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Review

Kuhn and the actual practice of science: Examining the extent to which Kuhn's analysis is scientific

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In the structure of scientific revolutions hereunder referred to as SSR (1962), Kuhn claimed to have captured correctly how science is practiced. However, his critics such as Shapere (1984) argued that Kuhn's account is far from being a true account of how science is practiced. Consequently, this led to a philosophical dispute on whether or not Kuhn's work was a correct interpretation of how science is practiced. In the light of the foregoing debate Kuhn published his The Essential Tension (1977) to defend his position in his earlier book the SSR. In the context of this debate, this article is a philosophical analysis to determine whether or not Kuhn's SSR is a correct empirical description of how science is practiced.

Key words: Practice of science, Kuhn, paradigm, paradigmatic science, science, scientific method.

INTRODUCTION

This article concerns itself with the examination of the nature of the scientific enterprise by explicating how the scientist "operates" in his business. It should be noted that scientists themselves have been interested not merely in cataloguing and describing the world of nature as they find it but in making the working of nature intelligible with the help of compact and organized theories. Correspondingly, philosophers of science are obliged to consider not merely nature in isolation; that is, as a mere assemblage of empirical facts waiting to be discovered. They are also interested in the manner in which the human perceives and interprets those facts when bringing them within the grasp of an intelligible theory and the respects in which the validity of the resulting theoretical ideas (or concepts) are affected by that processing of the empirical data (Encyclopedia of Philosophy, 1973). The problems posed by this interaction of humans and nature have been complex and confused. There is need, therefore, to clarify the way the scientist "operates" in his/her enterprise in order to determine how he/she interprets the empirical data that present themselves to him/her. That is done in the section that immediately follows. Before that is done, distinction is made between two aspects of science implicitly found in the scientific method. From the scientific method one can identify two aspects of science, namely: formal science and empirical science. The former embraces the sciences of mathematics and formal logic. The latter, which is also known as natural science, embraces all the sciences called "physical" and "social" for example, chemistry, physics, economics and sociology among others. Formal science asserts nothing about natural phenomena; it is independent of experience and none of its proofs rests on how facts actually stand. Empirical science, where the term "empirical" means "relating to experience" deals with some aspect of what can be experimentally known; the empirical sciences use observations which are accumulated by the method of induction.

In his analysis of matter, Aristotle gave two accounts of induction which had great influence on subsequent thought. In 'prior analytics', ii, 23, Aristotle talks of induction as a kind of syllogism in which we reach universal conclusion from an exhaustive survey of the cases it covers. In 'posterior analytics' 1 and 18, he talks of induction as the establishment of a universal truth by consideration of an instance or instances which reveal to thought, the necessity of the connection. The two

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accounts of induction have been called summative and intuitive induction, respectively; “none of which is identified with empirical science by which universal propositions are established in empirical sciences” (Encyclopedia Britannica, 1973: 18). From the foregoing discussion, it is noted that science can be classified into: 1) Formal science and; 2) empirical science. This chapter will concern itself with examination of the salient and common ground of the common understanding of what science is: “a collection of empirical and formal statements about nature, the theories and data that at a given moment in time comprises accepted scientific knowledge” (Helge, 1994: 22). This article is divided into two sections. In the subsection that follows immediately, an examination of the scientific practice is shown. The next section concerns itself with relating “practice of the scientific enterprise”; as clarified in the first section to Kuhn’s account of science with the express aim of determining whether or not he has given a correct account of the actual practice of science; it should be noted that Kuhn argues that he has produced a correct account of science as it is practiced currently. During the period he was a ‘junior fellow’ of the Society of Fellows of Harvard University, 1958 to 1959; he “was surprised at...exposure to out of date scientific theory and practice (which) radically undermined some of (his) basic conceptions about the nature of science and the reasons for its special success” (Kuhn, 1962: 5). He adds: “during my last year as a ‘junior fellow’, an invitation to lecture for the Lowell Institute in Boston provided a first chance to try out my still developing notion of science” (Kuhn, 1962: 8).

