute the geometric mean of the returns. Instead of using the percents, each return is represented as a multiplier indicating how much higher the value is after the year. This multiplier is 1.13 for a 13% return and 0.95 for a 5% loss. The multipliers for this example are 1.13, 1.22, 1.12, 0.95, and 0.87. The geometric mean of these multipliers is 1.05. Therefore, the average annual rate of return is 5%. The following table shows how a portfolio gaining 5% a year would end up with the same value ($1,276) as the one shown above.

Year	**Return**	**Value**
1	5%	1,050
2	5%	1,103
3	5%	1,158
4	5%	1,216

5	5%	1,276

Harmonic Mean
The harmonic mean is used to take the mean of sample sizes. If there are k samples each of size n, then the harmonic mean is defined as:

$$n_h = \frac{k}{\frac{1}{n_1} + \frac{1}{n_2} + \dots \frac{1}{n_k}}$$

For the numbers 1, 2, 3, and 10, the harmonic mean is:

$$n_h = \frac{4}{\frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \frac{1}{10}} = 2.069.$$

= 2.069. This is less than the geometric mean of 2.78 and the arithmetic mean of 4.

Median

The median is the middle of a distribution: half the scores are above the median and half are below the median. The median is less sensitive to extreme scores than the mean and this makes it a better measure than the mean for highly skewed distributions. The median income is usually more informative than the mean income, for example.

The sum of the absolute deviations of each number from the median is lower than is the sum of absolute deviations from any other number.

Example :

The numbers 1, 2, 3, 7, 8, 9, 12 have a mean of 6 and median of 7.

The mean minimizes sum of squared deviations.
The sum of the squared deviations from the mean is:
$(1-6)^2 + (2-6)^2 + (3-6)^2 + (7-6)^2 + (8-6)^2 + (9-6)^2 + (12-6)^2 = 25 +16 + 9 + 1 + 4 + 9 + 36 = 100$.

From the median:
$(1-7)^2 + (2-7)^2 + (3-7)^2 + (7-7)^2 + (8-7)^2 + (9-7)^2 + (12-7)^2 = 36 + 25 + 16 + 0 + 1 + 4 + 25 = 107$.

The median minimizes sum of absolute deviations.
The sum of the absolute values of the deviations from the mean are:
$|1-6| + |2-6| + |3-6| + |7-6| + |8-6| + |9-6| + |12-6| =$
| 5 + 4 + 3 + 1 + 2 + 3 + 6 = 24.

From the median:
$|1-7| + |2-7| + |3-7| + |7-7| + |8-7| + |9-7| + |12-7| =$
6 + 5 + 4 + 0 + 1 + 2 + 5 = 23.

The mean, median, and mode are equal in symmetric distributions. The mean is typically higher than the median in positively skewed distributions and lower than the median in negatively skewed distributions, although this may not be the case in bimodal distributions.

Computation of Median

When there is an odd number of numbers, the median is simply the middle number. For example, the median of 2, 4, and 7 is 4.

When there is an even number of numbers, the median is the mean of the two middle numbers. Thus, the median of the numbers 2, 4, 7, 12 is (4+7)/2 = 5.5.

Sampling Distribution of Median

The standard error of the median for large samples and normal distributions is:

$$\sigma_{median} = 1.253\frac{\sigma}{\sqrt{N}}$$

Thus, the standard error of the median is about 25% larger than that for the mean. It is thus less efficient and more subject to sampling fluctuations. This formula is fairly accurate even for small samples but can be very wrong for extremely non- normal distributions. For non-normal distributions, the standard error of the median is difficult to compute.

The sampling distribution simulation can be used to explore the sampling distribution of the median for non-normal distributions.

Mode

By far the simplest, but also the least widely used, measure of central tendency is the mode. The mode in a distribution of data is simply the score that occurs most frequently. In the distribution of sexual partners data, the mode is "1" because it is the most frequently occurring score in the data set. If you have had only one sexual partner in the last year, it would be reasonable therefore to say that you are fairly typical of UNE students (or at least of those students who responded to the question). Importantly, you cannot necessarily claim that "most" UNE students had only one sexual partner last year. From the frequency distribution, notice that actually fewer than half of the respondents reported having only one sexual partner. So "most" students reported having something different to 1 sexual partner. Still, "1" was the most frequent single response to this question, and so it is the mode or **modal** response. In some cases, however, such a conclusion would be justified. For example, from Figure 3.4, you can see that the modal ethnic group in the U.S. in 1990 was "white" and "most" people living in the U.S. were "white."

Recall that one way of describing a distribution is in terms of the number of modes in the data. A unimodal distribution has one mode. In contrast, a bimodal distribution has two. Now this might seem odd to you. How can there be more than one "most frequently occurring" score in a data set? I suppose statisticians are a bit bizarre in this way. We would accept that a distribution is bimodal if it seems that more than one score or value "stands out" as occurring especially frequently in comparison to other values. But when the data are quantitative in nature, we also want to make sure that the two more frequently occurring scores are not too close to each other in value before we accept the distribution as one that could be described as "bimodal." So there is some subjectivity in the decision as to whether or not a distribution is best characterised as unimodal, bimodal, or multimodal.

4. Summary:

Measures of central tendency are measures of the location of the middle or the center of a distribution. The definition of "middle" or "center" is purposely left somewhat vague so that the term "central tendency" can refer to a wide variety of measures.

Measures of central tendency, or "location", attempt to quantify what we mean when we think of as the "typical" or "average" score in a data set.

The arithmetic mean is what is commonly called the average: When the word "mean" is used without a modifier, it can be assumed that it refers to the arithmetic mean. The mean is the sum of all the scores divided by the number of scores. The formula in summation notation is:

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where μ is the population mean and N is the number of scores.

The mean is a good measure of central tendency for roughly symmetric distributions but can be misleading in skewed distributions since it can be greatly influenced by scores in the tail. Therefore, other statistics such as the median may be more informative for distributions such as reaction time or family income that are frequently very skewed

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For normal distributions, the mean is the most efficient and therefore the least subject to sample fluctuations of all measures of central tendency.

The formal definition of the arithmetic mean is $\mu = E[X]$ where μ is the population mean of the variable X and E[X] is the expected value of X.

The geometric mean is the nth root of the product of the scores. Thus, the geometric mean of the scores: 1, 2, 3, and 10 is the fourth root of 1 x 2 x 3 x 10 which is the fourth root of 60 which equals 2.78. The formula can be written as:

Geometric mean = $$\left(\prod X\right)^{\frac{1}{N}}$$

where ΠX means to take the product of all the values of X. The geometric mean can also be computed by:

4. taking the logarithm of each number
5. computing the arithmetic mean of the logarithms
6. raising the base used to take the logarithms to the arithmetic mean.

If any one of the scores is zero then the geometric mean is zero. The geometric mean does not make sense if any scores are less than zero.

The geometric mean is less affected by extreme values than is the arithmetic mean and is useful as a measure of central tendency for some positively skewed distributions.

The harmonic mean is used to take the mean of sample sizes. If there are k samples each of size n, then the harmonic mean is defined as:

$$n_h = \frac{k}{\frac{1}{n_1} + \frac{1}{n_2} + \ldots \frac{1}{n_k}}$$

For the numbers 1, 2, 3, and 10, the harmonic mean is:

$$n_h = \frac{4}{\frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \frac{1}{10}} = 2.069.$$

= 2.069. This is less than the geometric mean of 2.78 and the arithmetic mean of 4.

The median is the middle of a distribution: half the scores are above the median and half are below the median. The median is less sensitive to extreme scores than the mean and this makes it a better measure than the mean for highly skewed distributions. The median income is usually more informative than the mean income, for example.

The sum of the absolute deviations of each number from the median is lower than is the sum of absolute deviations from any other number.

The mean, median, and mode are equal in symmetric distributions. The mean is typically higher than the median in positively skewed distributions and lower than the median in negatively skewed distributions, although this may not be the case in bimodal distributions.

