Research Methodology

Design and Criteria of Scientific Research

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Introduction

- Research refers to search for knowledge.
- Research is organized learning, looking for specific things to add to our store of knowledge.
- Research is defined as a scientific investigation of phenomena which includes the collection, presentation analysis and interpretation of facts that link man's speculation with reality (Calmorin 1994).

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1. Introduction

- The **aim of research** is to study the unknown and to discover useful things, answer unanswered questions or create that which doesn't currently exists.
- “Research is a process of steps used to collect and analyze information to increase our understanding of a topic or issue" -Creswell
- “In the broadest sense of the word, the definition of research includes any gathering of data, information and facts for the advancement of knowledge"- Martyn Shuttleworth

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Introduction

- Research is the investigation of a particular topic through a series of well-organized processes.
- The major goals of research include establishing facts, -analyzing information, reaching new conclusions, etc. Attempting to replicate previously published (and thus not new) results with the aim of confirming them is also research. A systematic-critical review and compilation of previous results in a certain area can also raise knowledge levels, and can therefore also be regarded as research

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Introduction

- The effectiveness of a research programmeme depends on a number of factors right from the identification of a relevant problem. The probability of success of a research project is greatly enhanced when the "**beginning**" is correctly defined. The term beginning indicates the **planning of research**, a precise statement of goals and justification.
- The resources necessary to conduct the study is to be determined by the researcher. This is important because, due to deficiency of such resources the researcher may fail to complete research on time and in budget.

2. Research planning and design

- Planning and designing a research form an important part of the research activity.
- It requires some interest, experience and expertise.

- **Common steps to plan a research:**
  - **Find a topic** specific enough to let you master a reasonable amount of information on it.
  - **Ask questions** about that topic until you find some that catch your interest.
  - **Determine** what kind of **evidence** that your readers will expect in support of your answers.
  - Determine whether you can **find sources** that have those data.

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- According to Justin D Congdon and Arthur E Dunham (1999) research plan consists of two general areas:

  (i) Research concepts and contexts and

  (ii) Research logistics

i) An outline of the logistics section of a research plan:

1. Identify what information needs to be collected and how it will be collected.

   (a) Develop a logistical and quality control **plan for data collection**, handling, and storage procedures, including who will be responsible for each procedure.

   (b) Design **data sheets** that prompt the person collecting data for each measurement. Data sheets should also be made with data recording. entry into computer files, editing and data analyses in mind.

   (c) Prior to actual data collection, carefully "walk through" as many of the **techniques and procedures** as feasible to detect problems with protocols and equipment.

   (d) **Evaluate incoming data** for recurring errors; frequent review may reveal unsuspected patterns that, if identified and responded to quickly, provide opportunities to improve research protocol or direction.

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i) An outline of the logistics section of a research plan:

2. **Talk to other investigators** currently working with similar types of studies about logistics, research protocol, quality control plans, and types of data analyses.
3. As soon as possible following data collection, the data should be entered into computer files and then **reviewed to detect problems** associated **with data** sheets, data recording and entry, and with computer files.
4. Order supplies as far in advance as reasonable and funds are available.
5. **Plan for the unexpected** (equipment failure, accidents, illness, unusual weather).

ii) An outline of the concepts and context sections of a research plan:

1. Literature survey
   (a) Become familiar with the literature **to identify a research problem** and to explore the areas that may impact the research plan.
   (b) **Explore ways** that enhance the integration of the study into broader areas and ways to collect, analyze, and present your data so that they are useful to others.
2. Carefully and **state the problem** in the form of concise questions or as working or null hypotheses.
3. **Make a list of possible scenarios** related to your research questions and then rank the most probable ones.
4. Discuss **all** aspects of the research proposal with colleagues as you develop them. Investigators that work in the same or closely related fields **are valuable sources of information.**
5. **Write a detailed research proposal**.

In words of **Justin D Congdon and Arthur E Dunham (1999),**

"The process of writing a detailed proposal will help identify problems with research concepts, questions, and logistics and will enhance integration of various aspects of the proposed research".

Research Design

The **purpose** of research design is to ensure that the data collected through various methods **must lead** us **to a solution** to the defined **problem**.

The research design has the following aspects:

1. A **clear statement** of a scientific problem.
2. **Procedure and techniques** to be used for gathering information.
3. **Methods** to be used for processing and analyzing data

3. Selection of research topic

- includes various criteria :

  that may set by the **interest** of

  the researcher, the society, the government, etc.

- The researcher must consider a number of **factors** related to :

  the purpose, planning, design, execution and completion of the research.

  - One major problem in selection of a topic is that the topic may be too broad.
  - There is no step-by-step procedure to narrow a topic.