The actual practice of science

According to D. W. Y. Kwok, in his book, Scientism in Chinese Thought (1965): “The scientist operates on four fundamental principles: Firstly, the need for observation: the empirical principle. Secondly, to achieve exactitude in measurement….he must employ quantitative means: the quantitative principle. Thirdly, he deals with causal relations and often uses abstractions to represent them. For this end, he must locate meaningful recurrences of behavior and then formulate general laws or equations which describe and explain such behavior: the mechanical principle of science. Fourthly, is a general assumption of all scientists which may be called an attitude of mind, a principle inherent in the concept of research: the principle of progress through science…co-operation for non-personal ends, a co-operation in which all scientists of the past, present and the future have a part” (pp: 21 and 22). Each of the four mentioned principles: a) The empirical principle, b) the quantitative principle, c) the mechanical principle and d) the co-operative principle has its own characteristic procedures. They are, therefore dealt within that order.

The empirical principle

Empiricism is the belief that knowledge ultimately rests on firsthand, direct and original experience. In the realm of natural science, it means that attending to exploring, investigating and scrutinizing natural phenomena attains human knowledge about a natural phenomenon. Consequently, the task of a scientist is to explain actual events, processes or phenomena in nature. According to Patrick (1978: 20), “the scientist in his study of any group of phenomena first collects facts: analyses and classifies them”. On one hand, the facts in question may be discovered by using observational methods; that is, by recording them as and when they occur naturally, without employing any special contrivance affecting their occurrences. This situation is, of course, the normal case in astronomy, in which the objects of study cannot be influenced or controlled. For instance, on October 10, 1846, William Lassell observed Neptune. His powerful telescope also enabled him to observe a tiny dot, which circled around Neptune every five days. This, he concluded was Neptune’s moon. His telescope did not influence the activities around Neptune. The facts in question may, on the other hand be discovered by using experimental methods that is, by devising special equipment or apparatus with the help of those processes or phenomena are caused to occur on demand and under specially controlled conditions as is the case in physics and chemistry. For instance, a scientist can experimentally show that hydrogen combines with oxygen at two atoms of hydrogen to one atom of oxygen. This is symbolized as:

$$4H + O_2 \longrightarrow 2H_2O$$

Whichever way the scientist uses to obtain empirical facts, a philosophical difficulty at once arises about the results of the scientist’s empirical studies: for a philosopher of science must ask how such raw empirical facts can be sifted, stated and described in a way that throws light on the scientist’s own theoretical problems. Do all empirical facts serve as raw materials for science? Is a scientist concerned with every particular empirical event or only with general phenomena or regularities recognizable in those events? Going by this principle, the scientist is required to analyze the situation at hand very carefully and collect all the facts bearing on it. He/she must be fair and impartial and unprejudiced in the observation of the facts. Prejudice leads the scientist astray in the reflective thinking of his/her daily life.

The history of knowledge is replete with examples in which custodians of knowledge committed ‘sins’ to knowledge because of prejudice. Here, the well known case between the Church and Copernicus on the shift from geocentricism to heliocentricism can be cited. This freedom from prejudice is an ideal which is very difficult to realize. In the physical sciences, the idea of objectivity has seen realized in a remarkable fashion by a great army of patient, persistent and unprejudiced workers. The rich contributions, which they have made to knowledge, attest to the fruitfulness of the scientific method.

The quantitative principle

If we ask, “Why are some areas of knowledge more precise and definite than others?” we soon discover that ‘measurement’ is science’s principal means of reducing vagueness in favour of clarity and precision. Measurement is a procedure through which the scientist arrives at quantitative estimates of the variables and magnitudes considered in their theories. The Encyclopedia Britannica puts it thus: “By now, there is a well developed body of knowledge upon which scholars are agreed about many of the techniques and precautions to be employed in practice in the measurement of empirical quantities, in the calculation of probable errors or significant deviations, and so on” (p: 384). Historically, the first scientific measurements were of “long-short” distances and of “heavy-light” weights. Once distance was precisely measured, then the three measurement of length, breadth and thickness made it possible to also measure volume – thus to change the vague polarity of “large-small” into precisely measured amounts. Measurement is the criterion, which most sharply differentiates the physical sciences from the social and moral sciences. In areas such as law, theology, psychology, sociology and economics, where precise measurement is lacking, much attention is given to the definition of terms so that all can agree as to their meaning. Here is an example from theology. Among the ancient Israelites, there was a section governing the sacrifice of the “red heifer” as shown in the bible (Numbers 19: 2 to 9). But how is a “red heifer” to be defined? Five rabbinical schools of thought arose and as a result a “red heifer” was defined in the following five ways as shown by Herbert J. Searles in his book Logic and Scientific Methods (1956: 44 to 55):

1) A heifer is red when every hair on its body is red;
2) A heifer is red when it is almost all red;
3) A heifer is red when the majority of its hairs are red;
4) A heifer is red when a considerable number of its hairs are red;
5) A heifer is red when one hair is red.