By far the simplest, but also the least widely used, measure of central tendency is the mode. The mode in a distribution of data is simply the score that occurs most frequently. In the distribution of sexual partners data, the mode is "1" because it is the most frequently occurring score in the data set. If you have had only one sexual partner in the last year, it would be reasonable therefore to say that you are fairly typical of UNE students (or at least of those students who responded to the question). Importantly, you canÕt necessarily claim that "most" UNE students had only one sexual partner last year. From the frequency distribution, notice that actually fewer than half of the respondents reported having only one sexual partner. So "most" students reported having something different to 1 sexual partner. Still, "1" was the most frequent single response to this question, and so it is the mode or **modal** response. In some cases, however, such a conclusion would be justified. For example, from Figure 3.4, you can see that the modal ethnic group in the U.S. in 1990 was "white" and "most" people living in the U.S. were "white."

5. Model Questions:

1. Discuss the use of measures of central tendency in research.
2. What is a mean. Discuss various types of means with examples.
3. What is median. How will you compute the median?
4. What is mode? How is it computed?

6. Reference Books:

1. Daniel, W (1983) Biostatistics – A foundation for analysis in health sciences, John Wiley, New York.
2. Rao, C.R (1993) Statistics must have a purpose, Sankhya A, Vol.55.
3. Snedecor, G.W. and W.G. Cochran (1994) Statistical Methods, 8th edition, East West Press, New Delhi.
4. Sturges, H.A. (1926) The choice of class intervals, Journal of American Statistical Association , Vol21, pp.65-66.

Unit 4 : Lesson 2 : Measures of Dispersion – Standard Deviation, Correlation and Chi – Square

1. Objective of the Lesson:

The objective of the lesson is to:

- Introduce you to the measures of dispersion
- Help you to understand standard deviation and correlation
- Help you to understand chi square

2. Structure of the Lesson:

- Standard Deviation
- Correlation
- Correlation coefficients
  - Chi square test
  - Significance and effect size

Standard Deviation

In probability and statistics, the standard deviation of a probability distribution, random variable, or population or multiset of values is a measure of the spread of its values. It is usually denoted with the letter σ (lower case sigma). It is defined as the square root of the variance.

To understand standard deviation, keep in mind that variance is the average of the squared differences between data points and the mean. Variance is tabulated in units squared. Standard deviation, being the square root of that quantity, therefore measures the spread of data about the mean, measured in the same units as the data.

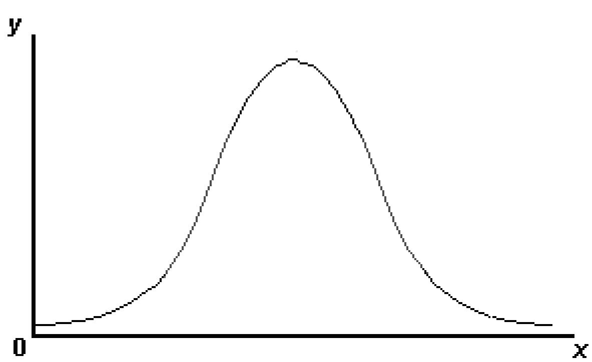
Said more formally, the standard deviation is the root mean square (RMS) deviation of values from their arithmetic mean.

For example, in the population {4, 8}, the mean is 6 and the deviations from mean are {−2, 2}. Those deviations squared are {4, 4} the average of which (the variance) is 4. Therefore, the standard deviation is 2. In this case 100% of the values in the population are at one standard deviation of the mean.

The standard deviation is the most common measure of statistical dispersion, measuring how widely spread the values in a data set are. If many data points are close to the mean, then the standard deviation is small; if many data points are far from the mean, then the standard deviation is large. If all the data values are equal, then the standard deviation is zero.

When you think about it, that's just common sense. Not that many people are getting by on a single serving of kelp and rice. Or on eight meals of steak and milkshakes. Most people lie somewhere in between.

If you looked at normally distributed data on a graph, it would look something like this:



The **x**-axis (the horizontal one) is the value in question... calories consumed, dollars earned or crimes committed, for example. And the **y**-axis (the vertical one) is the number of datapoints for each value on the **x**-axis... in other words, the number of people who eat **x** calories, the number of households that earn **x** dollars, or the number of cities with **x** crimes committed.

Now, not all sets of data will have graphs that look this perfect. Some will have relatively flat curves, others will be pretty steep. Sometimes the mean will lean a little bit to one side or the other. But all normally distributed data will have something like this same "bell curve" shape.

The **standard deviation** is a statistic that tells you how tightly all the various examples are clustered around the mean in a set of data. When the examples are pretty tightly bunched together and the bell-shaped curve is steep, the standard deviation is small. When the examples are spread apart and the bell curve is relatively flat, that tells you you have a relatively large standard deviation.

Correlation

Correlation is a statistical technique which can show whether and how strongly pairs of variables are related. For example, height and weight are related - taller people tend to be heavier than shorter people. The relationship isn't perfect. People of the same height vary in weight, and you can easily think of two people you know where the shorter one is heavier than the taller one. Nonetheless, the average weight of people 5'5" is less than the average weight of people 5'6", and their average weight is less than that of people 5'7", etc. Correlation can tell you just how much of the variation in peoples' weights is related to their heights.

Although this correlation is fairly obvious your data may contain unsuspected correlations. You may also suspect there are correlations, but don't know which are the strongest. An intelligent correlation analysis can lead to a greater understanding of your data.

There are several different correlation techniques. The Survey System's optional Statistics

Module includes the most common type, called the Pearson or product-moment correlation. The module also includes a variation on this type called partial correlation. The latter is useful when you want to look at the relationship between two variables while removing the effect of one or two other variables.

Like all statistical techniques, correlation is only appropriate for certain kinds of data. Correlation works for data in which numbers are meaningful, usually quantities of some sort. It cannot be used for purely categorical data, such as gender, brands purchased or favorite color.

Rating scales are a controversial middle case. The numbers in rating scales have meaning, but that meaning isn't very precise. They are not like quantities. With a quantity (such as dollars), the difference between 1 and 2 is exactly the same as between 2 and 3. With a rating scale, that isn't really the case. You can be sure that your respondents think a rating of 2 is between a rating of 1 and a rating of 3, but you cannot be sure they think it is exactly halfway between. This is especially true if you labeled the mid-points of your scale (you cannot assume "good" is exactly half way between "excellent" and "fair").

Most statisticians say you cannot use correlations with rating scales, because the mathematics of the technique assume the differences between numbers are exactly equal. Nevertheless, many survey researchers do use correlations with rating scales, because the results usually reflect the real world. Our own position is that you can use correlations with rating scales, but you should do so with care. When working with quantities, correlations provide precise measurements. When working with rating scales, correlations provide general indications.

The main result of a correlation is called the correlation coefficient (or "r"). It ranges from -1.0 to +1.0. The closer r is to +1 or -1, the more closely the two variables are related.

If r is close to 0, it means there is no relationship between the variables. If r is positive, it means that as one variable gets larger the other gets larger. If r is negative it means that as one gets larger, the other gets smaller (often called an "inverse" correlation).

Correlation Coefficients

The numerical summary includes the mean and standard deviation of each variable separately plus a measure known as the *correlation coefficient* (also the *Pearson correlation coefficient,* after Karl Pearson), a summary of the strength of the linear association between the variables. If the variables tend to go up and down together, the correlation coefficient will be positive. If the variables tend to go up and down in opposition with low values of one variable associated with high values of the other, the correlation coefficient will be negative.

"Tends to" means the association holds "on average", not for any arbitrary pair of observations, as the following scatterplot of weight against height for a sample of older women shows. The correlation coefficient is positive and height and weight tend to go up and down together. Yet, it is easy to find pairs of people where the taller individual weighs less, as the points in the two boxes illustrate.

Correlations tend to be positive. Pick any two variables at random and they'll almost certainly be positively correlated, if they're correlated at all--height and weight; saturated fat in the diet and cholesterol levels; amount of fertilizer and crop yield; education and income. Negative correlations tend to be rare--automobile weight and fuel economy; folate intake and homocysteine; number of cigarettes smoked and child's birth weight.

The correlation coefficient of a set of observations $\{(x_i,y_i): i=1,..,n\}$ is given by the formula

$$r = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2\sum_{i=1}^{n}(y_i-\bar{y})^2}}$$

Chi square test

A chi-square 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 (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.

