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Department of English Studies

(Major) Sciences of Language

(Module) Social Sciences & Humanities

(Class) Undergraduate

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INTRODUCTION TO SCIENCE AND SCIENTIFIC METHOD

Outcomes: Upon the completion of this tutorial, you will be able to :

1. *Define* science and the scientific method;
2. *Outline* its goals and scopes ;
3. *Elicit* its products & methods ;
4. *Single out* its types.

Food-for-Thought Questions: *Try to answer these questions with peers and teacher.*

1. *What is science?*
2. *What are its goals and products?*
3. *In what way are social sciences different from natural sciences & formal sciences?*
4. *To what extent are these three sciences complementary?*
5. *To what extent can we claim that social studies are beneficial?*
6. *Are inductive and deductive reasoning methods mutually exclusive?*
7. *What is the role of skepticism in science ?*

Touch a scientist and you
touch a child

Ray Bradbury

Terminology Used in This Tutorial :

Science, hard science, soft science, quantitative, qualitative, empirical, analytical, critical, pure research, applied research, social studies, formal sciences, natural sciences, deduction

A Point to Ponder & Wonder

Peruse, i.e., read, this short passage and discuss the teacher and peers the different steps of the scientific thought.

Men love to wonder, and
that is the seed of science

Ralph Waldo Emerson

It was late summer of 1666, young Isaac Newton was sitting in his garden at Woolsthorpe Manor, Lincolnshire. Suddenly, an apple fell from a tree. Young Isaac

Newton was intrigued by the incident. He was curious to know why the apple fell straight down, rather than sideways or even upward. This led him to explain this natural phenomenon by experimentation. He finally concluded that Earth has gravity acceleration that equals 9.8m/s and came up with Newton's Second Law (i.e., $F = m g$).

Introduction

When people use the term *science* (or *scientific*), they often refer to the quality of being **systematic** and **objective**. To a great extent, this is correct. Broadly speaking, science attempts to discover and establish **general rules** that govern behavior and the world all while being orderly and objective. Moreover, science and error are interrelated and, therefore, it does not claim absolute **truth**. Science cherishes constant research and verification of already established **facts**. In sum, science aims to produce more and more accurate **natural** explanations of how the **natural world** works, what its components are, and how the world became the way it is now.

Tutorial 1 is composite in nature (i.e., collected from different sources including my own thoughts) and introduces you to *science* and its types and scope. My objective is to help you identify what is meant by science and scientific method(s). This would help you come to grips with what it means to be *scientific* and assist you in conducting *research* in your (under)graduate studies.

Definition of "Science"

The word *science* comes from Latin (*viz*, *scientia*) meaning **knowledge**. Science is, basically, an "empirical" field, that is, it develops a body of *knowledge* by *observing things* and *performing experiments*. According to Oxford Advanced Learners' Dictionary (**OALD**), science is *knowledge about the structure and behaviour of the natural and physical world, based on facts that you can prove, for example by experiments*. Bernard and Bernard (2013: 3) note "Science is about the systematic creation of knowledge that provides us with the kind of control over nature [...] that we have always sought". According to Coolican, "Science --- not a subject but a way of thinking" (2009: 4).

The most rewarding work is usually to explore a hitherto untouched field.

**Edgar Bright Wilson ,
1990**

Categories of Science

Science comes to be classified into four (02) categories:

1. **Pure (or Basic) science:** Pure or basic science refers to the **acquisition of new knowledge regardless of its application**. Scientists are interested in knowing for the sake of knowing and eventually the advancement of science.

2. **Applied Science:** Applied science refers to the application of scientific findings to find practical solutions. It proves to be concerned with the practical **use of the findings** (i.e., to meet human needs).

Sources of the scientific knowledge

From where do people obtain what they come to know? Different sources contribute to the acquisition of knowledge.

1. **Authority:** How do Muslim know that Jesus was born miraculously (namely, without a father)? And how do Muslims know that Jesus was not crucified? It was revealed to them through the Prophet Muhammed (PBUH) by the Supreme Being (i.e., Allah) and they base their belief on the authority of God. An *authority* is someone who has the power to affirm the existence of such or such piece of information. Parents, teachers, scientists, and governors are all considered authorities. Although some scientists reject a metaphysical (i.e., God or religious) interpretations, "[w]e frequently accept a large amount of information on the basis of authority, if for no other reason than we do not have time or the expertise to check it out firsthand" (Pagano, 2009, p.4).

2. **Tradition (or Custom):** People often go back in time to see how people of past thought about some issue. Muslim scholars regularly refer to the Four Imams (Abu Hanifa, Malick, Shafi'i and Ibn Hanbel) to explain and issue *fetwas*. Another example is grandma recipes: to cure an earache, it is enough to drip in the ear a few drops of warm olive oil. It is not uncommon to hear the old people advising young parents to avoid overclothing their children by saying "Better let them feel cold than be in sweat"¹.

3. **Experimentation (or Empiricism):** According to Burke and Christensen (2010, p. 13), "Empiricism is the idea that all knowledge comes from experience". Observation, thanks to the five senses (namely, sight, hearing, smell, taste, and feel), and experimentation (in laboratories) are the backbone of empiricism. Ideally, experimentation is dispassionate (i.e., objective, and unemotional). It is also unbiased and ethical (i.e., moral).

4. **Personal Experience:** John Locke (1632-1704), the English philosopher, believes that people are born *tabula rasa*, a blank slate, which is filled by their natural surroundings (family, friends, schools, socio-economic status, political situation, etc.). Often, people learn the hard way, not until they get their fingers burned, children will not fear fire. On the contrary, all children are fascinated by fire and all the other things that may harm them.

5. **Intuition (or Hunch):** Cambridge Dictionary defines intuition as "an ability to **understand** or **know** something **without needing** to think about it or **use reason** to

¹ برود و لا تعرفو

discover it ...". Intuition is that sixth sense that you cannot explain that there is something missing. In the same vein, Profetto-McGrath et al.² (2010, p.10) identify intuition as " [...] a type of knowledge that cannot be accounted through reasoning or prior instruction".

Scientific Reasoning

Logical, sensible, scientific thinking in obtaining knowledge utilizes two kinds of reasoning tools : induction and deduction. "In general, the less we know about a research problem, the more inductive we'll be- the more we let observation be our guide- and the more we know about a problem, the more deductive we'll be" (Bernard & Bernard 2013: 12).

The art and science of asking questions is the source of all knowledge.

Thomas Burger

Induction : In their book *Quantitative Health Research : Issues and Methods*, Curtis and Drennan (2013:134) state "Induction refers to research where theories are developed or generated from, for example, observation [...]". In other words, inductive reasoning relies on specific events and **infers** (i.e. , reads between the lines) general rules or abstractions. It should be noted that inductive reasoning leaves room for **uncertainty** (not a 100% percent sure). Consider the following example :

Wael has blue eyes; his father has blue eyes, too. His sister, Ferial, most likely has blue eyes.

Deduction : In their book *The A-Z of Social Research : A Dictionary of Key Concepts in Social Research* , Miller and Brewer (2003: 67) define **deduction** as "[...] the process of **reasoning** by which **logical conclusions** are drawn from a set of general premises. The goal of deduction is to **confirm** or **reject** a hypothesis. One classical example is the following :

Man is **mortal**

John is a man

Therefore, **John is mortal**

Note that real scientific research is not purely inductive nor purely deductive (Bernard and Bernard 2013: 12). Scientists relies on these working together to solve problems.

Goals of Science

² Profetto-McGrath, J., Polit, D. F. & Beck, C. T. (2010). Canadian Essentials of Nursing Research. Lippincot Williams & Wilkins

According to Diggle et. al. ³(2011, p. 1), the goal of science is to understand nature. Beside understanding natural phenomena, science intends to control these; think of hurricanes, Covid-19, and cheating in the examinations, etc. It is widely acknowledged that science has three goals. The first goal of *science* is to research to *understand*. The second goal of science is to *explain*. The third goal is to dispense *solution to solve a problem*. All in all, goals of science could be outlined as follows:

1. Investigate to **understand** the natural world;
2. **Explain** events in the natural world;
3. Use those explanations to make **predictions** and/ or **dispense solutions**;
4. **Control**.

Science Functions

The following checklist acknowledges the functions of science.

1. Science **focuses** on the **natural world** ;
2. **Aims** to **explain** the natural world ;
3. **Uses** testable ideas ;
4. **Involves** the scientific community
5. **Leads** to ongoing research
6. **Benefits** from scientific behavior

Types of Science

Science is divided into two broad categories (1) *hard* and (2) *soft* sciences :

1. Hard Sciences

1.1 Natural sciences : Natural sciences seek to uncover the rules that govern the natural world. They rely upon quantitative (i.e., empirical/ experimental) methods of investigations. We can point out to some such as *astronomy, biology, chemistry, physics, and Earth sciences (e.g., geology) as natural sciences*.

1.2 Formal sciences : Formal sciences refer to the disciplines concerned with formal systems (not the content), such as *logic, mathematics, statistics, theoretical computer science, information theory, game theory, systems theory, decision theory, and portions of linguistics*. According to Einstein, pure mathematics is, in its way, the poetry of logical ideas.

The scientist is motivated primarily by curiosity and a desire for truth

Irving Langmuir

³ Diggle, P.J., Chetwynd, A. G. and Chetwynd, A. (2011). Statistics and Scientific Method: An Introduction for Students and Researchers. OUP

2. Soft Science

William Thompson (1824) first coined the term *social studies* to mean both the social sciences and the humanities. *Social studies refer to the systematic study of human thought, behavior⁴ and society.*

2.1 Social Sciences : A *social science* is a field of study that undertakes to study with society, people, behaviors, cultures, and attitudes. It uses empirical methods of investigation. Some such fields of study comprise : *anthropology, economics, political science, sociology, psychology, linguistics, and geography, etc*

2.2 The Humanities : The humanities are a group of disciplines that seek to understand, appreciate and critique the human conduction in all its depth and range of meaning. Humanities rely upon the interpretive, critical and/ or reflective methods of investigation. Some such disciplines in humanities we may count *history, languages, philosophy (of certain subjects), religion, performing arts, and cultural anthropology, etc.*

In science credit goes to the man who convinces the world, not the man to whom the idea is first occurred

Francis Galton

Scientific Methods/ Procedures

The meticulous process of *gathering* and *analyzing* data is called the "scientific method". Science follows a certain pattern or system in its attempt to uncover the underlying reasons behind natural phenomena. "The real purpose of the scientific method is to make sure nature hasn't misled you into thinking you know something you actually don't know" (Robert Persig 1999 in Coolican 2009: 25)

1. Observation : Observation refers to the application of the five senses (sight, hearing, touch, smell, and taste) in the operation of noticing a natural phenomenon.

2. Hypothesis & Prediction : The hypothesis is an "educated guess," formed as a statement that you propose to be the answer to the research question. The hypothesis is, therefore, your general, tentative statement of how you think the scientific phenomenon in question works.

3. Experimentation : Experimentation means to conduct a practical experimentation (e.g. in a laboratory) to test or verify the hypothesis.

4. Conclusion/ Result/ Rule : This is a summary of the experiment's results, and how those results match up to your hypothesis.

⁴ Bernard, H. R. & Bernard, H. R. (2013). *Social Research Methods: Qualitative and Quantitative Approaches*. SAGE

6. Repetition/ Replication : An experimentation that cannot be repeated is a miracle. In science, an experimentation needs to be carried out repeatedly and on different occasions with relatively the same results.

Pillars of Sciences : Science reposes on three pillars. These are positivism, rationalism, and skepticism.

1. Positivism : It usually refers to the experiments that scientists conduct. It is also known as experimentalism, empiricism, or quantitative research. What is known stems from experience. "We come to understand what is true from what we are exposed to" (Bernard and Bernard 2013 :8).

2. Rationalism : It considers reasonable, i.e., logical, thinking as the chief source of obtaining knowledge. Richard Feynman advises "Have no respect whatsoever for authority; forget who said it and instead look what he starts with, where he ends up, and ask yourself "Is it reasonable?"

3. Skepticism : Originally from Greek meaning those who are not satisfied with the actual explanation and still searching for truth. Skepticism refers to the application of doubt to the scientific findings. In science, nothing is taken for granted; everything ought to be taken with a pinch of salt. The famous American physicist Richard Feynman notes "[...] science is culture of doubt". An Arab proverb advises to *believe half of what you hear*.

Characteristics of Science

Science has some inherent characteristics that differentiate it from other non-scientific human activities. Guy et. al. (cited in Catane 2000: 4) outlines these five characteristics:

1. It is **empirical**, which means it rests on sense data.
2. It is **logical**; it believes that there is an ultimate link between logical thinking and empirical fact.
3. It is **generalizing**; it has no inherent interest in individual cases as it seeks general principles.

Without the products of research, man would be still living in the neolithic age

Catane, Juliet

Scientists are explorers

Richard Feynman

Many scientists owe their greatness not to their skill in solving problems but to their wisdom in choosing them.

Wilson, B. (2012). An introduction to scientific research.

4. It is **abstract**; it is not interested in concrete things but it is increasingly concerned with what is called "ladder of abstraction" [...] the scientist can always look for ways of combining characteristics of data to seek the most general understanding of a phenomenon that it can be.

5. It is **public** not private; it is concerned with things that can be publically observed and tested.

Quiz

Task One : Are the following Statement true or false ? Write (T) or F) in the space provided.

____ . Science is error-free.

____ . Science is about understanding natural phenomena.

____ . Experimentation is a key operation in scientific methods.

____ . Hypothesis is your attempt to explain why things happen the way they do.

Task Two : Compare and contrast.

Natural Sciences & Formal Sciences

Social Sciences & Humanities

Inductive & Deductive Reasoning

Pure Science vs. Applied Science

Task Three : Classify in the grid below the following disciplines.

Poetry-geometry-geology-algebra-archeology-sculpture-literature-algorithms-law-fine arts-political science- microeconomy-linguistics-neuroscience-psychology-geophysics-literary criticism-astronomy-history-biology

Humanities	Social sciences	Formal Sciences	Natural Sciences

Task Four : Write in no more than 300 words on the following topic.

Topic One: *Equipped with his five senses, man explores the universe around him and calls the adventure Science.* - Edwin Powell Hubble

Topic Two: *Science and everyday life cannot and should not be separated.*” – Rosalind Franklin