Although measurement classifies natural sciences as more exact than other sciences, there are still unresolved philosophical disputes. For instance, some philosophers regard any scientific theory concerned with measurable (quantifiable) magnitudes as intrinsically superior to a qualitative one, however rich and well organized the latter may be. This is a popular misconception which is shared by many writers as the following quotation from John (1972: 41) attests: “Science today is quantitative rather than qualitative. It expresses the relationship of the intensities of the electric current and of the illumination of an incandescent lamp and compensates for its inability to answer the question “how” by its wealth of data as to “how much”. Research monograph and textbooks alike emphasize the observable quantitative relationship and rarely venture far into the speculative hinterland where “how” must precede “how much”. As we teach science today in our schools the effort of learning the quantitative relationships too frequently leaves neither the instructor nor the student leisure for fruitful inquiry or speculation as to the mechanism itself”.

The mechanical principle

The aim of science is not only to discover and describe events and phenomena in the world but also and more importantly to explain scientifically these events and phenomena as they occur. Nagel (1961: 4) observes: “Science seeks to discover and to formulate, in the general terms, the conditions under which events of various sorts occur, of such determining conditions being the explanations of corresponding happenings.” From Nagel’s observation, the formal structure of science can be noted. Every natural science has statements which include also formal and mathematical statements. These may be mathematical algorithms or procedures. The formal structure of science has dominated recent debate in the philosophy of science. The debate is explicitly based on presupposition inherited from Rene Descartes and Plato, that the intellectual content of any natural science can be expressed in a formal propositional system having a definite and essential logical structure. The logical structure is what Nagel concisely called “the structure of science”. Nagel has written a book titled: The Structure of Science (1961) in which he explicates the logical structure of science. The same techniques were taken over into the philosophy of mathematics by a pioneer German logician Gottlob Frege, and into symbolic logic by Bertrand Russell and his collaborator Alfred North Whitehead. From 1920 on, the Viennese positivists and their successors, attempted to empty them in the philosophy of science hoping to demonstrate the validity of formal patterns of scientific inference by the straight forward extension of methods already familiar in deductive logic (Wheatley, 1970: 99 to 105). The search for a logical structure in science is based on the expectation that it would be possible to demonstrate the existence of formal structures that were essential to any science and thereby identifying the science’s laws, principles, hypotheses and observations (Cannavo, 1984: 113 to 114).

Underlying the mechanical principle is the basic scientific axiom of experimental science that, circumstances being unchanged, a like cause will produce a like result. The scientist is then, interested in discovering the laws, which govern events in the universe. These laws are referred to as laws of nature. The laws of nature are statements of the mechanical phase of nature. They state the uniformity of correlation and sequence which events manifest. Here are some examples of laws of nature. These examples have been drawn from A. F. Chalmers work (1980: 36).

1) All iron rusts when exposed to air (provided there is moisture also);
2) All metals conduct electricity;
3) All poison kill.

One characteristic of the laws of nature is that they apply to all members of a given class without exception. For instance a scientist to arrive at claim that: “All poison kills”, he must have tested all kinds of poison available at all times and all places. Hence, laws of nature must be spatio-temporal (Encyclopedia of Philosophy, vol. 3 and 4, 1967: 411 to 413). Since laws of nature apply to all places and times, a scientist can use them as a basis for prediction. For example, a scientist can successfully predict given any piece of metal that piece of metal will conduct electricity in future instances. The mechanical principle can then be summed up as the search for laws of nature, which govern uniformities in the universe.