Specifically, a chi-square test for independence evaluates statistically significant differences between proportions for two or more groups in a data set.

1. Pearson's chi-square test, also known as the Chi-square goodness-of-fit test, commonly referred to as the chi-square test
2. Yates' chi-square test also known as Yates' correction for continuity
3. Mantel-Haenszel chi-square test
4. Linear-by-linear association chi-square test

Significance and effect size

In the social sciences, the significance of the chi-square statistic is often given in terms of a p value (e.g., p = 0.05). It is an indication of the likelihood of obtaining a result (0.05 = 5%). As such, it is relatively uninformative. A more helpful accompanying statistic is phi (or Cramer's phi, or Cramer's V).[1] Phi is a measure of association that reports a value for the correlation between the two dichotomous variables compared in a chi-square test (2 × 2). This value gives you an indication of the extent of the relationship between the two variables. Cramer's phi can be used for even larger comparisons. It is a more meaningful measure of the practical significance of the chi-square test and is reported as the effect size.

Chi-square test for contingency table

A chi-square test may be applied on a contingency table for testing a null hypothesis of independence of rows and columns.

Pearson's chi-square test ($\chi 2$) is one of a variety of chi-square tests – statistical procedures whose results are evaluated by reference to the chi-square distribution. Its properties were first investigated by Karl Pearson.

It tests a null hypothesis that the relative frequencies of occurrence of observed events follow a specified frequency distribution. The events are assumed to be independent and have the same distribution, and the outcomes of each event must be mutually exclusive. A simple example is the hypothesis that an ordinary six-sided die is "fair", i.e., all six outcomes occur equally often. Pearson's chi-square is the original and most widely-used chi-square test.

Chi-square is calculated by finding the difference between each observed and theoretical frequency for each possible outcome, squaring them, dividing each by the theoretical frequency, and taking the sum of the results. The number of degrees of freedom is equal to the number of possible outcomes, minus 1:

$$\chi^2_{n-1} = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

where

Oi = an observed frequency;

Ei = an expected (theoretical) frequency, asserted by the null hypothesis;

n = the number of possible outcomes of each event.

Pearson's chi-square is used to assess two types of comparison: tests of goodness of fit and tests of independence. A test of goodness of fit establishes whether or not an observed frequency distribution differs from a theoretical distribution. A test of independence assesses whether paired observations on two variables, expressed in a contingency table, are independent of each other – for example, whether people from different regions differ in the frequency with which they report that they support a political candidate.

A chi-square probability of 0.05 or less is commonly interpreted by applied workers as justification for rejecting the null hypothesis that the row variable is unrelated (that is, only randomly related) to the column variable. The alternate hypothesis is accepted that both the variables have an associated relationship.

Example

For example, to test the hypothesis that a random sample of 100 people has been drawn from a population in which men and women are equal in frequency, the observed number of men and women would be compared to the theoretical frequencies of 50 men and 50 women. If there were 45 men in the sample and 55 women, then

$$\chi^2 = \frac{(45-50)^2}{50} + \frac{(55-50)^2}{50} = 1.$$

If the null hypothesis is true (i.e., men and women are chosen with equal probability in the sample), the test statistic will be drawn from a chi-square distribution with one degree of freedom. Though one might expect two degrees of freedom (one each for the men and women), we must take into account that the total number of men and women is constrained (100), and thus there is only one degree of freedom (2 − 1). Alternatively, if the male count is known the female count is determined, and vice-versa.

Consultation of the chi-square distribution for 1 degree of freedom shows that the probability of observing this difference (or a more extreme difference than this) if men and women are equally numerous in the population is approximately 0.3. This probability is higher than conventional criteria for statistical significance, so normally we would not reject the null hypothesis that the number of men in the population is the same as the number of women.

4. Summary:

In probability and statistics, the standard deviation of a probability distribution, random variable, or population or multiset of values is a measure of the spread of its values. It is usually denoted with the letter σ (lower case sigma). It is defined as the square root of the variance.

To understand standard deviation, keep in mind that variance is the average of the squared differences between data points and the mean. Variance is tabulated in units squared. Standard deviation, being the square root of that quantity, therefore measures the spread of data about the mean, measured in the same units as the data.

Said more formally, the standard deviation is the root mean square (RMS) deviation of values from their arithmetic mean.

Correlation is a statistical technique which can show whether and how strongly pairs of variables are related. For example, height and weight are related - taller people tend to be heavier than shorter people. The relationship isn't perfect. People of the same height vary in weight, and you can easily think of two people you know where the shorter one is heavier than the taller one. Nonetheless, the average weight of people 5'5" is less than the average weight of people 5'6", and their average weight is less than that of people 5'7", etc. Correlation can tell you just how much of the variation in peoples' weights is related to their heights.

The correlation coefficient of a set of observations $\{(x_i,y_i): i=1,..,n\}$ is given by the formula

$$r = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2\sum_{i=1}^{n}(y_i-\bar{y})^2}}$$

A chi-square 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 (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.

5. Model Questions:

1. What is standard deviation ? How will you compute standard deviation?
2. What is correlation ? Mention the formula in calculating Pearson's correlation coefficient.

6. Reference Books:

1. Daniel, W (1983) Biostatistics – A foundation for analysis in health sciences, John Wiley, New York.
2. Rao, C.R (1993) Statistics must have a purpose, Sankhya A, Vol.55.
3. Snedecor, G.W. and W.G. Cochran (1994) Statistical Methods, 8^{th} edition, East West Press, New Delhi.
4. Sturges, H.A. (1926) The choice of class intervals, Journal of American Statistical Association , Vol21, pp.65-66.

Unit 5 : Lesson 1 : Data Processing, Analysis and Interpretation of Data

1. Objective of the Lesson:

   The objective of the lesson is to:

   - Introduce you to Data processing, analysis and its interpretation

2. Structure of the Lesson:

   - Data Processing
   - Data Analysis
   - Use of graphics in data presentation
   - Presenting data using tables
   - Presenting data using charts and graphs

Data Processing

Data processing is any computer process that converts data into information or knowledge. The processing is usually assumed to be automated and running on a computer. Because data are most useful when well-presented and actually informative, data-processing systems are often referred to as information systems to emphasize their practicality. Nevertheless, both terms are roughly synonymous, performing similar conversions; data-processing systems typically manipulate raw data into information, and likewise information systems typically take raw data as input to produce information as output.

To better market their profession, a computer programmer or a systems analyst that might once have referred, such as during the 1970s, to the computer systems that they produce as data-processing systems more often than not nowadays refers to the computer systems that they produce by some other term that includes the word information, such as information systems, information technology systems, or management information systems.

In the context of data processing, data are defined as numbers or characters that represent measurements from observable phenomena. A single datum is a single measurement from observable phenomena. Measured information is then algorithmically derived and/or logically deduced and/or statistically calculated from multiple data. (evidence). Information is defined as either a meaningful answer to a query or a meaningful stimulus that can cascade into further queries.

More generally, the term data processing can apply to any process that converts data from one format to another, although data conversion would be the more logical and correct term. From this perspective, data processing becomes the process of converting information into data and also the converting of data back into information. The distinction is that conversion doesn't require a question (query) to be answered. For example, information in the form of a string of characters forming a sentence in English is converted or encoded from a keyboard's key-presses as represented by hardware-oriented integer codes into ASCII integer codes after which it may be more easily processed by a computer—not as merely raw, amorphous integer data, but as a meaningful character in a natural language's set of graphemes—and finally converted or decoded to be displayed as characters, represented by a font on the computer display. In that example we can see the stage-by-stage conversion of the presence of and then absence of electrical conductivity in the key-press and subsequent release at the keyboard from raw substantially-meaningless integer hardware-oriented data to evermore-meaningful information as the processing proceeds toward the human being.

Conversely, that simple example for pedagogical purposes here is usually described as an embedded system (for the software resident in the keyboard itself) or as (operating-)systems programming, because the information is derived from a hardware interface and may involve overt control of the hardware through that interface by an operating system. Typically control of hardware by a device driver manipulating ASIC or FPGA registers is not viewed as part of data processing proper or information systems proper, but rather as the domain of embedded systems or (operating-)systems programming. Instead, perhaps a more conventional example of the established practice of using the term data processing is that a business has collected numerous data concerning an aspect of its operations and that this multitude of data must be presented in meaningful, easy-to-access presentations for the managers who must then use that information to increase revenue or to decrease cost. That conversion and presentation of data as information is typically performed by a data-processing application.

