Journal of Research in Philosophy and History
Vol. 4, No. 2, 2021
www.scholink.org/ojs/index.php/jrph
ISSN 2576-2451 (Print) ISSN 2576-2435 (Online)

Original Paper

Paradigms and Four Levels of Scientific Controversies

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Received: March 23, 2021 Accepted: April 15, 2021 Online Published: May 23, 2021
doi:10.22158/jrph.v4n2p21 URL: http://dx.doi.org/10.22158/jrph.v4n2p21

Abstract

A paradigm transition or change is essential in the development of science. During the transition, there are intense debates and controversies among scientists. In this paper, we attempt to analyze controversies in four levels and also three types of researchers.

1. Introduction: Paradigms

A paradigm was defined by T. S. Kuhn. In essence, he mentioned that in the history of science, there are periods during which there is a high degree of agreement, both on theoretical assumptions and on the problems to be solved within the framework provided by those assumptions. The resulting coherent tradition of scientific research is called a paradigm. Thus, an epoch-making progress in a field of science is made by a paradigm change.

We can learn how a scientific field progresses by studying the circumstances of paradigm changes, because the progress of each field of science has been a series of paradigm changes. This may correspond to a changing of a textbook, changing from an old one to a newly published book, which describes an entirely different theory.

By learning the history of science, we can learn that first of all, we are presently working in a particular paradigm, and also where we stand in the history of the progresses in our own field.

During a paradigm change, there are a period of intense debates and controversies. It is worthwhile to analyze such controversies in a general term.

In this paper, an attempt is made to classify controversies into four levels. History can be learned in terms of controversies and the resulting paradigm changes, rather than just who did, what and when.

It is hoped that this paper may be used as a guide of learning that there are four levels of controversies and that there are three types of researchers in this respect.

2. Controversies

Level one: Minor Model Modifications

In a paradigm, a particular theory establishes a model, that is supposed to represent a "real" phenomenon. We try to improve it. The model may be like the famous Mona Lisa's portrait. We discuss whether her eyes should be bigger or smaller, she should have a dimple, etc. In terms of mathematical equations, the improving corresponds to adding or subtracting a term in a set of equations. In terms of observations, it is to improve the accuracy as an example.

We are almost always involved in this level of controversies. We do not even realize that we belong to a particular paradigm. Kuhn mentioned that those engaged in a paradigm is mopping it up.

It is most important to realize that we are not aware of the fact that we are mopping up a paradigm. A paradigm is far from "truth".

Level 2: Both Ends of a Pencil

This case is when two major paradigms confront one another. This level of controversies is like arguing that a pencil *is* a sharp-and-hard object or it is a round-and-soft one. Both sides of scientists cannot recognize the pencil as whole. Since natural phenomena are like a multi-dimensional object, each scientist (or a group) can often see only one dimension by his own instrument.

Since both scientists are so involved his own theory or observation, they cannot solve the problem. It is often the case that an uninvolved scientist or a new generation of scientists recognizes that the object is actually a pencil. One of the classic examples in cosmology was the earth-centered universe or the sun-centered universe.

A little more advanced case of this level may be analogous to a dog-cat argument. Both cats and dogs have four legs, two ears and one nose; both are hairy. Two groups of scientists argue the animal is a cat or a dog, based on their accurate measurements. It is often the case that one scientist, who does not belong to either group, might invent an audio-instrument and use to determine if the animal is a cat or a dog.

Level 3: Breaking Paradigm or "Breakthrough"

In a paradigm, all theoretical examinations and all observations seem to confirm it. However, it is often the case that a more extensive examination of related data set suggests that there are contradictory observations. It is also often the case that these contradictory observations are disregarded, so that they are dismissed and forgotten.

An example can be found in a study of sunspots. The established paradigm since as far as back as 1961 is that a thin magnetic flux tube under the phostospheric surface emerges, breaking through at two points. These can be identified as *a pair of spots*. So far, all theoretical studies and observations seem to confirm this theory, although the presence of the magnetic flux tube under the photosphere has not even been confirmed. The magnetic flux tube is a good assumption, but is simply an *assumption, not the fact.* However, there exist *single* spots, often called isolated, independent or unipolar spots. They are shown in many standard textbooks of the sun, but are disregarded. However, they have been disregarded as a "broken pipe".

Level 4: A Discovery

Perhaps, the best example of a discovery is when M. Curie started to work on a mysterious phenomenon, in which a stone produced an image on a glass photo-plate. She discovered radium. Many speculated and argued about the cause of the image.

Discoveries are often made by a single person or a single group.

The history of science is full of such cases. However, it is often the case that stories of a discovery are distorted by an "instant flash" of new idea or is said to be serendipity. In most cases, it is the product of a single scientist, who agonizes the problem over many years.

3. Three Types of Researchers

Based on the above discussions, it may be worthwhile to mention three types of researchers.

a. Researchers who do not recognize that they are working on a particular paradigm. If they find a contradictory observation to his paradigm, they put it "under the rug". Thus, they remain in the first level of controversies. Most of us belong to this group.

b. Researchers who can recognize contradictory observations, but who try to find the solution within their own paradigm. They participate in the second and third level of debates. Many of us belong to this group.

c. Researchers who recognize contradictory observations and doubt their own paradigm. A few scientists belong to the fourth level of controversies. They are the ones who make paradigm transitions.

4. Concluding Remarks: Research Processes

Based on the above discussions, I suggest the order of steps to be taken in processes in *natural sciences.*

1) In natural science, the research begins with observations, examining existing observations or finding new phenomena.
2) Then, by assembling all related observed data sets, one has to conceive several possible chains of processes.
3) I believe that this is the most important process in research. This is the stage, when a paradigm is born.
4) A mathematical formulation or computer simulation comes next as a method to confirm the established paradigm.

I believe that many researchers confuse this order of research processes. In working on a particular paradigm, people skip the first step and go straight into the third step; this occurs often when a senior researcher suggests a problem for a young researcher without telling him the history of his field. Thus, they are not well informed of observations in simulating a phenomenon under study by computers. This is one of the reasons a paradigm can last for a long time.

It is also unfortunate that young scientists tend to rely on computers so much, they spend much time in programing, forgetting the original purpose of his/her own scientific purpose.

In natural science at least, insufficient observations and insufficient conceiving process are the main reason for a long life of a paradigm and controversies mentioned in the above. I believe that it is essential to assemble as many observations as possible (including seemingly contradictory ones) and to try to conceive the most reasonable chain of processes.