Co-operative principle

In their struggle to overcome prejudice and to gain objectivity, members of the scientific community set forth varied and competing hypotheses – and then await the confirmations or disconfirmations of these hypotheses by others. According to Ehlers (1976: 151), “a scientist is not a prophet. He does not enunciate that a fruit form the housetops and expect others to believe him.” The scientist reports his/her assumptions, experimental procedures and logically derived conclusions as accurately as he/she can. His/her colleagues then check these assumptions and repeat his/her experiments under various and varied conditions. Only then are his/her original conclusions accepted and in most cases, they are accepted only with further revisions and modifications that may have been found necessary. Scientists report their findings in scientific ‘publications’. A scientific publication is more than a mere statement that “so and so” has discovered “such and such” facts. Ehlers states: “Any scientific publication worthy of the name must include a clear and open description of all the relevant details of the methods whereby the data were gathered, or of the thinking and the assumptions on which the deductions are drawn. In this way it is possible for others to repeat the observations or the deductions (Ibid.)”. The reason for transforming private knowledge into public knowledge is that single individuals are more likely to be mistaken than groups of individuals. Although it is generally true that single individuals are more likely to be mistaken than groups of individuals, sometimes the individuals are more likely to be mistaken than groups of individuals, sometimes the individual is right and the group is wrong. At the center of the co-operative principle is the view that science is a social process (Wield, 1984; Ziman, 1995). In the nineteenth century, for instance science expanded successfully into new fields of inquiry. This was greatly aided by the establishment of social centers to cater for scientific development. The Encyclopedia Britannica (Vol. 16: 373) puts it, “this was greatly aided by the establishment of new and reformed universities in which research was fostered, as well as teaching and of communication through specialists, journals and societies”. National and international meetings for both general science and specialists became common by the end of the century. The principle of social organized research, rather than inquiries by isolated individuals became effective. The encyclopedia adds that in the early twentieth century: “Science was professional in its social organization, reductionist in style and positive in spirit….Almost all research was done by highly trained experts, employed wholly or mainly for this work within special institutions. Communities of scientist, organized by discipline and by nationality, enjoyed a high degree of autonomy in the setting of goals and standards of research and in the certification, employment and rewarding of their members” (Wield, 1984; Ziman, 1995).

From the foregoing discussion, it can be summarized that the co-operative principle is that principle which governs the scientist in his/her operations within the larger social set up. So, much for the principles that a practicing scientist follows in the execution of his/her duty. It is now the concern of the next section to examine whether or not Kuhn has given a correct description of the actual practice of science as described further in the study.

KUHN AND THE ACTUAL PRACTICE OF SCIENCE

It relates to the Kuhnian paradigmatic account of science with the actual practice of science with the express aim of determining whether or not Kuhn has given the correct description of science the way it is practiced. This section first states Kuhn’s claim and then proceeds to point out whether or not Kuhn’s account of science reflects the actual practice of science. Consider this quotation (Kuhn, 1962: 176 to 178): “If this book were being rewritten, it would therefore open with a discussion of the community structure of science, a topic that has recently become a significant subject of sociological research and that historians of science are also beginning to take seriously. ….Most practicing scientists respond at once to questions about their community affiliations, taking for granted that responsibility for the various current specialties is distributed among groups of at least roughly determinate membership…. A scientific community consists, in this view, of the practitioners of a scientific specialty. To an extent unparalleled in most other fields, they have undergone similar education and professional initiations; in the process they have absorbed the same technical literature and drawn many of the same lessons from it. Usually the boundaries of that standard literature mark the limits of a scientific subject matter, and each community ordinarily has a subject matter of its own. Communities of this sort are the units that this book has presented as the producers and validators of scientific knowledge. Paradigms are something shared by the members of such groups. Without reference to the nature of these shared elements, many aspects of science described in the preceding pages can scarcely be understood".

There are two distinct steps we need to take in order to clarify a passage like this. First we must identify what point the writer is trying to establish; that is, one must identify the writer's conclusion. Secondly, we must unveil the argument by which he/she attempts to establish his/her conclusion. As Jon (1970: 89) puts it, "it is frequently the case in philosophy that we cannot fully understand some thesis until we understand the argument which leads up to it". Attention now is drawn on how one can go through the two steps in understanding the aforementioned Kuhnian passage. Kuhn gives his conclusion in the first sentence of the last paragraph of the quoted passage: "Communities of this sort are the units that this book has presented as the producers and validators of scientific knowledge." In other words, the practice of science is determined by the activities of the scientific community. Having got hold of Kuhn's conclusion, attention is now turned to untangling the argument by which he tries to establish it. To do this, what might be called a "first reading" of the Kuhnian passage is given. Then the same argument is reconstructed. Kuhn is of the opinion that the role played by scientific community in any practice of science is immense. That is why he opens his passage with this sentence: "If this book were being rewritten, it would therefore open with a discussion of the community structure of science...." A scientific community is determined by the paradigm its members share. In case of questions concerning their conception of science, "most practicing scientists respond at once to questions about their community affiliations, taking for granted that responsibility for the various current specialties is distributed among groups of at least roughly determinate membership". The concerned community consists of the practitioners of a scientific specialty. "As a result, the members of a scientific community see themselves and are seen by others as the men uniquely responsible for the pursuit of a set of shared goals, including the training of their successors". Since these communities share the same goals, judgment in scientific matters are "unanimous". He concludes by saying, "without reference to the nature of these shared elements, many aspects of science described in the preceding pages can scarcely be understood". From the foregoing "first reading" of Kuhn's argument, one gathers that Kuhn's account of science lays emphasis on the scientific community: "a community which shares same goals; that is paradigms" (Kuhn, 1962: 178).