When the domain from which the data are harvested is a science or an engineering, data processing and information systems are considered too broad of terms and the more specialized term data analysis is typically used, focusing on the highly-specialized and highly-accurate algorithmic derivations and statistical calculations that are less often observed in the typical general business environment. This divergence of culture is exhibited in the typical numerical representations used in data processing versus numerical; data processing's measurements are typically represented by integers or by fixed-point or binary-coded decimal representations of real numbers whereas the majority of data analysis's measurements are often represented by floating-point representation of real numbers.

Practically all naturally occurring processes can be viewed as examples of data processing systems where "observable" information in the form of pressure, light, etc. are converted by human observers into electrical signals in the nervous system as the senses we recognise as touch, sound, and vision. Even the interaction of non-living systems may be viewed in this way as rudimentary information processing systems. Conventional usage of the terms data processing and information systems restricts their use to refer to the algorithmic derivations, logical deductions, and statistical calculations that recur perennially in general business environments, rather than in the more expansive sense of all conversions of real-world measurements into real-world information in, say, an organic biological system or even a scientific or engineering system.

Data Analysis

Raw data is collected during scientific investigations which need to be transformed into some format that allows interpretation and analysis between the variables. Data can be presented in a variety of formats such as tables, graphs, maps, diagrams illustrations, flow charts etc.

Once data has been displayed in an appropriate format and all investigative tasks are completed then understanding what it means is a matter of **interpreting and analysing** the data so that conclusions can be drawn.

Interpretation	**– Identify trends in different variables.**
Correlating	**– Identifying how one factor affects another.**
Analysing	**– Understanding what the data represents.**

The purpose of many investigations is to determine whether a relationship does exist between two variables. ie To see if a correlation exists. Consider the data displayed on the line and scatter graphs in Figure 1 and 2 below .

To interpret graphs trends or patterns must be identified. If a trend exists, this will suggest some kind of relationship between the two variables. Many relationships are possible.

For analyzing the data, it has to be presented in some form.

The following table illustrates how the data can be presented :

Nature of Independent variable	**Nature of Dependent variable**	**Type of Graph**
Data continuous Individual readings	Data continuous Individual readings	Line graph
Data continuous No independent variable identified	Data continuous No dependent variable identified	Scatter graph
Data discontinuous Data grouped into non-numerical categories	Dependent variable **measured** or **counted**	Bar / Column graph
Data continuous Data grouped into numerical size / sample intervals	Dependent variable counted	Histogram

Data can be presented using graphs and charts that makes it easy to interpret.

Use of Graphics in Data Presentation

Quality data presentations ensure user understanding by taking advantage of how users already process information, reduce the number of thought processes required to understand the data, and breakdown fundamental obstacles to understanding.

Good quality presentations of data includes a number of steps :

- **Take advantage of how we already process information**
- **Reduce the number of processes required to understand the data**
- **Tear down some fundamental obstacles to understanding**

Statistical graphics may be used to present the data. These graphics :

- **show the big picture**
- **are paragraphs of data**
- **are best when constructed to convey one finding or concept**

Since the purpose is to show the data, the researcher must maximize Data density and Data ink.

Presenting data using tables

Numerical tables generally serve one of two purposes. Just about all of the numerical data included in this book was originally found in "look up" tables, databases or spreadsheets compiled by government statistical agencies or nongovernmental organizations. The general and limited purpose of these database tabulations is to present all the numerical information available that might be relevant to a wide variety of data users. For the most part, the textual discussion accompanying these tabulations serves only to describe how the data were obtained and to define what the numbers mean. The analytical tables contained in social science research, however, serve a different purpose: the presentation of numerical evidence relevant to support specific conclusions contained in the text. To serve this purpose much care must be given to the selection of the data and to the design of the table.

Research reports and analyses based on numerical information should accommodate two different audiences: those who read the text and tend to ignore the data presented in tables and charts and those who skim the text and grasp the main ideas from the data presentation. To serve the later audience, tables should be self-explanatory, conveying the critical ideas contained in the data without relying on the text to explain what the numbers mean. When done well, the tables will complement the textual discussion and the text will provide a general summary of the most important ideas to be derived from the data – without repeating each and every number, or many of the numbers, contained in the table.

There are three general characteristics of a good tabular display. The table should present meaningful data. The data should be unambiguous. The table should convey ideas about the data efficiently.

Whether or not the data are meaningful has to do with how closely the data relate to the main points that you are trying to make in your analysis or report. The data and the relationships among the data contained in a table constitute the premises, or evidence, offered to support a conclusion. Ideally this should be an important conclusion, an essential part of the analysis you are making.

Whether or not the information presented in a table is unambiguous depends largely on the descriptive text contained in the titles, headings, and notes. The text should clearly and precisely define each number in the table. The titles, headings and footnotes should convey the general purpose of the table, explain coding, scaling and definition of the variables, and define relevant terms or abbreviations

An efficient tabular display will allow a reader to quickly discern the purpose and import of the data and to draw a variety of interesting conclusions from a large amount of information. How quickly a reader can digest the information presented, discern the critical relationships among the data, and draw meaningful conclusions depends on how well the table is formatted.

Presenting Meaningful Data

Report the most meaningful data, data that measure something important about the cases you are analyzing. Knowing just which data are meaningful and which are not requires an understanding both of the specific subject matter you are writing about and a good understanding of where the data come from and how they are collected. When reporting social indicator data, whether data are meaningful or not depends on the appropriate counts, divisors and comparisons that will be represented in the table.

Defining rows and columns. As a general rule, similar data ought to be presented in the columns. Mixing data of different types in the same column is disorienting.

Time: In tables where the time points define the columns, display years in adjacent columns, from left to right. Where the time points are in a column, sort so that the most recent year is at the bottom. Time series trend data of more than five time points is generally better displayed in a time series chart than in a table. Times series charts convey trends more efficiently than tables, but with some loss of accuracy.

The professional education journal Phi Delta Kappan sponsors an annual poll of public attitudes concerning the nation's public schools. Every year in numerous tables, their polling report displays data tables with the years backward, with the most recent year's data in the first column on the left.

The same principle applies in the case of other ordered categories such as age groups, years of education (or educational attainment), temperature ranges, height or weight: the categories representing the largest magnitudes should generally appear on the right or at the bottom of the table.

Consistency: When a paper or report contains more than one table, the formatting ought to be consistent across tables: same fonts, same heading style, and same borders.

Combining tables. While cramming too much data and too many different kinds of data into a single table should be avoided, you should also look for opportunities to combine several tables into one.

Charts and Graphs

A graphical chart provides a visual display of data that otherwise would be presented in a table; a table, one that would otherwise be presented in text. Ideally, a chart should convey ideas about the data that would not be readily apparent if they were displayed in a table or as text.

The three standards for tabular display of data -- the **efficient** display of **meaningful** and **unambiguous** data -- apply to charts as well. As with tables, it is crucial to good charting to choose meaningful data, to clearly define what the numbers represent, and to present the data in a manner that allows the reader to quickly grasp what the data mean. As with tabular display, data ambiguity in charts arises from the failure to precisely define just what the data represent. Every dot on a scatterplot, every point on a time series line, every bar on a bar chart represents a number (actually, in the case of a scatterplot, two numbers). It is the job of the chart's text to tell the reader just what each of those numbers represents.

Designing good charts, however, presents more challenges than tabular display as it draws on the talents of both the scientist and the artist. You have to know and understand your data, but you also need a good sense of how the reader will visualize the chart's graphical elements.

Two problems arise in charting that are less common when data are displayed in tables. Poor choices, or deliberately deceptive, choices in graphic design can provide a distorted picture of numbers and relationships they represent. A more common problem is that charts are often designed in ways that hide what the data might tell us, or that distract the reader from quickly discerning the meaning of the evidence presented in the chart.

