# Guide to Scientific Research

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**Abstract**

*The central purpose of this paper is to highlight the scientific nature of a basic research in any branches of knowledge. In order to make research really scientific, the researcher needs to religiously follow certain procedures starting from sample selection and data collection down to data analysis and report writing, followed by dissemination of findings for public consumption. The procedures envisaged in this paper are commonly followed by scientists across various fields of study. The paper also emphasizes that in scientific research, common sense and intuition have no place vis-a-vis divine knowledge and experiment. In order to guide the analyses of the data, scientist must bear in mind the unit and focus of his study.*

**Keywords:** *Proposition, Generalization, Operational Defilation, Foci Analysis, Hypothesis and Theory.*

## 1.0 INTELLECTUAL CONTEXT

The kind of scientific research we will discuss here is a special case of scholarship. Any research which falls outside of this scholarly tradition is deemed to be non-scholarly. In this sense, applied research is non-scholarly. Hence the particular research we will deal with is required to be designed to answer only the intellectual questions. Applied or operations research are usually designed to answer program or project related issues and problems; those may be important or urgent but do not always strictly follow the scientific procedures. This much clarity is needed at the outset to understand the scientific orientation of scholarly or basic research. Historically scholarly research is located in Universities and research institutions and their findings are made public. By contrast the pure research done in the industries and Government organizations is often maintained secretly and considered these as their property and public should not have easy access. The ultimate purpose of scholarly research is to know what we don't know, and answer the questions which are hitherto not answered. Therefore, scholarly research has to be most basic and scientific in order to become valid source of knowledge. Also, it must have philosophical orientation in respect of data gathering, generalization and truth telling. In this sense, it has relation with philosophy.

## 2.0 RELATION WITH PHILOSOPHY

For the sake of clarity and better understanding of the term "**philosophy**", a few words seem to be in order. Philosophy refers to any body of knowledge. It is closely related to religion, mathematics, natural sciences, education and politics. Diogenes Laertes, the first historian of philosophy of the third century established the traditional division of philosophy into three parts, namely, a) natural philosophy; b) moral philosophy and c) metaphysical philosophy. Natural philosophy is concerned about the constitution and process of transformation in the physical world. Moral philosophy deals with justice which raises the question of something as right or wrong. Metaphysical philosophy is the study of existence of things, causation, logic and other abstract objects. After careful study of these three divisions, one can find that scholarly research i.e. basic research is closely related to philosophy in the following two specific areas.

### 2.1 Epistemology

It faces the problem of determining the basis of knowledge. It asks the question, "how do we know, what we know?". Scientific methodology is clearly related to this question, though one may develop a perfectly consistent scientific theory without claiming "really to know the world". He, in fact, depends on method of knowing.

### 2.2 Moral Philosophy

It deals with the question of right or wrong, good or bad, and raises the moral question, "under what basis, something is called good or right or wrong?". To the scientist, what constitutes 'good' or 'right' or 'wrong' constitutes data. Ethics deals with the determination of what is good or bad based on data which should be collected by following scientific procedures.

## 3.0 THE ETHICAL BASIS OF ACADEMIC FREEDOM

Scientists including social scientists have to be ethical; and academic freedom is their pre-requisite. They must be allowed to entertain explanation of their findings. Academic freedom is the consequence of the demand to be honest. Though the scientists or scholars may be wrong, they cannot be willfully so. Academic freedom they need has to be ethical. In other words, they must speak the truth based on their scholarly research. Veracity i.e. truth telling is their right to freedom which they must enjoy. Scientists are highly concerned with methodology for two basic reasons. First, they are members of a culture which they seek to study, and they want to arrive at a general theory by substantiating the facts based on hard data. Second, they must develop methods which permit generality by avoiding personal and cultural biases.

## 4.0 METHODOLOGY

While there is presumably a relation between pure and applied science, the two are not the same. We will restrict our discussion only to pure science, or, science done in the context of scholarly work. Strictly speaking, methodology is normative. It simply specifies the procedures which a body of scientists have more or less agreed to. It says then, how a scientist ought to behave if his work is to be acceptable. Any deviation in following the procedure is unscientific and hence, unacceptable. Scientific inquiries are confined to positive statements. If deals with those questions which can be verified by observations. The purpose of research is to have reliable and valid knowledge by following the scientific method.