A reconstruction of the same argument is now desirable and the schematizations of Kuhn's argument are as follows:

1) Scientific change is determined by "paradigm shifts"'
2) Scientific communities are determined by the paradigms they uphold;
3) Therefore, scientific change is not universal.

It is now shown how each premise is related or leads to the conclusion. Each premise will be taken singly. In the first premise, Kuhn reasons that in normal science, scientists "know what the world is like". But when scientists start questioning this "normal science" that becomes the start of a scientific change; that is, scientists start looking at nature from a different paradigm. The second premise is related to the first premise in this way. According to Kuhn, scientists work within a community committed to a shared framework of theory; and "the members of a scientific community see themselves and are seen by others as the men uniquely responsible for the pursuit of a set of shared goals including the training of their successors" (Kuhn, 1962: 77). The foregoing explains why we have the community of "physicists, chemists, astronomers, zoologists and the like" (Kuhn, 1962). From the two premises, Kuhn inferred the conclusion. If scientific change is determined by "paradigm shifts" and since "scientific communities" are determined by paradigmatic adherence then in cases of competing paradigms, scientific change will not be universal, since each competing paradigm will have its disciples. This argument is a case of a strong inductive argument. It is improbable that the conclusion is false and the premises are true. The evidential link between the premises and the conclusion is strong. It is now the concern of the following part to examine whether Kuhn's account captures the actual practice of science. In the previous study, it was stated that the scientist operates on four fundamental principles; namely: 1) The empirical principle; 2) the quantitative principle; 3) the mechanical principle and 4) the co-operative principle. Consequently, any account of science, which does not follow these principles, does not reflect the actual practice of science. The four principles are implicitly entailed in the scientific method, which is rule governed. The fourth principle is also sociological in nature, since it deals with the societal organization of science. Kuhn's account of science centers on the co-operative principle since he lays great emphasis on scientific communities. Therefore, although Kuhn's account of science does not satisfy the strict criteria of science according to the scientific method, it meets some broader criteria for 'scientific accounts' latent in the sociological practice of science (Helge, 1994: 23). That Kuhn's account of science meets some broader criteria for scientific accounts latent in the sociological practice of science is a sharp move from the traditional view of the sociology of science associated with the work of Robert Merton which makes a sharp distinction between science as a cognitive system and science as a social system and thus opening up the possibility of sociological studies of the development and evaluation of specific ideas. This means that, to the extent that Kuhn's account of science meets the "co-operative principle" of science as argued in this article, to the same extent, Kuhn's account of science reflects the actual practice of science.

The same argument can be presented in the following schemata:

1) Scientific practice is governed by the scientific method;
2) The scientific method required the practicing scientist to follow the following four principles:

i) The empirical principle,
ii) The quantitative principle,
iii) The mechanical principle,
iv) The co-operative principle.

1) Kuhn's account follows only the co-operative principle; since Kuhn emphasizes the role of the 'scientific community' in his notion of science;
2) The analysis of scientific community reveals that it is sociological in its nature;
3) Therefore, to the extent that Kuhn's account of science is sociological in nature, then to the same extent, Kuhn's account of science captures the actual practice of science.