Highlighting comparisons. The purpose of properly sorting the data, correctly arranging the rows and columns, combining what could be multiple tables into one and other efficiency rules is to allow the reader to quickly grasp the most meaningful comparisons that the data allow.

Income Mobility in the 70s and 90s

Where families started, by Quintile	Where families ended up 10 years later, by Quintile				
	Poorest	Second	Third	Fourth	Richest
1969-1979					
Poorest	**49.4**	24.5	13.8	9.1	3.3
Second	23.2	**27.8**	25.2	16.2	7.7
Third	10.2	23.4	**24.8**	23.0	18.7
Fourth	9.9	15.0	24.1	**27.4**	23.7
Richest	5.0	9.0	13.2	23.7	**49.1**
1988-1998					
Poorest	**53.3**	23.6	12.4	6.4	4.3
Second	25.7	**36.3**	22.6	11.0	4.3
Third	10.9	20.7	**28.3**	27.5	12.6
Fourth	6.5	12.9	23.7	**31.1**	25.8
Richest	3.0	5.7	14.9	23.2	**53.2**

Source: Bradbury and Katz, 2002

Table 17: Highlighting the important comparisons

Table 17 contains data on income mobility that were originally presented in two tables in an article by Katharine Bradbury and Jane Katz. Their basic point is that the poor were somewhat more likely to escape poverty in the 1970s than they are in the 1990s, while the rich are more likely to remain rich. The crucial evidence is in the diagonals of the tabulations and putting those data in bold allows the reader to discern the point more quickly.

Borders: A common and simple table format is used in most of the tables on these pages. It includes a thin straight border under the title and heading cells and under the main body of data. There is usually no need for vertical borders. Often, the title is in bold. Putting the headings in bold is advised only if they are very short headings, and not if it is inconsistent with the format for other tables in the report. The tables include only horizontal lines; partly this is due to MLA style guidelines that were originally designed for manuscripts prepared with manual typewriters.

MLA and APA style guidelines recommend that table titles be italicized (one of the few recent acknowledgements that manual typewriters are no longer in use) and aligned to the left with the text underlined and that the table number be placed (again aligned to the left) above the title. These style recommendations, however, are for papers that are not in final form, i.e., manuscripts that will later be formatted by a publisher. The MLA style guides also specify that tables (and the text of manuscripts) be double spaced and that the tables be placed at the end of the manuscript; this is for the convenience of manuscript proofreaders and not for readers.

The Components of a Chart

There are three basic components to most charts:

- the labeling that defines the data: the title, axis titles and labels, legends defining separate data series, and notes (often, to indicate the data source),
- scales defining the range of the Y (and sometimes the X) axis, and
- the graphical elements that represent the data: the bars in bar charts, the lines in times series plot, the points in scatterplots, or the slices of a pie chart.

Titles. In journalistic writing a chart title will sometimes state the conclusion the writer would have the reader draw from the chart. In academic writing, the title should be used to define the data series, without imposing a data interpretation on the reader. Often, the units of measurement are specified at the end of the title after a colon or in parentheses in a subtitle (e.g. “constant dollars”, “% of GDP”, or “billions of US dollars”).

Axis titles. Axis titles should be brief and should not be used at all if the information merely repeats what is clear from the title and axis labels. It is not necessary to repeat either the phrase or the word “percent” in the axis title.

Axis scale and data labels. The value or magnitude of the main graphical elements of the chart are defined by either or both the axis scale and individual data labels. Avoid using too many numbers to define the data points. A chart that labels the value of each individual data point does not need labeling on the y axis. If it seems necessary to label every value in a chart, consider that a table is probably a more efficient way of presenting the data.

Legends. Legends are used in charts with more than one data series. They should not be placed on the outside of the chart in a way than reduces the plot area, the amount of space given to represent the data.

Gridlines. If used at all, gridlines should use as little ink as possible so as to not overwhelm the main graphical elements of the chart.

The source. Specifying the source of the data is important for proper academic citation, but it also can also give knowledgeable readers who are often familiar with common data sources important insights into the reliability and validity of the data.

Other chart elements. The amount of ink given over to the non-data elements of a chart that are not necessary for defining the meaning and values of the data should be kept to an absolute minimum. Plot area borders and plot area shading are unnecessary. Keep the shading of the graphical elements simple and always avoid using unnecessary 3-D effects. In most of the charts that follow, even the vertical line defining the the Y-axis has been removed, following the commendable charting standards of *The Economist* magazine.

Types of Charts

Most charts are a variation on one of four basic types: pie charts, bar charts, time series charts and scatterplots. Choosing the right type of chart depends on the characteristics of the data and the relationships you want displayed.

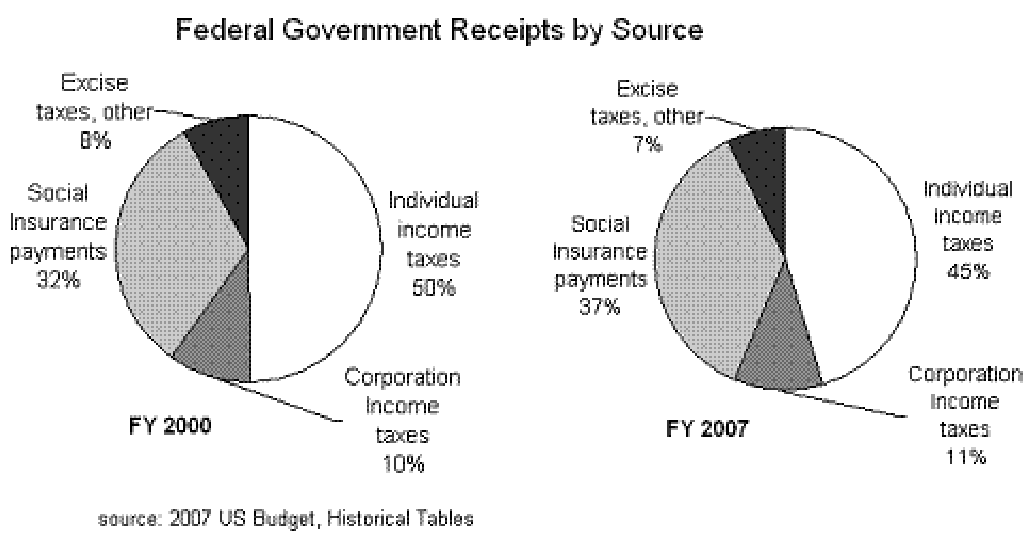
Pie Charts

Pie charts are used to represent the distribution of the categorical components of a single variable. Note that as a general rule, multivariate comparisons provide for more meaningful analysis than do single variable distributions and for this and other reasons pie charts should be rarely used, if at all.

Rules for pie charts:

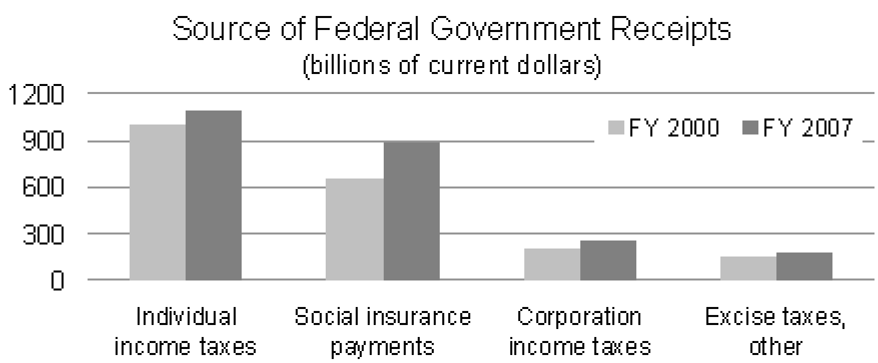
- Avoid using pie charts.
- Use pie charts only for data that add up to some meaningful total.
- Never ever use three dimensional pie charts; they are even worse than two dimensional pies.
- Avoid forcing comparisons across more than one pie chart.