## 5.0 Characteristics of Science

Science includes both a goal and the means to obtain that goal. Briefly, the goal of science is a theory. By theory we mean a "verifiable generalization of high order which in some sense explains observed phenomena." It may be defined as a set of inter related propositions some of which can be tested empirically [1]. Theories are summary statements about many observed activities. If the theories are valid, a limited number of theoretical propositions should be able to explain many observed facts. Indeed, according to our usage of the term, a theory systematizes laws, hypothesis and other generalization of a science. Thus, science is held to include the means for obtaining a theory and we may well consider those means as an aspect of theory. Certainly, methodology has theoretical implications and the researchers ought to be aware of this. Some of the important characteristics of science are:

### 5.1 Science is Empirical

At some point, science rests upon common sense data. This characteristic of science neither excludes abstract concepts nor inferential knowledge. It merely means that science is concerned with a knowable real world and empirical information, and not on sense data.

### 5.2 Science is Propositional

It deals with propositions, that is, statements having truth value about things. Sociology, for example, deals with propositions about human behavior. Civil engineering deals with infrastructural development; and the like. Proposition, once accepted in science, can always be questioned. Propositions must have verifiable truth.

### 5.3 Science is Logical

Logic is defined as the discourse of argument. At some point in his inquiry, the scientist reaches a conclusion regarding the acceptability or rejection of his set of propositions and some justification for the conclusions he has made. Logic is simply the rules in which inferences are made.

### 5.4 Science is Operational

Scientific statements can be broken down into propositions which can be further operationalized into logical arguments, so as to make someone understand the underlying meaning.

### 5.5 Science is Public

It means that scientific data or information can be communicated to another scientist. Scientific research results must be known to the general public if they are to be benefited from these. Research findings are public good utilities [2]. Public are ultimate beneficiaries. Science has no value, if it cannot deliver the benefits to the public at large. Scientific research results can be utilized by another scientist with proper citation.

### 5.6 Science is Problem- Solving

All inventions are intended to solve problems or improvement upon on-going things. When the scientist identifies something as problem and tries to dig out reasons, he then formulates hypothesis or research questions and prepares data gathering instrument(s) to collect facts and makes generalization, in the light of his findings. Thus, he makes his findings valuable. All his efforts are intended to solve the problems which the people have been facing.

### 5.7 Science Tends to be Abstract

A general scientific theory is highly abstract. For instance, the equation for law of gravity is simply a set of abstract symbols. Any scientific knowledge is found to be abstract.

### 5.8 Science is Ongoing

Science never rests. It keeps on searching the truth. Something which is found as 'correct' today, by a researcher can be challenged by another researcher tomorrow. To lend support to the existing theory or opposing it, he shall have to conduct research again, so as to have sufficient data to prove or disprove the earlier theory. In this sense, scientific research is therefore, ongoing.

## 6.0 STEPS IN SCIENTIFIC RESEARCH

In order to make one's research scholarly or scientific, one has to follow certain steps to dig out real knowledge. There is no way that a scientist can skip one step at the expense of the other. These steps are common to all.

### 6.1 Selection of Problem Area

In order to proceed with his research agenda, the most desirable first step of a scientist is to select his research topic which must be manageable one. He should then operationally define key variables as contained in his hypotheses or research questions. In other words, the research topic must be unambiguous and measureable one. This is necessary to test the theory against facts. For instance, If the task is to discover a relationship between road communication and economic development in a particular area, the key words must be operationally defined so as to measure the relationship between two variables [3]. While selecting the topic, scientist needs to be exceptionally careful so that his personal biases must not enter into the selection process in any way. He must reduce his proposition into a workable framework so that he can discern some hypothesis to pursue his research. The selection must be guided by the consideration of the importance of solution of his problem. In doing so, he has to give the rationale of his selection of his research topic and research setting.

### 6.2 Acquaintance with Current Theory and Knowledge

In order to have better insight into his problem, researcher needs to collect relevant literatures and studies, preferably recent ones so that he can get some light and raises some research questions or hypotheses to guide the analysis of his data. Review of relevant literatures will help him what questions were previously not answered or tested? What were the results? And what question should be asked now? Such review will give him moral strength and help him to develop logical arguments.

### 6.3 Definition of the Problem

As stated elsewhere in this paper that problem identified already needs to be operationally defined. Operational definition means demarcation of the boundary of the research problem/ topic. Such demarcation puts himself in right track and prevents him from asking many unnecessary questions or developing hypotheses. If the problem remains undefined, then research should be unmanageable, lousy, fallible and most likely to be unscientific.

### 6.4 Development of Hypotheses or Research Questions

In order to guide the analysis of the data, some hypothesis should be developed which may be in the form of theoretical hypothesis ($H_1$) or null hypothesis ($H_0$) or put some research questions keeping in view the basic purpose or specific objectives of his research. Such hypothesis or research questions shall ultimately help him in constructing the data gathering instrument (s) containing series of questions. Note that hypotheses are a proposed solution of the problem under investigation. Hence, they are vital for the development of instrument.

### 6.5 Selection of the Respondents

It is important that study area should be selected by following standard procedures and thereafter, respondents should be selected by simple random sampling, cluster sampling method or multistage sampling, as the case may be. In selecting the sample area and respondents, researcher must not be bias. If selection of sample spot and the respondents is not done by following the rules of sampling, then entire research tends to be unscientific.

### 6.6 Delineation of the Source Data

The hypotheses or research questions shall indicate what data are needed and the structure of the arguments tells what form they should be. Some data may be of many types, such as, target population, office records, observation, library works and so on. Sometimes, more than one source of data is needed to comprehensively address research problem. Depending upon the nation of the study, researcher may need mutt--level data.

### 6.7 Development of the Instrument

At this stage of research, the scientist is in critical phase. He needs to develop instrument(s) as required strictly being guided by his research objectives, hypotheses or research questions. He shall have to decide whether he/she will keep the data gathering instrument (s) with close-end or open-ended questions. Draft instruments should have pre-test and based on pre-test results, it should be finalized [4]. Data gathering becomes vulnerable, if it has too many open ended questions. He may divide his instrument(s) into several sections keeping in view hypotheses or research questions or key empirical variables to be tested.

### 6.8 Formal Acquisition of Data

After finalizing the instrument(s) it will be administered among the respondents in the sampled area. However, there is one prerequisite that the interviewers shall have to be trained in the data collection instrument(s) with professional excellence so that data, thus collected, become error free, highly reliable and valid and no kind of threats to internal or external validity occurs. In order to ensure both reliability and validity, there should be cross checks and counter checks of the instrument(s). Data collection is a religious function and no tempering with data should be tolerated. Falsification in any stage of data collection shall boomerang the results and nullify the purpose of scientific research.

### 6.9 Analysis of Data

Data, thus collected, must be analyzed according to the analytical plan which should be prepared priori. Appropriate univariate, bivariate or multivariate analyses should be carried out keeping in view the hypotheses or research questions. Appropriate tables and graphs may be used to describe and present research results.

### 6.10 Formal Write-Up and Conclusions

There should be formal write-up utilizing the data. Based on analyses of the data, some recommendations should be made and conclusions drawn which may be theoretical in nature.

### 6.11 Presentation Among Fellow Scientists/ Scholars

It would be highly professional that the findings should be presented before the fellow scientists and various stakeholders for their learned views. Based on their comments, the document needs to be recast and finalized, followed by dissemination to all relevant stakeholders in order to make the research findings really public.

## 7.0 UNITS AND FOCI OF ANALYSIS

In order to keep the scientific enquiry in tract, researcher must keep in mind his unit and focus of analysis. Units mean what the research is about. In other words, it means the “object” about whom or which, research is intended. In his analysis, he should be guided by this consideration. In his journey to search for truth, he must keep in mind his hypotheses or research questions in which the unit(s) of analysis are embedded. Focus or foci of analysis is to highlight the key questions he has addressed; and based on his findings, he needs to focus or highlight his discovery. In other words, focus means what the scientist or researcher is looking for.

## 8.0 SOURCES OF KNOWLEDGE

Human beings derive their knowledge from the following sources.

**a)** Divine knowledge;

**b)** Experimentation;

**c)** Observation;

**d)** Common sense and Intuition; and

**e)** History

### 8.1 Divine Knowledge

Research is intended to dig out true knowledge - knowledge that is worthy and highly reliable. Acquisition of such knowledge makes one knowledgeable and learned. Guided by this consideration, divine knowledge that comes from God Himself is the most valid and reliable knowledge. Since Adam (AS) down to prophet Mohammad (SM), reportedly there were more than 1,24,000 prophets upon whom some knowledge in the form of guidelines was revealed from Allah Sobhanutala through 100 sahifas (a set of instructions or guidelines) and 4 holy books -- Taurat upon Musa (AS), Jabur upon Dawood (AS), Engil upon Jesus (AS) and the holy Quran upon Mohammad (SM) were revealed. All these are embodiment of divine knowledge relating to present and the life hereafter. Knowledge and instruction provided in those books and guidelines have cent percent, future, verifiable truth. One can totally believe in divine knowledge as true knowledge without any reservation. Belief in divine knowledge is an article of faith; and any non-compliance is sacrilege.

### 8.2 Experimentation

The main reason for experimentation is to generate true knowledge about the effect of one variable (independent) upon another variable (dependent) after controlling the effect of all other variables in the theoretical model which postulate their relationship. Thus a good experiment should have three elements: random arrangements of respondents of experimental groups, control on extraneous variables and manipulation of independent variables. For example, one may say that income is positively related to education.

**Education -> Occupation -> Income**

While this statement is true, one may still notice some variation in their relationship, when occupation as control or extraneous variable is introduced in the model. The original bivariate relationship will change. Note that occupation has many categories.

### 8.3 Common Sense and Intuition

Any proposition showing the relationship of one variable with other based on sense data or individual's intelligent guess, is vulnerable. It may be true or false. Hence, one cannot safely depend on this. Knowledge based on common sense and intuition cannot be called scientific as it is based on guess estimate. Knowledge based on this source is most likely to be untrue and fallible. Hence, such knowledge is by and large unscientific and untenable.

### 8.4 Observation

Observation could be a potential source of knowledge, provided observer himself/ herself objectively look at the phenomenon under inquiry. He or she should not observe things other than the object what he/she is actually looking for. Observation should not suffer from any non-observation or mal-observation. In order to get true knowledge, observer should guard himself/herself against any subjective consideration. In observation, one may use camera to capture the scenario in actual form. Data collected through observation method is qualitative but knowledge available from this source may not be cent percent accurate.

### 8.5 History

History is a source of knowledge. It connects the past with the present to hold lessons for the future. So, we must carefully read events in retrospect and properly record it so that we may get true knowledge about events. One may note that multiple sources should be consulted to get correct information about the event(s) under investigation. Historical data are generally chronological and sometimes, sequential. These may not be available from other sources of knowledge. Sometimes, information available from other sources needs to be firmed up by historical data with an exception of divine knowledge If we want to know the rise and fall of various regimes or hegemony, we need to study history.

### 8.6 Discoveries and Inventions

In discoveries, things already exist somewhere in the universe, human beings only make efforts find them out. Whereas, inventions are people's creations. Both are unique Source of knowledge. Research method needs not has to be strictly adhered to.

## 9.0 CONCLUSION

Discussion so far brings us to the understanding that research works in order to become scientific must follow certain rules and procedures. Compliance with these rules and procedures is normative. For any scientist, this tenet is sine qua non. It is to be noted that any basic research has to be scholarly and scientific and based on verifiable truth. Also, it is important for the researcher to be clear in his understanding of theory, propositions and hypotheses so that he/she knows what he/she is pursuing. In basic research, common sense and intuition have no place except providing some sense data which may help in formulating research hypotheses or research questions. Applied and operations research cannot be called scientific as they may skip some scientific procedures. Often, units and foci of research are not spelled out which is why, it is difficult to appreciate research findings. The purpose of research is to generate knowledge and provide theory. Basic research may generate knowledge only when it is based on experiment by following experimental designs and scientific procedures. Researcher must know other sources as well e.g. divine knowledge, common sense and intuition as well as, (iii) history and scientific discoveries and inventions.

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