The various **stages** involved **in selecting a topic for research** can be summarized as follows:

- **Brainstorm** for ideas Read general background information
- **Focus** in on a manageable topic
- **Define** your topic as a focused research question

4. Criteria for good research problem

There are no universal criteria for the evaluation of a research problem.

According to Kerlinger (1973) good research problems must meet three criteria.

First: the research problem should describe the **relationship between two or more variables.**

Second: the research **problem** should **take the form of a question**.

Third: the research problem must be **capable of being tested** empirically (i.e., with data derived from direct observation and experimentation).

As per the guidelines issued by the University of Amsterdam (2008) a good research problem satisfies the following criteria:

- **Question mark:** The research problem can be in a declarative or in a form. The University recommends formulating the research problem as a question. This gives something to hold on to during the rest of your thesis because it is simple: there is a question and in the text you look for an answer.
- **Possibility to respond:** Some questions are impossible to answer in a scientific way, for example, ***'how beautiful is the colour yellow***'. We don't have the scientifically justified instruments to answer this question. It must also be possible to answer the question in a practical way so it must be researchable, meaning you have to be able to collect evidence that will answer the question.

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As per the guidelines issued by the University of Amsterdam (2008) a good research problem satisfies the following criteria:

- **Relevance in connection to the research goals:** The research problem and the research goals are closely connected to each other. If an answer to the problem doesn't meet the goal of the research, one of them should be adapted. For example, it's wrong to connect a describing problem to an advising goal.
- **Attainability:** The problem must be one that can be solved during the amount of time you have. So it can't be too broad (ex: 'How can we have world peace?"). But it also can't be too narrow (ex: How does my neighbour think about Americans?").
- **Open question:** The research problem should be an open question. That means it cannot be answered by "yes" or "no". But also with open questions you should watch out for the possibility of a shallow answer.

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As per the guidelines issued by the University of Amsterdam (2008) a good research problem satisfies the following criteria:

- **Unmistakability:** Your research problem must be clear and there has to be only one way to interpret it. For example, the question: "What do Vietnamese people think about the West?' is unmistakable because it is not clear what is meant by 'the West', it can be a lot of things.
- **Punctuality:** The problem must be clearly specified. For example: Don't write 'How can prejudices against Americans be combated?'

  if you mean: ‘”How can prejudices that live among Vietnamese students for American businessmen be combated?”

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As per the guidelines issued by the University of Amsterdam (2008) a good research problem satisfies the following criteria:

- **Brevity:** Although your research problem should be as punctual and specific as possible, not all fencings must be placed in your research problem. It must be a brief and fluent sentence. You can specify your terms with definitions in a commentary.

It is essential to use simple words in defining the technical terms and scientific words used in the statement of the problem. Also the basic assumptions related to the research problem should be made clear.

5. Sources of Research Idea:

- Ideas for research can be obtained through various sources:

'experience,

theory and

applied issues'

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Sources of Research Idea:

Experience: **Experience and observation** of things and events that goes on around is a rich source of research ideas. Such observations generate a number of questions in our mind.

Observations can be unsystematic or systematic.

- For example, reading of newspaper or watching an event on television is an observation.
- On the other hand reading a journal paper for the preparation of a class is a systematic observation.

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Sources of Research Idea:

Theory: Theory can be regarded as a **set of assumptions** about the causes of behaviour and rules that specify how those causes act.

- Theories are also rich sources of research ideas.

Theories can lead in two ways:

1. A theory allows you to predict the behaviour expected **under new combinations of variables.**
2. A theory can generate research ideas when **two or more alternative theories account for the same initial observations**.

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Sources of Research Idea:

Applied Issues: Many of the research ideas originate from an attempt **to solve** the problems faced by the humanity. This constitutes the applied research.

Majority of research programmes falls under this category.

It is easy to identify the **problems in the society** because the consequences of such problems can be felt directly.

Examples: Population explosion, energy crisis, drinking water, medicine, etc., are some fields where the issues are plenty and scope for research is wide.

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6. Principles of Good Research

All types of research shares a common objective of knowledge generation.

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As per Tamsin White (2006), the principles of good research:

- There is a **clear statement** of research aims, which defines **the research question**.
- There is an information sheet for participants, which sets out clearly what the research is about, what it will involve and consent is obtained in writing on a consent form prior to research beginning.
- **The methodology is appropriate** to the research question. So, if the research is into people's perceptions, a more qualitative, unstructured interview may be appropriate. If the research aims to identify the scale of a problem or need, a more quantitative, randomized, statistical sample survey may be more appropriate. **Good research can often use a combination of methodologies**, which complement one another.

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As per Tamsin White (2006), the principles of good research:

- The research should be carried out in an unbiased fashion. As far as possible the researcher should not influence the results of the research in any way. If this is likely, it needs to be addressed explicitly and systematically.
- From the beginning, the research should have **appropriate and sufficient resources in terms of people, time, transport, money, etc., allocated to it**.
  - The people conducting the research **should be trained** in research and methods and this training should provide:
  - **Knowledge** around appropriate information gathering techniques. An **understanding** of **research issues**. An understanding of the **research area**. An understanding of the issues around dealing with vulnerable social care clients and housing clients, especially regarding risk, privacy and sensitivity and the possible need for support.

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As per Tamsin White (2006), the principles of good research:

- Those involved in designing, conducting, analyzing and supervising the research should have **full understanding of the subject area**.

- In some instances, it helps if researcher has experience of working in the area. However, this can also be a negative factor, as sometimes research benefits from the fresh eyes and ears of an outsider, which may lead to less bias.
- If applicable, the information generated from the research will inform the policy making process.

All research should be ethical and not harmful in any way to the participants.

7. GUIDELINES FOR RESEARCH SKILLS AND AWARENESS

- For the successful completion of a research programme the researcher **must possess some skills** and he/she must have **awareness** about all spheres **of the research process.**

- In order to access these skills and awareness the researcher must be able to provide a **positive response** to the following questions (issued by the UCD Graduate School, Dublin).

GUIDELINES FOR RESEARCH SKILLS AND AWARENESS

- **Have I good knowledge** of advances and developments in my field?
- **Can I demonstrate** knowledge of research in related fields and disciplines?
- **Do I comprehend** and **can I effectively employ** appropriate research methodologies?
- **Can I critically analyze and synthesize** new and complex information from diverse sources?
- **Can I formulate and apply solutions** to research problems and effectively interpret research results?

8. RESEARCH VALIDITY and RELIABILITY

VALIDITY OF RESEARCH

- It refers to **the conceptual scientific** soundness of a research study**.**
- words validity describes the **extent to which a measure accurately** represents the **concept** it claims to measure.
- Messick (1999) defines validity as "an overall evaluative judgement of the degree to which empirical **evidence and theoretical rationales support the adequacy and appropriateness of interpretations and actions**".
- Knowledge about the validity creates a certain level of consciousness in the mind of the researcher because the **primary aim of any type of research is to produce valid conclusions.**

The validity is broadly classified into two: external validity and internal validity.

8. RESEARCH VALIDITY and RELIABILITY

- **External validity** addresses the ability to apply with confidenc,e the **findings of the study to other people and other situations**, and ensures that the 'conditions under which the study is carried out are representative of the situations and time **to which the results are to apply**' (Black 1999, cited in Roberts P et al., 2006).

- External validity is otherwise known as **the generalizability**.

- A study has external validity **when the results generalize to other populations, settings, and circumstances**

There are some factors and characteristics that impose **limitations** on the generalizability of results and these are referred to as **threats to external validity.**

- **Sample characteristics**
- **Stimulus Characteristics and Settings**
- **Reactivity of the Experimental Arrangements**
- **Multiple-Treatment Interference**
- **Novelty Effects**
- **Reactivity of Assessment**
- **Pretest and Post-test Sensitization**
- **Timing of Assessment and Measurement**

Sample characteristics: This threat to external validity refers to a phenomenon whereby the results of a study apply only to a particular sample. Accordingly, it is unclear whether the results can be applied to other samples that vary on characteristics such as age, gender, education, and socioeconomic status (Kazdin, 2003c, cited in Geoffrey Marczyk et al.).

Stimulus Characteristics and Settings: This threat to external validity refers to an environmental phenomenon in which particular features or conditions of the study limit the generalizability of the findings (Brunswik, 1955; Pedhazur & Schmelkin, 1991, cited in Geoffrey Marczyk et al.).

Reactivity of the Experimental Arrangements: This threat to external validity refers to a potentially confounding variable that is a result of the influence produced by knowing that one is participating in a research study (Christensen, 1988, cited in Geoffrey Marczyk et al.).

Multiple-Treatment Interference: This threat to external validity refers to research situations in which (1) participants are administered more than one experimental intervention (or independent variable) within the same study or (2) the same individuals participate in more than one study (Pedhazur & Schmelkin, 1991, cited in Geoffrey Marczyk et al.).

•**Novelty Effects:** This threat to external validity refers to the possibility that the effects of the **independent variable may be due in part to the uniqueness** or novelty of the stimulus or situation and not to the intervention itself. In other words the novelty of the intervention or situation acts as a confounding variable, and it is that novelty (and not the independent variable) that is the real explanation for the results (Geoffrey Marczyk et al., 2005).

•**Reactivity of Assessment:** This threat to external validity refers to a phenomenon whereby participants' awareness that their performance is being measured can alter their performance from what it would otherwise have been (Christensen, 1988; Kazdin, 2003c

•**Pretest and Post-test Sensitization:** These related threats to external validity refer to the effects that pretesting and post-testing might have on the behaviour and responses of the participants in a study (Pedhazur & Schmelkin, 1991, cited in Geoffrey Marczyk et al.). It is generally observed that in many forms of research, participants are pretested to quantify the presence of some variable of interest and to provide a baseline of behaviour against which the effects of the experimental intervention (independent variable) can be evaluated.

•**Timing of Assessment and Measurement:** This threat to external validity is particularly common in longitudinal forms of research, and it refers to the question of whether the same results would have been obtained if measurement had at a different point in time (Kazdin, 2003c, cited in Geoffrey Marczyk et al., 2005).

Internal validity addresses the **reasons for the outcomes of the study**, and helps to reduce other, often unanticipated, reasons for these outcomes.

- Internal relates to the extent to which the design of a research study is a good test of the hypothesis or appropriate for the research question.

Threats to internal validity identified by many people like Cook & Campbell (1979) and Pedhazur & Schmelkin (1991).

- **History**
- **Maturation**
- **Instrumentation**
- **Testing**
- **statistical regression**
- **selection biases**
- **Attrition**
- **diffusion or imitation of treatment**
- **and special treatment or reactions of controls**

- **History:** History as a threat to internal validity refers to events or incidents that take place during the course of the study that might have an unintended uncontrolled-for impact on the study's final outcome or the dependent variable; (Kazdin, 2003c, cited in Geoffrey Marczyk et Al.).
- **Maturation:** Maturation refers to intrinsic changes (biological and psychological) within the participants that are usually related to the passage of time.
- **Instrumentation:** Instrumentation as a threat to internal validity refers to changes in the assessment of the independent variable, which are usually related to changes in the measuring instrument or measurement procedures over time (Christensen, 1988; Kazdin, 2003c, cited in Geoffrey Marczyk et Al.).
- **Testing:** This threat to internal validity refers to the effects that taking a test on one occasion may have on subsequent administrations of the same test (Kazdin, 2003c, cited in Geoffrey Marczyk et al.).

- **Statistical Regression:** This threat to internal validity refers to a statistical phenomenon whereby extremely high or low scores on a measure tend to revert toward the arithmetic mean or average of the distribution with repeated testing (Christensen, 1988 and Kazdin, 2003c, cited in Geoffrey Marczyk et al.).
- **Selection Biases:** This threat to internal validity refers to systematic differences in the assignment of participants to experimental conditions. Selection biases are prevalent in quasi-experimental research in which participants are assigned to experimental conditions or comparison groups in a nonrandom fashion (Christensen, 1988; Kazdin, 2003c, cited in Geoffrey Marczyk et al.)
- **Attrition:** This threat to internal validity refers to the differential and systematic loss of participants from experimental and control groups. Diffusion or Imitation of treatment: This threat to internal validity is common in various forms of medical and psychotherapy treatment effectiveness research. This reason for this is (i) unintended exposure of a control group to the actual or similar intervention (independent variable) intended only for the experimental condition or (ii) the experimental group does not receive the intended intervention at all (Kazdin, 2003c; Pedhazur & Schmelkin, 1991, cited in Geoffrey Marczyk et al.).

RELIABILITY IN RESEARCH

- The term **reliability represents the consistency of a measurement**. According to Geoffrey Marczyk et al. (2005, p. 103), "it is concerned with the consistency or stability of the score obtained from a measure or assessment over time and across settings or conditions". If the measurement is reliable, then there is less chance that the obtained score is due to random factors and measurement error. "Reliability describes how far a particular test, procedure or tool, such as a questionnaire, will produce similar results in different circumstances, assuming nothing else has changed' (Roberts P et al., 2006).
- **There are three aspects of reliability: equivalence, stability and internal consistency** (homogeneity). An understanding of the distinction between these three is important in assessing the reliability of a research programme.

- **Equivalence** Equivalence refers to **the amount of agreement between two or more instruments that are administered at nearly the same point in time**.. Equivalence is measured through a parallel forms procedure in which one administers alternative forms of the same measure to either the same group or different group of respondents. This administration of the various forms occurs at the same time or following some time delay. The higher the degree of correlation between the two forms, the more equivalent they are [20]. Equivalence will be important when the measurement process entails subjective judgments or ratings being made by more than one person.
- **Stability:** Stability is said to occur **when the same or similar scores are obtained with repeated testing with the same group of respondents**. Stability represents the consistency of the score from one time to the next. Stability is assessed through test-retest.
- **Internal consistency** (homogeneity): Internal consistency concerns the extent to which **items on the test or instrument are measuring the same thing.** The individual items in a test must be highly correlated with each other so that high reliability can be achieved for the entire test. The appeal of an internal consistency index of reliability is that it is estimated after only one test administration and therefore avoids the problems associated with testing over multiple time periods [21].

9. ARTEFACT AND BIAS

During the course of research researcher may encounter with **certain unintended variables that may influence the result of the study**. Such variables are referred to as a potential confound, artefact, or source of bias.

Artefacts, refer to variables that should have been systematically varied, either within or across studies, but that were accidentally held constant.

Artefacts are thus threat to external validity

In order to minimize or to eliminate the sources of bins proper designing of the research is required.

- **The heterogeneity** of research participants alone can contribute innumerable sources. Research participants bring a wide variety of physical, psychological, and emotional traits into the research context" (Geoffrey Marczyk et. al., 2005, p. 68).
- **Environmental factors** can influence result of a study.
- **Issues related to measurements** can introduce artefacts and bias.
- The **use of poorly validated or unreliable measurement strategies** can contribute to misleading results (Leary, 2004, cited in Geoffrey Marczyk et al., 2005, p. 68).

These different characteristics can directly affect the results of a study.

- **Experimenter Bias:** Many people pointed out that the **researcher themselves are the first source of artefact and bias**.

- **Participant effects: The participants** involved in a research process can be a source of artefact and bias. There are commonly referred to as the participant effects. "It refers to a variety of factors related to the unique motives, attitudes, and behaviours that participants bring to any research study" (Kruglanski, 1975;

10. Scientific Methodology

- We can't solve problems by using the same kind of thinking we used when we created them. -Albert Einstein

- Begin at the beginning and go on till you come to the end; then stop.
  -Lewis Carrol, Alice in Wonderland

Scientific Methodology

A methodology provides **a framework** for the generation of knowledge.

Scientific methodology defines and differentiates scientific knowledge from other types of knowledge.

In its simplest form scientific methodology denotes the way in which **science is approached**.

The main aspect of scientific methodology is that all theories are subjected **to improvements or alterations due to contextual changes.**

Research Methodology: A Self-Learning Manual defines **scientific method** as: ***'a method of investigation by which scientific or any other impartial systematic knowledge is acquired is called a scientific method.*** Scientific method is a universally applicable, systematic method of understanding a phenomenon and verifying the truth.

Scientific methodology includes a systematic observation, collection and interpretation of data.

Scientific method possesses some general characteristics.:

- Scientific methods **employ a systematic approach**.
- Scientific methods are **based on objectivity**.
- **Every conclusion** viewed through a scientific method **must be verifiable.**
- Scientific **law**s are **universally applicable and testable**.
- The scientific **conclusions are predictable**.

Scientific method consists of well-organized elements. Although there are some disagreements.

- **Empirical approach:** In this approach **decisions** are made **based on data derived from direct observations and experimentations**. It emphasizes on direct systematic and careful observation.
- **Observations:** Observation includes the creation of awareness of the world around us and making careful measurements. **Observations should be systematic and free from biases**.
- **Questions:** From careful observations we get the idea for our research. The next step is to **transform that idea into an answerable question**. The question can be answered through available scientific methods and procedures.
- **Hypotheses:** Through a hypothesis a researcher tries to present **a possible explanation of the identified problem**. This is then tested by analyzing data and can be either supported or refuted.
- **Experiments:** Experiments are conducted **to verify the hypothesis**. The researcher has to design the experiments properly to conduct the study. Analysis: After gathering the required data, the next procedure is its analysis. Statistical techniques are required for this. The type of the statistical technique depends on the nature of the question and the nature of the accumulated data.
- **Conclusions:** After the analysis of the data the researcher will draw a conclusion about the result. The conclusion should be **supported by the data analysis**. Researchers should not draw broad conclusions.
- **Replication:** Replication means the conducting of the **same experiment for second time** with another group of participants **to verify** that the same results are obtained. Replicability of a conclusion increases its reliability.

RULES AND PRINCIPLES OF SCIENTIFIC METHOD

M-Principles:

1. One ought (duty) to accept only those theories that explain **all the successes of their predecessors** and repeat none of their failures; otherwise they are to be rejected.
2. One ought to **avoid ad hoc theories**.
3. Given some **rival hypotheses** and a large set of facts they all explain then one ought to pick that hypothesis that best explains all the facts
4. One ought **to accept the simplest theory** and reject those that are more complex.
5. One ought to **avoid theories that postulate unobservables** unless they have an operational basis.
6. When a new theory replaces its immediate predecessor but also contradicts it, then one ought to **adopt as the new theory** the theory that contains the older theory, approximately under certain assumptions of values of parameters of the new theory.
7. In conditions of experimentation on human subjects, one ought **to prefer double-blind over single-blind experiments** and never perform an unblinded experiment.

An alternative form of these principles is that hypothetical ought-imperatives.

The principles can be summarized as follows, (**Robert Nola and Howard Sankey**, 2007, p. 60):

1. One ought to **avoid ad hoc hypotheses** (r) rather than accept ad hoc hypotheses (r) if one values highly refutable theories (v).
2. One ought to **accept those theories that explain all the observational successes** of their predecessors (r) since this is more likely to lead to truth (v) than accepting those theories that do not explain all their predecessor's observational successes (r).
3. Where there is a **conflict between theory** T and what we observe, then one ought to form new theory 7 by making the minimum adjustments to T (r), since new 7 is more likely to evade falsification (v) than would any other theory in which the modifications are more than the minimum (*).
4. One ought to accept the theory that makes **novel true predictions** since this is more likely to lead to the truth (v) than accepting any rival theory that captures the same observational information but makes no novel predictions (*).

Geoffrey Marczyk et.al. (2005, pp. 270-272

These are **general principles** and are based on the nature of the scientific method.

- **Keep your eyes open:** Researcher should have an open eye to **see what is happening around**. The formulation of a powerful research problem results from the careful observation of the world around.
- **Be an Empiricist:** Scientific method **strongly relies on empiricism(supports**). Empiricism emphasizes on direct and systematic observation. This feature distinguishes science from pseudosciences. Therefore, a good researcher should be an empiricist.
- **Be creative:** Creativity is the characteristic of a scientific mind. Creativity should play a vital role in all stages of research process. It is particularly **important in generating research ideas and in experimental design**.
- **Research budgets research:** This principle emphasizes the importance of **following a logical progression when conducting research.** Each research study should be the next logical step in the overall of research Therefore, it is important that research studies answer discrete questions that flow logically from prior research studies.

- **Adhere to ethical principles:** This principle is very important but is not overemphasized. Ethical guidelines should be observed by all researchers. **The violation of ethical principles may hurt the participants and the reputation of other researchers**.
- **Have fun:** Researcher should **enjoy the research**. Research can be exciting. so take pride in being part of something that will advance science and potentially improve the way we all live.
- Observation of these principles will **help** the researcher **in designing and conducting the study in an effective manner.**

HYPOTHESIS

After the formulation of research problem the researcher suggests a possible solution for the problem. This possible solution of **a** is called a hypothesis. It is a declarative statement that predicts an expected outcome.

The formulation of a hypothesis is very important. It serves as a link between the theory and investigation. It provides a basis for selecting variables, samples and the research methodology.

- "It serves the important function of linking together the related facts and information and organizing them into whole" (Good, 1963).

Different Types of Hypotheses

- Null hypothesis (H, or H)
- Alternate hypothesis (H, or H)

"A null hypothesis always predicts that there will **be no relationship between the variables being studied** whereas the alternate hypothesis always predicts that there will **be a relationship between the variables being studied**" (Geoffrey Marczyk et al., 2005. p.38).

- The null hypothesis should contain the statement of equality. That is, for null hypothesis we would have either =,<= or >=.
- ❑ Hence, the hypotheses are tested only for three situations: (i) not equal to, (ii) greater than, and (iii) smaller than.
- The null and alternate hypotheses are complementary to each other

A further classification of hypotheses is as follows:

- **Explanatory hypothesis:** Hypothesis about the **cause of a phenomenon** is called an explanatory hypothesis. For example, the statement, "increase in the amount of carbon dioxide causes global warming", is an explanatory hypothesis.
- **Descriptive hypothesis:** Hypothesis about **the law which governs a phenomenon** is called a descriptive hypothesis. The statement, "colours observed in thin oil films are **due to** the interference of light", is a descriptive hypothesis.
- **Tentative hypothesis:** This type of hypothesis is formed when the **phenomenon cannot be fully understood.** Here we see that how far the hypothesis is successful in explaining the phenomenon. Famous examples are the corpuscular theory and wave theory of light. Both are able to explain some phenomena; but are not final.
- **Representative fictitious hypothesis:** It is an about **certain a phenomenon**. One **cannot prove it directly**. When it is proved to be correct it becomes a theory or a law. Newton's idea of gravitation was a fiction; but became a law when it was proved.

TESTING A HYPOTHESIS

Hypothesis testing or significance testing is a method for testing a hypothesis about a variable in a phenomenon, using data measured through careful observation. The goal of hypothesis testing is to establish a cause-effect relationship between an independent variable and a dependent variable.

Different steps involved in a hypothesis testing may be summarized as follows:

- **Formulation of the statement**: This is the first stage in which **a null hypothesis and an alternate hypothesis are stated**. These statements should be very clear and should be in accordance with the nature of the problem under consideration. It is to be noted that an indication of the type of test to be used is given by the statement of the hypothesis itself (for details see Research methodology by Suresh Chandra and Mohit Kr Sharma).
- **Choice of significance level**: Usually, **a null hypothesis is tested on a pre-determined level of significance** and it is to be specified before calculating the test parameter, called test static. It is also known as Type 1 error.

TESTING A HYPOTHESIS

- **Decision for a law of distribution**. Once the level of significance is decided, the next task is **to determine an appropriate sample distribution like normal distribution.**
- **Computation of statistical parameters for random sampling**. After selecting a random sample, the statistical parameters are calculated. **They include arithmetic mean, variance, standard deviation, etc.**
- **Computation of test-parameter**: Test-parameter like test **static is calculated from the statistical parameters** obtained in the previous step.
- **Making a decision.** This is the final step where a comparison of the calculated test static is made with the value obtained corresponding to the significance level. From such a comparison, a decision can be made **that whether the hypothesis is to be rejected or not.**

11. RESEARCH ETHICS

- ***Ethics is a system of public, general rules for guiding human conduct.***

  - Gert. B

- ***"Scientific ethics is an institutional code of conduct that reflects the chief concerns and goals of science."*** ***-David B Resnik***

- **Research ethics is defined as the standards of conduct for scientists in their professional endeavours.**
- Research ethics emphasizes that the **researcher has more responsibility towards the society**. 'Research ethics also concerns **the internal relationship among researchers**, as well as the relationship between researchers **and other people**. The reliability and quality of a research work is based on good scientific practice based on ethical principles. When even one part of a research work is conducted unethically, the integrity of the entire project is called into question.

ETHICS: VALUES AND PRINCIPLES

Ethics and morality are philosophical concepts and have an important place in scientific research.

- **Truth**
- **Freedom**
- **Responsibility**
- **Integrity**
- **Collaboration**
- **Professionalism**

ETHICS: VALUES AND PRINCIPLES

- **Truth:** The fundamental **aim of research is generation of knowledge**. Every scientist has the responsibility to contribute towards the **knowledge expansion**. Moreover every creation of a scientist should be beneficial to the humanity as a whole. To achieve these goals scientists in every branch of science have to follow the methods of scientific research in each branch, and the rules of conduct in the scientific community in general.
- **Freedom:** In order to achieve the goals of scientific research by scientists the research should be based on the **principle of scientific research freedom**, which is one of the most prominent expressions of the democratic system. However, **some practical restrictions are imposed upon freedom** of scientific research by the principles of the democratic system, for the adequate safeguarding of human life, welfare, dignity and liberty. Within the framework of democratic principles the scientists undertake the research activities in the areas of development and application.
- **Responsibility:** Every scientific or experiment has **direct effect on human lives and on human physical and mental health, welfare, dignity and liberty**. Scientists are responsible for any direct effect of the research upon those participating as patients or subjects (animals, plants, etc.), in scientific research or experimentation.

ETHICS: VALUES AND PRINCIPLES

- **Integrity:** Scientific method has well organized components. Scientists perform every scientific research in accordance with all the requirements of the scientific method with an aim to produce highly accurate results. Scientists collect and analyze data with high precision and accuracy. The conclusions are based on thorough analysis of data collected through experiments and their generalization.
- **Collaboration:** The scientist acts within a universal framework of scientific Collaboration, based on the shared scientific goals. The scientist fosters scientific Collaboration by maintaining an atmosphere of openness, mutual assistance and trust among scientists, their and juniors students. It is also to be considered that a scientist may possess pursuant rights to intellectual property for scientific achievements to which he has made a unique or significant contribution.
- **Professionalism:** Many consider research is a profession. The scientist engages in his scientific activities in a professional manner, making judicious and continual use of the scientific knowledge. The investigations made by a scientist lead to some development in his area of expertise. Moreover the activities of a scientist are based on the ethics of scientific research. A scientist imparts the values and principles of scientific research to all those conducting research or experimentation under his supervision, particularly to students in every course of study serving to prepare them for professional activity within the scientific research community.

There may be many variations or additions in these principles.

For example, David B Resnik and Adil E Shamoo (2009)

- **Honesty:** Honesty is expected in every action of a researcher. This includes reporting data, results, methods and procedures, publication status, research contributions, and potential conflicts of interest. A researcher should never fabricate, falsify, or misrepresent data.
- **Objectivity:** It is the duty of a researcher to preserve objectivity in all stages of the research programme. The experimental design, data analysis, data interpretation, peer review and other aspects of research are expected to be objective.
- **Openness:** Openness is one of the basic principles of scientific research. Researchers should possess open-mindedness to share data, results, ideas, tools, materials, and resources. They should always be open to criticism and new ideas. Confidentiality: Even though a researcher should have an open mind to share the ideas and materials related to research, he should protect confidential communications, such as papers submitted for publication, personnel records, business or military secrets, and records that identify individual research subjects or patients.
- **Carefulness:** The ultimate aim of any research is to find the truth. Therefore, a researcher should be very careful in all actions related to the research. Researchers should not commit errors. Careless errors in experimentation, methodology, etc., should be avoided. The researcher should keep good records of all research activities, such as data collection, research design, consent forms, and correspondence with agencies or journals.

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- **Respect for colleagues**: Research is not an individual task. Nobody can complete research in isolation. A researcher is always surrounded by colleagues, students, and subordinates. Give due respect to all of them. Do not hurt or discriminate them against on the basis of sex, race, ethnicity, religion, or other characteristics. It is the duty of every researcher to help to educate, train, and advise the next generation of scientists. Respect for intellectual property: Intellectual property includes patents, copyrights, etc. They are the results of serious researches made by many scientists for years. Therefore a researcher should always respect such intellectual properties. Never use unpublished data, methods, or results without permission. Proper credit should be given wherever credit is due.
- **Respect for the law:** Researchers are part of certain institutions. They should understand and follow relevant laws and institutional policies. Respect for research subjects: This is important in a study where an animal or a human being is a subject for study. Proper respect and care should be given for animals when using them in research. The experiments should be designed properly to minimize harms and risks and maximize benefits.
- **Stewardship:** A researcher should have a good managing skill All resources such as human, financial, and technological resources must be used effectively. Proper care should be given to materials, tools, samples, and research sites. Social responsibility: Apart from the responsibility of the effect of research on the subject, every researcher has some social responsibilities. He should promote good social consequences and prevent bad ones through research, consulting, public education, and advocacy.

12. PLAGIARISM

- Plagiarism is the act of taking the writings of another person and passing them off as one's own.
- Plagiarism is the most common scientific misconduct.
- It is an act of scientific fraud.
- The word plagiarism derives from the Latin word plagiarius, meaning kidnapper or abductor. Plagiarism is defined as 'the act of passing off somebody else's ideas, thoughts, pictures, theories, words, or stories as your own'

The types of plagiarism:

- Authors usually copy phrases or sentences from other authors but fail to cite sources. This includes inaccurate and incomplete citing. The copying can be major portion of text from a single source, sentences or phrases from multiple sources.
- Sometimes the authors cannot identify the source of the cited information with an introductory or signal phrase and therefore it is not possible to present attribution.
- "The author borrows generously from his previous work, thus the final product is completely unoriginal" [15]. This is termed self-plagiarism. Redundant and duplicate publication comes under this category.
- Misrepresenting the true meaning of the original source when paraphrasing is also a kind of plagiarism. (Paraphrasing is a technique to avoid
- plagiarism which is discussed later in this section).
- Authors sometimes fail to use quotation marks around the phrase or sentence copied from a source
- Use of words or sentences that are too closely matched with the original documents is a kind of misuse in the paraphrase technique.

The methods to avoid plagiarism in scientific writing include:

- Proper note making
- Paraphrasing
- Summarising
- Quotations.

- **Proper note making: Usually refer a number of articles** related to the topic of study and usually keep a brief note. These notes are used when the researcher prepares the report of the findings.
- **Paraphrasing:** "Paraphrasing is the **restatement of information and ideas in one's own words** and style“. While paraphrasing the writer should use his own words. The paraphrase
- **Summarising:** "A summary is a shortened version of the original source without changing the meaning“. While summarising unnecessary details and examples are to be removed. If there is any direct quote, word or sentence, it should be enclosed in quotation marks. Do not forget to cite the source of the summary.
- **Quotations:** Quote is an exact reproduction of spoken or written words. An author can use the same text. However such phrases or sentences or even words should be enclosed in quotation marks. Also it is very important to cite the source in the text and to include the details of the source in the reference list or in the bibliography.