An example of a pie chart :



Pie charts should rarely be used. Pie charts usually contain more ink than is necessary to display the data and the slices provide for a poor representation of the magnitude of the data points. Do you remember as a kid trying to decide which slice of your birthday cake was the largest? It is more difficult for the eye to discern the relative size of pie slices than it is to assess relative bar length. Forcing the reader to draw comparisons across the two pie charts shown in figure 6 is also a bad idea: without looking at the data label percentages in the above figures one cannot easily determine whether the FY 2000 slices are larger or smaller than the corresponding FY 2007 slices

All the information in the pie charts above can be conveyed more precisely and with far less ink in the simple bar chart shown in figure below.



<u>Figure 8: Bar charts are better than pie charts.</u>

Nevertheless, people like pie charts. Readers expect to see one or two pie charts similar to those in figure 6 at the very beginning of an annual agency budget report. But it would be a big mistake to rely on several pie charts for the primary data analysis in a report.

As a general rule 3-D charts are not a good idea even when the data are three dimensional. In theory they provide for a precise representation of data, but it is rare that provide a basis for drawing a simple conclusion.

Bar Charts:

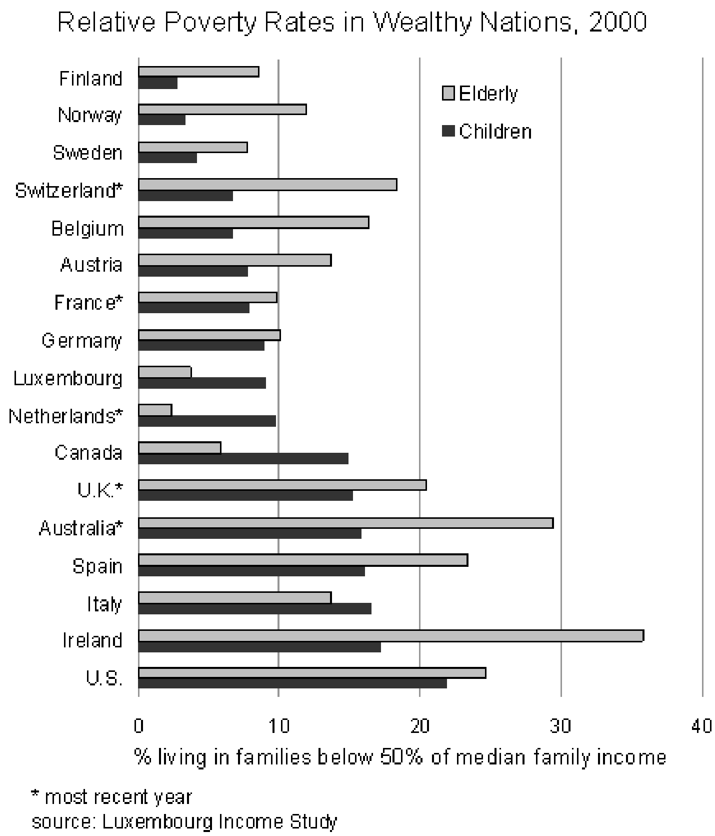
Bar charts typically display the relationship between one or more categorical variables with one or more quantitative variables represented by the length of the bars. The categorical variables are usually defined by the categories displayed on the X-axis and, if there is more than one data series, by the legend.

Rules for bar charts:

- Minimize the ink, do not use 3-D effects.
- Sort the data on the most significant variable.
- Use rotated bar charts if there are more than 8 to 10 categories.
- Place legends inside or below the plot area.
- With more than one data series, beware of scaling distortions.

Bar charts often contain little data, a lot of ink, and rarely reveal ideas that cannot be presented much more simply in a table. Minimizing the ink-to-data ratio is especially important in the case of bar charts. Never use a 3-D bar chart. Keep the gridlines faint. Display no more than seven numbers on the Y-axis scale. If there are fewer than five bars, consider using data labels rather than a Y-axis scale; it doesn't make sense to use a five-numbered scale when the exact values can be shown with four numbers.

An example of a bar chart :



The stacked bar chart works best when the primary comparisons are to be made across the data series represented at the bottom of the bar. Thus, placing the "teachers" data series at the bottom of the bars in figure 11 (and sorting the data on that series) forces the reader's attention on the crucial comparison and the obvious conclusion: American teachers are fortunate to have such a large supervisory and support staff.

One common bar charting mistake is including the legend on the right-hand side of the plot area (shown in figure 12), placing the legend inside the plot area, as in figure 9, or horizontally under the table title (as in figure 11) maximizes the size of the area given over to displaying the data.

Scaling effects occur when a bar chart (or a line chart, as we will see) two data series with numbers of a substantially different magnitude, the variation in the data series containing the smaller numbers.

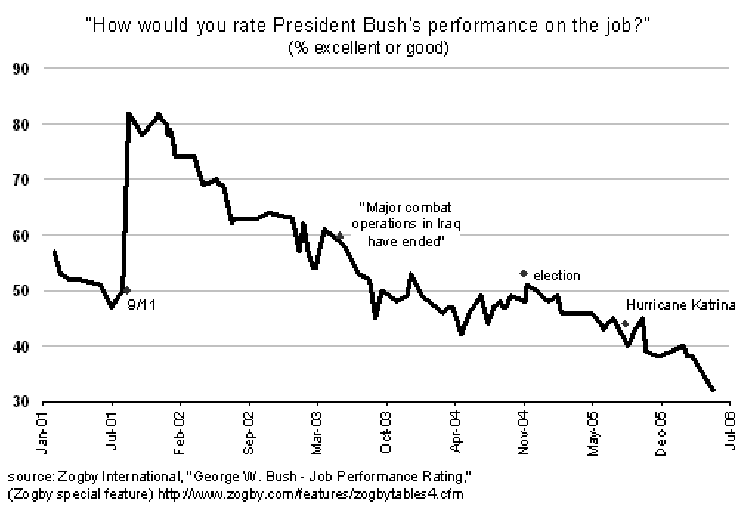
Times Series Line Charts:

The time series chart is one of the most efficient means of displaying large amounts of data in ways that provide for meaningful analysis. The typical time series line chart is a scatterplot chart with time represented on the X-axis and lines connecting the data points.

Rules for Time Series (Line) Charts

- Time is almost always displayed on the X-axis from left to right.
- Display as much data with as little ink as possible.
- Make sure the reader can clearly distinguish the lines for separate data series.
- Beware of scaling effects.
- When displaying fiscal or monetary data over-time, it is often best to use deflated data (e.g., inflation-adjusted or % of GDP)

Example of a line chart :



<u>Presidential approval: times series trend with annotations</u>

Scaling effects. When two variables with numbers of different magnitudes are graphed on the same chart, the variable with the large scale will generally appear to have a greater degree of variation; the smaller-scale variable will appear relatively "flat" even though the percentage change is the same

Many who have written about graphical distortion condemn the use of two-scale charts because the relative sizes of the two scales are completely arbitrary. This is true; had job approval and unemployment been plotted on the same 0 to 90 Y-axis scale, the unemployment rate would be an almost flat line at the bottom of the chart.

One solution to trendlines of different magnitudes is to rescale the variables, calculating the percentage change from a base year —but note that the selection of the base year can produce dramatically different results.

When several times series lines are printed in black and white, it is sometimes difficult to separate out the different tend lines. Mixing solid, dotted, and dashed lines for each variable may solve this problem, although it is sometimes difficult to distinguish between dotted and dashed lines.

Scatterplots

The two-dimensional scatterplot is the most efficient medium for the graphical display of data. A simple scatterplot will tell you more about the relationship between two interval-level variables than any other method of presenting or summarizing such data.

Rules for Scatterplots

- Use two interval-level variables.
- Fully define the variables with the axis titles.

