Unit I
The Nature of Science and Scientific Writing

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Man has always looked for explanations about the physical universe in order to understand the way things are, why they look or behave the way they do. The need to explain, predict, and control things that happen in this world has led us to systematize knowledge, processes, and events in this physical universe. Thus, it can be said that our survival in this universe has largely become possible through science. In this unit, we will discuss the nature of science and scientific writing.

Objectives

At the end of this unit, you should be able to:

- Define science in your own words;
- Describe the nature of science;
- Explain the functions of science;
- Discuss the processes of science; and,
- Explain the nature of a scientific paper.

What is science?

There are many ways of defining science. One way is to describe its nature and scope. Another way is to discuss the processes involved in it. The first way may be said to be static and theoretical, while the second may be viewed as dynamic. The **static view** of science focuses on the body of knowledge gained through experience, the theoretical explanation of natural phenomena. The **dynamic view** of science emphasizes the methodical activity or investigation of natural phenomena.

Science as a systematized body of knowledge originated from its Latin etymology**, *scientia***, which means knowledge. Thus, one of the functions of science is to **explain** the nature of the physical universe in order to understand its workings. Science offers tentative explanations about the way certain things in this universe act or behave the way they do. Through time, these explanations become theories, and then later they become principles or laws. This body of scientific knowledge allows us to understand more about our physical universe so that we can adapt to it and cope with the changes that take place in our big world.

Science is also **a methodical process of investigation**. In our attempt to explain natural phenomena in this world, we also learn ways to **predict** and **control** for them (the

other two functions of science), especially when they become detrimental to human existence. Scientific investigation or inquiry is based on systematic observations and experimentations. This is more commonly known as the **scientific method**. It involves the following steps:

1. **Observation**. Scientific investigation begins with the use of our senses, like the sense of sight, hearing, taste, smell, and touch. With these senses, we are able to identify problems that affect us.

2**, Identification and Statement of the Problem**. This involves the recognition of the specific problem to be investigated. It is usually expressed in a question form.

3. **Formulation of the hypothesis**. A tentative answer to the problem is made in the form of a statement that can be tested through experimentation.

4. **Experimentation**. Through the manipulation and control of one or more variables, the hypothesis is tested and evaluated.

5. **Conclusion**. Based on the findings of the experimentation, statements are made regarding the hypothesis of the study. These statements basically answer the research problem

Characteristics of Science

Science as a body of knowledge and as a process of investigation may be described broadly as objective, empirical, accurate, precise, systematic, and tentative. Just what do they mean?

- **Objective** – This refers to the attitude of the researcher. He/She must be free from biases and prejudices. Science emphasizes demonstrable truth. Thus, evidence in science is factual. Any claim must be verifiable and devoid of any personal and partial judgments.

- **Empirical** – Scientific claims are based on observations and experimentations. They must be observable phenomena. Closely related to being objective, science is replicable. Scientific truth can be rechecked through sensory experiences.

- **Accurate** – Experimentations must yield consistent data. Scientific claims are accurate if experimental data are close to each other.

- **Precise** – Scientific claims are evaluated on the basis of standard values. The closeness of the claims to the standards indicates a more refined degree of measurement.

- **Systematic**- Scientific investigation is done in a methodical way. It follows the scientific method discussed earlier, from the identification of the problem to the drawing of conclusions. It is based on a sound and logical inductive and deductive reasoning.

- **Tentative** – All scientific claims may be revised in the light of new evidences and discoveries. No claim is absolute and irrevocable. Thus, science is always made public for the scrutiny of everybody.

Processes of Science

Having discussed the characteristics of science, we can see that it requires a rigorous and disciplined approach, showing that it involves various processes. The dynamic view of science underscores these processes. In an article by Walter R. Brown (1968) in the *The Science Teacher,* he identifies five processes of science:

A. Application of Generalizations to New Situations

Science involves logical thinking. It teaches one the ability to deduce or to infer things from specific situations. Brown explains that this includes two sub-processes of scientific inquiry. They are:

1. **Ability to deductively apply principles to specific experiences**; and,
2. **Ability to extrapolate beyond given data**.

The first sub-process of science emphasizes **deductive reasoning** or the ability of a person to apply a general principle to a specific case or situation. For example in Physics, one learns about Newton's Law of Universal Gravitation that states : *The gravitational force between any two masses in the universe is directly proportional to the product of the masses and inversely proportional to the square of the distance between their centers.*

Knowing Newton's Law of Universal Gravitation , a person is able to explain the low tide and the high tide that we observe in the sea on earth. The high tide of the earth facing the moon is due to the gravity of the moon pulling the sea The sun exerts less pull on the earth's sea than the moon due to its distance. When the sun and the moon partially cancel out each other's pull, the effect is low tide.

Another sub-process of science is the ability of a person to go beyond the data. In the process of scientific investigation, a person must learn to determine the implications of the data. This means extending the meaning of the trends that are observed in a given situation. However, Brown cautions us to know the limits that we can safely do this.

B. Collection of Data

Another process involved in science is data collection, which requires a person to become trained in gathering information. This process includes various skills to learn such as the following:

1. **Ability to identify a problem;**
2. **Ability to delimit the problem;**
3. **Skill in reading and understanding data in various forms;**
4. **Ability to choose a course of action by determining what data are necessary for the solution of a problem; and,**
5. **Ability to choose the best authority.**

Problem identification is one of the most difficult tasks in scientific investigation. A person must have a questioning mind and must learn to ask "Why?." After he/she learns to specifically identify the problem, the person must know how to state the problem in such a way that he/she can find a solution to it. Part of this is recognizing the limits and the scope to which the problem can be worked out. This requires going over previous works that have been made along the identified problem and problem area. In his regard, the researcher must develop the skill to read and understand data that have been presented in various ways: textual, graphic, and tabular. From these data in various forms, the person must be able to determine what data are necessary to solve the problem that he/she has identified. Related to this is the ability of the researcher to judge the reliability of the sources of information.

C. Analysis of Data

Data analysis is highly determined by the hypotheses that state the relationships of variables considered in the study. Brown identifies these four sub-processes of science:

1. **Skill in formulating hypotheses;**
2. **Ability to organize lists of hypotheses;**
3. **Understanding cause-and-effect relationships; and,**
4. **Skill in testing hypotheses.**

According to Brown, the difficulty in stating the hypotheses lies in the logical processes involved in it. It is important that the proposed hypotheses are consistent with other known data, amenable to available experimental methods, and they are stated clearly. After hypotheses are evaluated and clearly stated, they must be ranked according to their probability of being true. This requires an understanding of the cause-and-effect relationships. A person must learn to distinguish the causes from the effects. Finally, a person must learn to devise a way to test the hypotheses.

D. Synthesis of Data

This process requires a person to learn the art of putting and integrating things into one unified whole. It leads to the formulation of generalizations and conclusions. The following skills must be developed along this scientific process:

1. **Ability to synthesize data into generalizations, and**
2. **Willingness to withhold judgment until sufficient information is available.**

A person who embarks on a scientific investigation must learn eventually to unite various data into a logical and unified generalization. This should lead to building a theory that will explain and predict accurately the results of other observations in the study. In this context, a person must learn to suspend judgment until all the information necessary for a valid conclusion has been gathered.

E. Evaluation of Data

Data evaluation focuses on weighing the value of evidence and arguments presented in the study. Thus, this process stresses three important skills:

1. **Ability to evaluate evidence;**
2. **Skill in evaluating arguments; and,**
3. **Ability to distinguish among assumptions, hypotheses, theories, and established principles.**

Evaluating evidence that has been collected through experimentation is a hard task. Two general criteria are often used: reliability and validity.

Reliability refers to the trustworthiness of the data in question. Questions that are raised in this regard are the following:

1. Were the variables of the experiment properly controlled?
2. Were the measuring instruments appropriate for the measurements being taken?
3. Were the instruments read accurately?
4. Are the data stable or will they change when the experiment is repeated?

Validity refers to whether the experiment really measures what it was intended to measure. Some questions that may be raised regarding this are:

1. Does logic support the manner in which the experiment was conducted?
2. Were the proper data collected?
3. Do the data answer the research objectives?

Many conclusions in science are probably based on insufficient evidences. Thus, these conclusions must be evaluated in terms of the logic of their arguments. In a

scientific inquiry, researchers must be taught the differences of the following: assumptions, hypotheses, theories, and established principles.

- **Assumption –** the lowest kind of conclusion based entirely upon crude logic and casual observation leading to its being taken for granted that something is true.
- **Hypothesis** – more likely to be correct since it is based on logic and evidence. Statistical hypotheses may be tested.
- **Theory** – a reasoned judgment or conclusion that has a great deal of experimental evidence indicating that it is probably true.
- **Principle** – a conclusion that has been evaluated by experts in the field and has been found to be accurate at all times and in all places.

What a Scientific Paper Is

After so much discussions about science, its nature, functions, and processes, we now come to explain what scientific paper is. It may be inferred from our earlier discussions that implicit in the definition of science is the need for reports of inquiry. Science is public; scientific findings must be disseminated for the scrutiny of the general public So , what is a scientific paper?

According to Robert A. Day, "A scientific paper is a written and published report describing original research results." However, he goes on to say that this short definition must be qualified. He noted that a scientific paper must be written in a certain way and that it must be published also in a certain manner as dictated by three centuries of tradition, editorial practice, scientific ethics, and printing/publishing procedures.

Day (1983) explained what a "valid publication" is using this definition of the Council of Biology Editors (CBE) :

> An acceptable primary scientific publication must be the first disclosure containing sufficient information to enable peers (1) to assess observations, (2) to repeat experiments, and (3) to evaluate intellectual processes; moreover, it must be susceptible to sensory perception, essentially permanent, available to the scientific community without restriction, and available for regular screening by one or more of the major recognized secondary services (e.g., currently, Biological Abstracts, Chemical Abstracts, Index Medicus, Excerpta Medica, Bibliography of Agriculture, etc., in the United States and similar facilities in other countries).

He simplified this definition by saying that a scientific paper is (1) the first publication of original research results, (2) in a form whereby peers of the author can repeat the experiments and test the conclusions, and (3) in a journal or other source document readily available within the scientific community.

The second criterion for a scientific paper is the particular kind of document containing certain specified kinds of information. A scientific paper should reflect the quality of thought as are needed for the rest of science: logic, clarity, and precision,

Summary

In this unit, we have discussed science as a systematized body of knowledge about the physical universe gained through experience and experimentation. We have also seen science as a disciplined and rigorous process of investigation about natural phenomena. This process is more commonly known as the scientific method. It involves processes such as application of generalizations to new situations, collection of data, analysis of data, synthesis of data, and evaluation of data. Implicit in the nature and scope of science is the need for reports of inquiry, thus the discussion about the nature of scientific papers.

References

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