CONCLUSION

The aim of this article has been to determine whether or not Kuhn's paradigmatic account of science captures the social practice of science. The Kuhnian paradigmatic account of science falters as a model account of how science is actually practiced because of the endemic epistemological presupposition of the "quest for certainty" latent in the Platonism which the idea of paradigm presupposes, that is, the idea that paradigms are moving to higher and perfect forms. The central doctrine in Platonism is the idea of 'forms'. Plato's forms are sometimes referred to as 'ideas' but Plato does not mean 'ideas' in a person's mind rather ideal forms or perfect examples – the perfect circle or perfect beauty. To avoid confusion, the word "forms" and not "ideas" is used. Plato's position regarding the forms can be briefly restated thus: knowledge consists in the apprehension of those qualities of the world, which never change, never alter. He believed that the world contained such constituent elements – the forms. He suggested that our ordinary concepts (for example, wisdom, justice, beauty and goodness) include the use of general terms and that in order for our ordinary statements to be meaningful, one must know what these general terms signify. To do this, Plato insisted one must do more than merely point to various particular things. Those things would only be, at best, examples of things that fall into general classifications but would not themselves be classifications. In short, Plato is saying that we have corresponding images to every concept. But it should be realized that we have some concepts without any corresponding images; for example, "God, liberty, or even slavery". These are abstract concepts to which there are no corresponding images although we distinguish cases of the application of these words from cases of their non application. The same is with the "Kuhnian paradigm". In other words, Kuhn's account of paradigms presupposes the "quest for certainty", that is, the search for an ideal paradigm to which all paradigms should correspond. This may not be attainable (Dewey, 1968: 765). In The Structure of Scientific Revolutions (1962), Kuhn stipulates how science progresses from what he calls "normal science" to "scientific revolution" and then back to normal science. Kuhn's argument is that a prevailing paradigm may sometimes fail to solve problems that may face a scientific community. Kuhn argues that repeated failure of the paradigm to solve a problem or other anomalies lead scientists to search for paradigm which can account for the anomalies. The new paradigm accounts for the earlier paradigm and the anomalies that faced the earlier paradigm. The assumption here is that the new paradigm is more perfect than the earlier one.

The presupposition underlying the choice of one paradigm and not the other is that the "chosen paradigm" is more "certain" to solve the problems or anomalies that led to the abandonment of the earlier paradigm. In other words, the new paradigm is more ideal than its predecessor(s). This Platonism is a metaphysical position, which cannot be defended in science and its philosophy, hence the failure of the said search for certainty latent in Kuhn's paradigmatic account of science. Despite the fact that Kuhn's paradigmatic account of science falters due to the Platonism, which the idea of paradigm entails, Kuhnian science explicitly presents the role played by the scientific community in the activities labeled under “science”. This leads to the inevitable conclusion that in order to understand explanations in philosophy, it is inadequate to simply label them, for example, as “scientific” “scientifically progressive” or “scientifically rational”. An examination must first be carried out thoroughly to find out not only what science is but also what science does. Such an examination should not ignore the practice currently existing, under the label. The history of science is witness as to how science is practiced and how it progresses. While we must acknowledge the positive contribution to the philosophy of science on the part of Kuhnian science, the functional completeness and comprehensiveness of scientific inquiry expressed in the scientific method cannot be over estimated.

REFERENCES

Cannavo S (1984). Nomic Inference: An Introduction to Logic of Scientific Inquiry. The Hague: Martinus Nijhooff.
Chalmers AF (1980). What is this thing called science? London: The Open University Press.
Dewey J (1968). “The control of Ideas by Facts” in The Process of Philosophy, Epstein, (1967), New York: Random House.
Ehlers HJ (1976). Logic: Modern and Traditional, Columbus: Merill Press Encyclopedia Britannica (1973) “Sci.” 16: pp. 6-18 and “Sci. Method” pp. 18-22, London: Encyclopedia Britannica, Inc.
Edwards P (ed) (1967). Encyclopedia of Philosophy, London: Macmillan Publishing Company, 5 & 6: 411-413.
Helge K (1994). Science in the era of Mrs. Thatcher. London: Macmillan
Kuhn T (1962). The Structure of Scientific Revolutions. New York: Freeman Press.
Kwok DW (1965). Scientism in Chinese Thought. New Haven: Yale University Press.
John M (1972). Philosophy of Scientific Method. New York: Hafner
Nagel E (1961). The Structure of Science: Problems in the Logic of Scientific Explanations. Harcourt: Brace & World Inc
Patrick G (1978). Introduction to Philosophy. New Delhi: Surject Publications.
Searles HJ (1956). Logic and Scientific Methods. London: Macmillan
Shapere D (1984). “The Structure of Scientific Revolutions” Phil. Rev., pp. 8-9.
Wheatley J (1970). Prologomena to Philosophy. New York: Prentice-Hall.
Wield D (1984). The Politics of Technology In notion. Milton Keynes: Open University Press.
Ziman J (1995). An Introduction to Science Studies. Oxford: Clarendon Press.