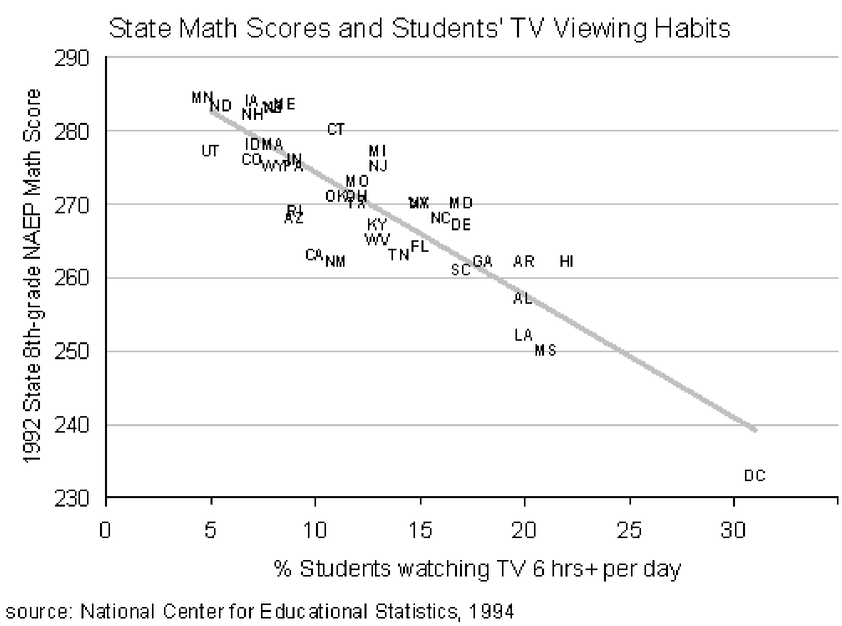
- Use the chart title should identify the two variables and the cases (e.g., cities or states)
- If there is an implied causal relationship between the variables, place the independent variable (the one that causes the other) on the X-axis and the dependent variable (the one that may be caused by the other) on the Y-axis.

· Scale the axes to maximize the use of the plot area for displaying the data points.

· It’s a good idea to add data labels to identify the cases.

With good labeling of the variables and cases and common-sense scaling of the X and Y-axes, there's not a lot that can go wrong with a scatterplot, although extreme outliers on one or more of the variables can obscure patterns in the data.

Example of a Scatterplot :



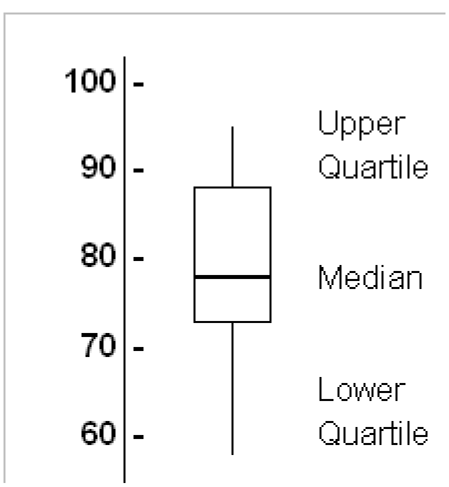
In the figure, TV viewing is the independent variable. (If you were trying to predict which types of students watch the most TV, the axes would be reversed.) The scatterplot contains two optional plotting features: a regression trendline denoting the linear relationship between the two variables and the use of State postal ID data labels to indicate each state's position on the chart (these labels require a special add-in to the Excel program). Although the chart suffers from overlapping data labels, the interpretation is straightforward; the higher the percentage of students in a state watching more than 6 hours of TV each day, the lower the state's math scores.

Boxplots

John W. Tukey invented the boxplot as a convenient method of displaying the distribution of interval-level variables.

Rules for Boxplots:

- A simple boxplot plots the median and four quartiles of data for an interval level variable.
- Boxplots are best used for comparing the distribution of the same variable for two or more groups or two or more time points.
- Boxplots are an excellent means of displaying how a single case compares to a large number of other cases.



The simple boxplot, as shown in the figure , displays the four quartiles of the data, with the "box" comprising the two middle quartiles, separated by the median. The upper and lower quartiles are represented by the single lines extending from the box. More detailed versions of the boxplot restrict the “whiskers” on the plot to 1.5 times the size of the boxes and plot the higher or lower values (outliers) as individual points. Some versions also plot the mean in addition to the median.

A single boxplot box rarely reveals much about the data, and graphs of single variable data distributions (using stem-and-leaf or histogram charts) rarely offer a more detailed graphic representation of the data distribution. The real advantages of the boxplot graphic comes through, however, in single charts using several boxplots to compare the distribution of a variable across groups or over time and an especially useful elaboration of the boxplot graph involves plotting an individual case over the boxplot to compare single cases to the overall distribution.

4. Summary:

Data processing is any computer process that converts data into information or knowledge. The processing is usually assumed to be automated and running on a computer. Because data are most useful when well-presented and actually informative, data-processing systems are often referred to as information systems to emphasize their practicality. Nevertheless, both terms are roughly synonymous, performing similar conversions; data-processing systems typically manipulate raw data into information, and likewise information systems typically take raw data as input to produce information as output.

More generally, the term data processing can apply to any process that converts data from one format to another, although data conversion would be the more logical and correct term. From this perspective, data processing becomes the process of converting information into data and also the converting of data back into information. The distinction is that conversion doesn't require a question (query) to be answered. For example, information in the form of a string of characters forming a sentence in English is converted or encoded from a keyboard's key-presses as represented by hardware-oriented integer codes into ASCII integer codes after which it may be more easily processed by a computer—not as merely raw, amorphous integer data, but as a meaningful character in a natural language's set of graphemes—and finally converted or decoded to be displayed as characters, represented by a font on the computer display. In that example we can see the stage-by-stage conversion of the presence of and then absence of electrical conductivity in the key-press and subsequent release at the keyboard from raw substantially-meaningless integer hardware-oriented data to evermore-meaningful information as the processing proceeds toward the human being.

Raw data is collected during scientific investigations which need to be transformed into some format that allows interpretation and analysis between the variables. Data can be presented in a variety of formats such as tables, graphs, maps, diagrams illustrations, flow charts etc.

Once data has been displayed in an appropriate format and all investigative tasks are completed then understanding what it means is a matter of **interpreting and analysing** the data so that conclusions can be drawn.

Interpretation	**– Identify trends in different variables.**
Correlating	**– Identifying how one factor affects another.**
Analysing	**– Understanding what the data represents.**

To interpret graphs trends or patterns must be identified. If a trend exists, this will suggest some kind of relationship between the two variables. Many relationships are possible.

Data can be presented using graphs and charts that makes it easy to interpret. Quality data presentations ensure user understanding by taking advantage of how users already process information, reduce the number of thought processes required to understand the data, and breakdown fundamental obstacles to understanding.

Good quality presentations of data includes a number of steps :

- **Take advantage of how we already process information**
- **Reduce the number of processes required to understand the data**
- **Tear down some fundamental obstacles to understanding**

Statistical graphics may be used to present the data. These graphics :

- **show the big picture**
- **are paragraphs of data**
- **are best when constructed to convey one finding or concept**

Numerical tables generally serve one of two purposes. Just about all of the numerical data included in this book was originally found in “look up” tables, databases or spreadsheets compiled by government statistical agencies or nongovernmental organizations. The general and limited purpose of these database tabulations is to present all the numerical information available that might be relevant to a wide variety of data users. For the most part, the textual discussion accompanying these tabulations serves only to describe how the data were obtained and to define what the numbers mean. The analytical tables contained in social science research, however, serve a different purpose: the presentation of numerical evidence relevant to support specific conclusions contained in the text. To serve this purpose much care must be given to the selection of the data and to the design of the table.

A graphical chart provides a visual display of data that otherwise would be presented in a table; a table, one that would otherwise be presented in text. Ideally, a chart should convey ideas about the data that would not be readily apparent if they were displayed in a table or as text.

The three standards for tabular display of data -- the **efficient** display of **meaningful** and **unambiguous** data -- apply to charts as well. As with tables, it is crucial to good charting to choose meaningful data, to clearly define what the numbers represent, and to present the data in a manner that allows the reader to quickly grasp what the data mean. As with tabular display, data ambiguity in charts arises from the failure to precisely define just what the data represent. Every dot on a scatterplot, every point on a time series line, every bar on a bar chart represents a number (actually, in the case of a scatterplot, two numbers). It is the job of the chart's text to tell the reader just what each of those numbers represents.

There are three basic components to most charts:

- the labeling that defines the data: the title, axis titles and labels, legends defining separate data series, and notes (often, to indicate the data source),
- scales defining the range of the Y (and sometimes the X) axis, and
- the graphical elements that represent the data: the bars in bar charts, the lines in times series plot, the points in scatterplots, or the slices of a pie chart.

