Research Methods for Simple and Complex Systems

By David Alderoty © 2015

Chapter 8) Scientific Method, and Case Studies For Simple and Complex Systems

Over 2,300 words

To contact the author left click for a website communication form, or use:
David@TechForText.com

To go to the previous chapter left click on one of the following links:
For HTML) www.TechForText.com/R/Chapter-7
For PDF) www.TechForText.com/R/Chapter-7/PDF.pdf

If you want to go to the table of contents of this chapter left click on these words

To Access Additional Information with Hyperlinks

After I complete a writing task, I select a number of websites from other authors, and link to them. The links are the blue underlined words, and they can be seen throughout this book. The in-line links, such as the link on these words, are primarily to support the material I wrote, or to provide additional details. The links presented at the end of some of the paragraphs, subsections, and sections are primarily for websites with additional information, or alternative points of view, or to support the material I wrote. The websites contain articles, videos, and other useful material.

The brown text that look like these fonts, represent quotes in this e-book. **You can access the original source, by clicking on a link presented just before a quote.**

If a link fails, use the blue underlined words as a search

phrase, with www.Google.com. If the failed link is for a video use www.google.com/videohp. The search will usually bring up the original website, or one or more good alternatives.

Definitions and Explanations of the Scientific Method, For Simple and Complex Systems

The Scientific Method, and Three Definitions

The scientific method is a methodology for deriving and testing a hypothesis. Presented below, there are three definitions, of the scientific method.

From the ***Dictionary.com Unabridged***. Retrieved from Dictionary.com website: http://dictionary.reference.com/browse/scientific method

> scientific method noun
> 1. a method of research in which a problem is identified, relevant data are gathered, a hypothesis is formulated from these data, and the hypothesis is empirically tested.

From the ***American Heritage® Stedman's Medical Dictionary***. Retrieved from Dictionary.com website: http://dictionary.reference.com/browse/scientific method

> The principles and empirical processes of discovery and demonstration considered characteristic of or necessary for scientific investigation, generally involving the observation of phenomena, the formulation of a hypothesis concerning the phenomena, experimentation to demonstrate the truth or falseness of the hypothesis, and a conclusion that validates or modifies the hypothesis.

From ***The American Heritage® New Dictionary of Cultural Literacy, Third Edition***. Retrieved from Dictionary.com website: http://dictionary.reference.com/browse/scientific method

> An orderly technique of investigation that is supposed to account for scientific progress. The method consists of the following steps: (1) Careful observations of nature. (2) Deduction of natural laws. (3) Formation of hypotheses — generalizations of those laws to previously unobserved phenomena. (4) Experimental or observational testing of the validity of the predictions thus made. Actually, scientific discoveries rarely occur in this idealized, wholly rational, and orderly fashion.

The above sentence is quite accurate. All of the definitions I have seen of the scientific method are idealized and oversimplified. This is because the scientific method is a complex methodology and cannot be accurately described with a few phrases. The definition and explanation I am presenting in the following subsection is several paragraphs in length. Thus, my presentation is a more realistic representation of the scientific method, as it applies to the physical, social, and biological sciences. However, the material I am presenting is **not** a complete description of all the variations of the scientific method, which would require a book length manuscript.

A Detailed Definition and Description of the Scientific Method for the Hard and Soft Sciences

The definition and description of the scientific method I am presenting applies to the simple and complex systems of the **hard** and **soft** sciences. This includes systems that involve physics, chemistry, biology, psychology, political science, sociology, etc. To avoid oversimplification, I am providing more details and explanations in my definition and description. This involves over 380 words, in the following five paragraphs.

The scientific method is a methodology for **devising** and **testing hypotheses**, with observational or experimental research. The **results of the** observational or experimental **research,** will determine if the hypothesis is true or false, or if it has to be modified. However, a hypothesis must be confirmed by a number of researchers before it is considered valid in the scientific literature, as described in the following three paragraphs.

With the simple systems of the hard sciences the observational or experimental **results** that initially confirmed the validity of the hypothesis, must be precisely **reproducible** by **other researchers.** If the results are **not** reproducible, the hypothesis is unproven, or invalid, from the perspective of the scientific literature.

With the complex systems of the **soft sciences**, (such as research involving psychology or sociology) the observational or experimental **results** usually cannot be reproduced **exactly** by other researchers. However, if most researches can obtain

approximately the same **results**, the hypothesis will be considered valid in the scientific literature. If this is **not** the case the hypothesis will most likely be classified as unproven or invalid from a scientific perspective.

Sometimes the hard sciences involve highly complex systems, which are as unpredictable as the systems studied in the soft sciences. This includes systems that involve volcanoes, earthquakes, ecology, biology, and whether. Thus, with the **complex systems** of the **hard sciences,** observational or experimental results are **not** perfectly reproducible. However, if most researches can obtain **approximately** the **same results**, the hypothesis will be considered valid in the scientific literature. If this is **not** the case the hypothesis will be classified as unproven or invalid from a scientific perspective.

A major component of the scientific method is devising hypotheses. There are many ways that researches **create hypotheses,** which might involve one or more of the following:

- From previous observational and/or experimental research
- From an attempt to explain phenomena
- From an attempt to prove or disprove a theory
- From the failure of a theory to account for observational or experimental results

- From logical induction, logical deduction, and/or with mathematical reasoning
- From creative thinking based on scientific literature
- From an attempt to solve a practical problem
- From an attempt to solve a theoretical or scientific problem
- From an attempt to invent a new device
- From an attempt to treat an illness
- From efforts to determine the cause of a disease
- From the failure of a theory

Concepts Related to the Scientific Method

Is a Hypothesis Necessary for Observational or Experimental Research?

The scientific method might convey the idea that you must have a hypothesis to carry out experimental or observational research. Actually research can be carried out without a hypothesis in some cases. This can involve a goal focused on obtaining general information, or a specific type of information, with experimental or observational research. Some examples are studying any of the following to obtain information: an ecological system, the ocean, a planet, a culture, a social group, human or animal behavior, etc.

Observational research without a hypothesis is not uncommon. However experimental research without a hypothesis is more unusual. Below there are five examples of experimentation without a hypothesis. (The first four are examples are hypothetical, and the last one is an experiment that was carried out in the early 1990s.)

- Creating artificial ecological systems, in aquariums or greenhouses, containing plants and animals, with the goal of determining what will happen to the plants and animals with oxygen levels of 10%, 20%, 30%, 40% and 50%

- An experiment to see what will happen if all of the following are added to a concentrated solution of sodium hydroxide: magnesium, aluminum, zinc, iron, copper, glucose, sucrose, starch, and cellulose

- An experiment to see what will happen if plants are grown with artificial light with different levels of violet, blue, red, and green

- An experiment to see what will happen if plants are grown with chemical nutrients, with alternatives for soil, such as clay, sand, gravel, silicon, powdered carbon, water, and oil and water

- An example of a real experiment is Biosphere 2. This involved the creation of a closed artificial ecosystem, with plants, animals, and eight human beings. See the following videos for details **1)** Jane Poynter: Life in Biosphere 2 **2)** Sally Silverstone & Linda Leigh - Biosphere 2

What is the Correct Strategy: Proving a Hypothesis, Or Testing a Hypothesis

Research should be carried out to test a hypothesis, and **not** to prove it. Carrying out research to **prove** a hypothesis is likely to be problematic for **two reasons**. This is explained in the following two paragraphs.

REASON-1) Trying to prove a hypothesis can be embarrassing, and imply that you are a failure, if your research indicates your hypothesis is incorrect. This might interfere with funding, for other research projects you want to carry out.

REASON-2) Carrying out research to **prove** a hypothesis can interfere with the research results. Specifically, when humans are trying to prove something, various psychological factors might interfere with accurate results. Research carried out this way, might produce erroneous results that suggest that an incorrect hypothesis is true.

What Criteria Determines if Observational or Experimental Research is Unsuccessful or Successful

Observational or experimental research is **unsuccessful** if little or no information was obtained, because of one or more of the following:

- There was a failure to carry out proper procedures
- Incorrect techniques or equipment was used

- The equipment malfunctioned

- There were inadequate funds to properly carry out the research

Observational or experimental research is successful if the above was not true, and if one or more of the following is true:

- There was reasonable amount of information obtained from the research. This suggests success even if the information was disappointing or uninteresting.

- The research is successful if it proved that the hypothesis is true, or false, or if the results indicate a need to modify the hypothesis All of the above represent important or useful information.

For example, if a robotic device is sent to another planet to search for life, and no life, water or oxygen is found, the research was successful. However, if the robotic device failed to function properly, and it was not possible to confirm that there was no life on the planet, the research is unsuccessful.

Examples of Experimental Studies

Listed below there are five examples of famous experiments, which can be accessed in a video format by clicking on the blue links. These experiments involve psychology or social psychology.

- **Video:** Milgram experiment - Jeroen Busscher A research paper on this experiment can be accessed by clicking on the following link: BEHAVIORAL STUDY OF OBEDIENCE1 STANLEY MILGRAM Yale University

- **Video:** 1971 Stanford Prison Experiment Psychology of Imprisonment

- **Video:** Asch Conformity Experiment

- **Video:** Harlow's Studies on Dependency in Monkeys

- **Video:** Bandura's Bobo Doll Experiment

Case Studies, with Related Concepts

What is a Case Study?

Based on a number of sources I encountered over the years, the term case study does **not** have a precise meaning. This terminology is sometimes used for hypothetical cases designed to challenge students. The term case studies are often used to represent the study of a disease, or psychological disorder, in a number of individuals. The term is also used to represent the study of the progression of a normal state, or specific pathological condition in an individual, over a period of time. The above underlined words relate to the definition I am using in this e-book. This is explained in detail in the following subsection.

A Precise Definition of a Case Study, for Simple and Complex Systems

Based on the way I am using the terminology, a case study, is a non-experimental study of a system, focused on how it changes over period of time. This can involve a sequence of changes of a system that take place over time. A case study can involve normal or pathological changes of a system that takes place over a period of days, weeks, months, or years. This can also involve a detailed history of a system, and how it changed, and what caused the changes, at specific points in time. In general, a case study involves a **change** that progresses with time, or a **sequence of changes** that take place over a period of time.

Case studies can be carried out with any type of system that changes in an interesting, or significant way over time. However, case studies usually involve systems that are comprised of people, such as an individual, a family, a group, a business, an organization, etc. This often involves dysfunctional or problematic changes, such as the development and progression of a medical condition, or a psychological disorder. See the following examples.

- A medical condition that progresses over time
- The developmental sequence and aging of an animal or human from infancy to old-age

- The developmental sequence of an individual, from infancy to adulthood in a poverty-stricken environment, with limited educational facilities

- The developmental sequence of an individual, from infancy to adulthood in a wealthy environment, with excellent educational facilities

- The sequence of experiences, learning, and failures, from infancy to adulthood that leads to criminal behavior

- The sequence of developmental stages of an insect, from an egg, larva, pupa, to an adult

- The developmental sequence of a skill over period of time, from novice, intermediate, advanced, to an expert

- The study of the normal or pathological development that takes place over an extended period of time, or throughout the lifecycle, of plants, animals, or people

- The normal or pathological changes in an ecological system, over a period of time

- The development of stars of different masses, from the time of their formation, to their extinction

- The evolutionary development of a specific plant or animal

Obtaining Information for a Case Study

The information for case study research can be obtained by observing the changes of a system that takes place over a period of time, or by examining historical records. When extended time intervals are involved, it is necessary to use historical records. This can involve educational, medical, psychiatric, criminal, public, and/or financial records. In some cases, historical information for a case study can be obtained from interviews of one or more individuals. When studying ancient civilizations, or prehistoric animals, archaeological literature and/or fossil records can provide the needed information.

The Advantage and Utility of Comparing Multiple Case Studies

Case studies focused on a specific problematic or dysfunctional condition can provide interesting, and/or highly useful information. With information of this nature, it may be possible to delineate a sequence of stages that typically lead to the adverse condition. Then it may be possible to reduce or prevent the adverse progression, by carrying out appropriate corrective actions. For example, if an individual appears to be in a developmental sequence that is leading to criminal behavior, early and appropriate corrective action may halt and/or reverse the dysfunctional development. This ideally would include replacing the dysfunctional development with a productive and healthy developmental sequence.

The Use of Case Studies in Medicine

Some examples are evaluating the effectiveness of a new drug by carrying out a case study of patients that receive the drug, and how their medical condition changed over time. Ideally this should include case studies of patients that did not receive the new drug, for comparison. This type of case study can have some advantages over research carried out under controlled laboratory conditions. Real life situations are **not** the same as controlled conditions carried out in a laboratory. This is because some patients might have multiple medical problems, and they may be very young or very old, and they might be taking a number of other medications. The above variations are usually eliminated when testing a drug under controlled laboratory conditions.

Study of a number of individuals with specific diseases, and the medications that were used to treat their condition, can provide very useful information. It can be used to evaluate medical techniques and medication, by evaluating different types of medical treatment that patients received to treat a specific disease. Case studies can indicate the most effective drugs or medical procedures for a specific disease. Studies of this nature can also indicate drugs and medical procedures that are ineffective.

For Supporting Information, Alternative Perspectives, and Additional Information, from Other Authors, on Case Studies, See the following Websites

If you want additional information, alternative perspectives see the following Internet based articles and videos: **1)** Case study, **2)** Examples of Psychology Case Studies, **3)** How to Write a Psychology Case Study Tips, Guidelines, and Examples By Kendra Cherry, **4)** PREPARING A CASE STUDY: A Guide for Designing and Conducting a Case Study for Evaluation Input By Palena Neale, PhD, **5)** Case studies: A hard look at GM crops, **6)** Definitions from Dictionary.com, **7)** MACMILLAN Dictionary

To go to the first page of this chapter left click on these words

HYPERLINK TABLE OF CONTENTS

Below is the hyperlink table of contents of this chapter. If you left click on a section, or subsection, it will appear on your computer screen. Note the chapter heading, the yellow highlighted sections, and the blue subheadings are **all active links.**

To go to the first page of this chapter left click on these words

If you want to go to the next chapter left click on one of the following links

For HTML) www.TechForText.com/R/Chapter-9

For PDF) www.TechForText.com/R/Chapter-9/PDF.pdf

If you want to see a list of all the chapters in this e-book go to www.TechForText.com/R