Bar charts typically display the relationship between one or more categorical variables with one or more quantitative variables represented by the length of the bars. The categorical variables are usually defined by the categories displayed on the X-axis and, if there is more than one data series, by the legend.

The time series chart is one of the most efficient means of displaying large amounts of data in ways that provide for meaningful analysis. The typical time series line chart is a scatterplot chart with time represented on the X-axis and lines connecting the data points.

The two-dimensional scatterplot is the most efficient medium for the graphical display of data. A simple scatterplot will tell you more about the relationship between two interval-level variables than any other method of presenting or summarizing such data.

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A single boxplot box rarely reveals much about the data, and graphs of single variable data distributions (using stem-and-leaf or histogram charts) rarely offer a more detailed graphic representation of the data distribution. The real advantages of the boxplot graphic comes through, however, in single charts using several boxplots to compare the distribution of a variable across groups or over time and an especially useful elaboration of the boxplot graph involves plotting an individual case over the boxplot to compare single cases to the overall distribution.

5. Model Questions:

1. Discuss the steps in data analysis.
2. How can graphs and charts be used to analyze data ? Discuss.
3. Discuss pie diagrams, bar charts and line graphs as data presentation tools.

6. Reference Books:

1. Daniel, W (1983) Biostatistics – A foundation for analysis in health sciences, John Wiley, New York.
2. Rao, C.R (1993) Statistics must have a purpose, Sankhya A, Vol.55.
3. Snedecor, G.W. and W.G. Cochran (1994) Statistical Methods, 8th edition, East West Press, New Delhi.
4. Sturges, H.A. (1926) The choice of class intervals, Journal of American Statistical Association , Vol21, pp.65-66.

Unit 5 : Lesson 3 : Writing a Research Proposal

1. Objective of the Lesson:

The objective of the lesson is to:

- Assist you in understanding how to write a research proposal

2. Structure of the Lesson:

- Writing a research proposal
- **Describing a research problem**
- **Why the research is important**
- **Contributions of research**
- Time frames
- Submission

Writing a Research Proposal

There is no single format for research proposals. This is because every research project is different. Different disciplines, donor organisations and academic institutions all have different formats and requirements. There are, however, several key components which must be included in every research proposal. The specific research problem will dictate what other sections are required.

Key components are:

- A description of the research problem.
- An argument as to why that problem is important.
- A review of literature relevant to the research problem.
- A description of the proposed research methodology.

• A description of how the research findings will be used and/or disseminated.

DESCRIBING A RESEARCH PROBLEM

Before your proposal can make sense to a reader, he or she must understand clearly what the proposed research will be about. Therefore, you would do well to begin this section with a clear and simple formulation of your research question. Read the following examples:

• This research project explores the extent to which vigilantism is growing within different sectors of the South African population. In particular the research focuses on the factors which promote and maintain vigilantism in our society.

• Many community projects in rural Mpumalanga rely on micro-enterprises (such as community gardens and spaza shops), to extend the income generating potential of communities. The following is an investigation of the extent to which these micro-enterprises do actually influence the broader economic position of these communities.

Flesh out this section with some or all of the following:

• Where does this research question come from?
  If it arises out of a debate in the literature, introduce that debate.

• Clarify or quantify any concepts which may not be clear.

Have a look at a very simple example:

This research project explores the extent to which vigilantism is growing within different sectors of the South African population. In particular the research focuses on the factors which promote and maintain vigilantism in our society. Recent reports in the media detailing the operation of extensive and organized vigilante groups have created public interest and concern, and there are important implications for policing policy. A "vigilante" is defined as being "a volunteer committee of citizens for the oversight and protection of any interest, especially one organized to suppress and punish crime summarily, as when the process of law appears inadequate" (Smith, 2001).

WHY THE RESEARCH IS IMPORTANT

This section, often referred to as the "rationale" is crucial, because it is one place in which the researcher tries to convince her/his supervisor/external examiner that the research is worth doing. You can do this by describing how the results may be used.

Think about how your research:

* may resolve theoretical questions in your area
* may develop better theoretical models in your area
* may influence public policy
* may change the way people do their jobs in a particular field, or may change the way people live.

Contributions of research

Are there other contributions your research will make? If so, describe them in detail. Look at the following example:

In the economic example of micro-enterprises in rural communities, the researcher might argue that the research will:

* provide an understanding of the economic impact of micro-enterprises
* support the government's plans for start-up loans to micro-enterprises
* demonstrate the usefulness of micro-enterprises as part of rural development, thereby contributing to the work of government and non-government rural development organisations.

Detail regarding each of these three points should be added to produce a convincing argument as to the usefulness of the research.

Literature review

The literature review presents one of the greatest challenges of the research proposal to experienced and inexperienced researchers alike.

The literature review:

* Provides a conceptual framework for the reader so that the research question and methodology can be better understood.
* Demonstrates to the expert reader that the researcher is aware of the breadth and diversity of literature that relates to the research question.

It is important that you are able to provide an integrated overview of your field of study. This means that you show awareness of the most important and relevant theories, models, studies and methodologies.

Examples: (The research topic is "the History of Mental Illness in Natal in the period up to 1945")

Empirical Research Methodology

Hypotheses

Specific research hypotheses to be tested during data analysis.

Research Design

Should the researcher plan to use several groups, or repeated testing to test particular hypotheses, this should be explained in this section. Most research methodology textbooks discuss the more commonly used research designs.

Sampling

Empirical research almost always depends upon a sample which is assumed to accurately represent a population. Therefore, the techniques by which the sample was chosen are vital to a discussion the validity of the research findings.

Empirical research methodology measurement instruments

When particular measurement instruments are used, it is often important to explain how those instruments were developed, where they have previously been used (if at all), and to what effect.

Data collection procedures

Detailed data collection procedures should also be included so that other researchers can replicate your method exactly if required.

Data analysis

Various techniques of quantitative and qualitative data analysis exist and should be described in detail in this section.

Structure

Use “ Spider Diagrams” to structure your proposal. A spider diagram is a tool for planning your writing.

A beginner can try the following:

1. Draw a box in the centre of a large sheet of blank paper. Write the title of your research proposal in that box.

2. Draw a "leg" from the central "body" towards the top right hand corner of the page. Label this "leg" with the first topic that you wish to deal with in your proposal.

3. Add more legs moving clockwise around the page until all the sections have been included, with the final one being
somewhere near the top left of the page.

4. Now divide each "leg" up into smaller "legs" with all the points that you wish to make in each section. (Again work
clockwise from the top left so that the sequence of ideas is maintained),

5. You may have to redraw your spider diagram several times until you find a structure that works for your proposal.

Make sure that you find a proposal structure that suits the needs of your research. If you are submitting to different organisations, make sure that you find out what those organisations' requirements are. Some institutions have very rigid formats and often proposals are disadvantaged because they do not conform to the requirements laid down. Apart from the sections outlined above, many organizations demand other sections as well. These sections could include:

Time frames

Inexperienced researchers tend to underestimate the amount of time that the various stages of research will take. Be generous when working out time frames and check them with a more experienced researcher.

Many people assume that any literate person can write a research proposal. This is not automatically true. Writing is a difficult skill to master and one that requires practice and some dedication. Some tips to help you in your writing include:

• Always structure your work in advance.
• Know what you want to say before trying to write it.
• Every sentence must contain one idea only.
• Each sentence must follow logically from the one before. A well written text is a "chain of ideas".
• While writing, keep your reader's needs in mind. This means providing a "verbal map" of your document so that
your reader knows what to expect, and placing "verbal signposts" in your text to explain what is coming next.

The student writing the research proposal must :

• produce a professional looking proposal
• be interesting
• be informative
• write in a way that is easy to read
• include a contents page
• use clear headings and sub-headings
• be concise and precise
• use simple language wherever possible
• construct clear arguments
• check your spelling and grammar
• reference your work fully using an acceptable format

Submission

Before submitting, make sure you have completed each of the
following steps:

1. Proof-read your work carefully.
2. Ask a friend or relative to read your proposal.
3. Ask an experienced researcher or your supervisor to read your proposal.

4. Summary:

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3. Ask an experienced researcher or your supervisor to read your proposal.

5. Model Questions:

1. Mention the steps in writing a research proposal.

6. Reference Books: