Journal of Research in Philosophy and History
Vol. 2, No. 1, 2019
www.scholink.org/ojs/index.php/jrph
ISSN 2576-2451 (Print) ISSN 2576-2435 (Online)

Short Paper

Syntheses, Creativity and Paradigm Change

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Received: January 15, 2019 Accepted: February 1, 2019 Online Published: February 20, 2019

doi:10.22158/jrph.v2n1p1 URL: http://dx.doi.org/10.22158/jrph.v2n1p1

Abstract

In this short paper, I emphasized that creativity in research is best demonstrated by a synthesis effort of observed facts, which could bring a paradigm change and produce a step-wise progress (“breakthrough”) in science.

Keywords

innovation, creativity, paradigm

1. Characteristics of Natural Science

Each phenomenon in nature is associated with many factors. Thus, the first important procedure in natural science is to determine and sort out, if possible, all the observed factors related to causes and effects of a particular phenomenon.

Taking global warming as an example, there are many contributing factors, such as solar effects, the amount of CO_2 released and its rate, absorbed by oceans, arctic sea ice conditions, deforestation, etc. Eruption of volcanos is another example; there are so many factors involved in a volcano to erupt.

These factors are variables and numerically parameterized for computation under a set of differential equations for quantitative and theoretical examination. Thus, they have to be quantified first for this purpose.

Natural science is different from the basic sciences, physics, chemistry and biology, although natural science is based on them. In a laboratory of physics, chemistry and biology, it is generally possible to treat most of the variables, making them constant or controlling, except two, say A and B in a simplest case. We can examine how B changes or depends on A by changing A controllably. In this way, we can quantitatively parameterize all the variables.

When we deal with a natural phenomenon, even if we knew all the factors, we cannot control most of them. Thus, although we want to quantify all the variables, there is considerable uncertainty in this process. The solution of the equations depends critically on each of a very large number of these variables and parameters.

The accuracy of the solution can be tested by the accuracy of prediction. If the prediction is unsatisfactory, it is difficult to determine which variable(s) and parameter(s) was inaccurate.

Nevertheless, natural science has made great progress in each field, such as solar physics, geomagnetism, meteorology, seismology, volcanology by overcoming these difficulties.

2. Synthesis

Suppose that one natural phenomenon depends factors, A, B, C, (D), (L),…..α, π, X, Y, Z, where (D) and (L) are unknown or not found (discovered) yet, α and π are mistakenly identified as the facts of a particular natural phenomenon. These factors are based on observations.

The first step after the observation is to synthesize these factors by choosing factors, which each scientist considers essential under his own idea, say A, J, M, S, T, X, and then consider a chain of processes, say (S X A M J) on the basis of physics, chemistry and biology. This process may be criticized as an act of "cherry-picking". Other scientists may consider other sets, for example the same set, but with different orders (ideas), say (M J A T S X) or (J M A X T S). In the latter case, the cause and effect are reversed. Some other scientists may choose entirely different sets, say (P O α F K), so that there will be many different syntheses.

This is a creative process, because creativity in science can be defined as an act of combining two or more *existing* factors in a logical sequence. In fact, when one can logically combine two factors, which have been thought to be utterly unrelated, such an act could be said to be "noble", highest act of creation. This definition is also applicable in business. As a concrete example, instead of making serious efforts of reducing polluting emissions from a car, a hybrid car is produced by combining two already existing parts, an engine and electric motor.

In the above process, it is reminded that there are (D) or π in choosing a set; in some cases, the factor F appears to be contradictory to K. Thus, these choices are enough to cause controversies. Fortunately, natural phenomena tend to repeat. One way to choose important factors is, as a first attempt, to find those factors that tend to appear repeatedly.

The test of these syntheses is a quantitative theoretical process by using the equations. However, there will be many sequences, which could survive the test. This is one of the reasons why controversies are so common in science, and are essential for the progress of natural science. This is the case in any scientific field, but perhaps more so in natural science, because of many unknown and uncontrollable factors.

3. Three Basic Steps

In this creative process, there are three basic steps to take:

Observe Synthesize Theorize

There have been a few scientists who could work on the three steps together. However, most scientists specialize as observers or theorists, namely the specialization. In many cases, the synthesis is based on observed facts by observers or theoretical consideration by theorists. In some cases, the synthesis is based on observed facts by theorists and theoretical consideration by observes. The author considers that the first two steps are basic and that theorizing (the third step) is simply a method to confirm the synthesis.

It is unfortunate that many observers confine themselves in observing. Although accurate observations are essential, a synthesis effort might provide an opportunity to find a new observation (L). If a theorist pays a more attention on synthesizing, rather than only manipulating equations or improving simulation methods, he may be able to suggest observers that there may be a missing factor (D). This is also a creative act.

Based on the above discussion, one can say that creativity is considered to be the most important element in research activity. Further, creativity is based on this synthesis process, in which scientists can demonstrate their creativity. The quality of a PhD thesis is judged on the basis of creativity which the candidate can demonstrate, even if he/she follows the professor's paradigm.

4. Paradigm

Among many sets of the sequence, there will be eventually one or two that survive under serious tests or become popular for various reasons, not necessarily for correct reasons. If such a set, called a model, becomes very popular, there is a tendency for a large number of scientists to swarm around it and attempt to improve it.

It is important to remind the readers that a scientific philosopher T. S. Kuhn (1962) pointed out that in the history of science, there are periods during which there is a high degree of agreement, both theoretical assumptions and on the problems to be solved within the frame work provided by those assumptions. The resulting coherent tradition of scientific research is called a paradigm. Scientists whose research is based on a shared paradigm are committed to the same rules for scientific practice.

The situation of paradigms is said to be somewhat analogous to a particular jigsaw puzzle solving, in which a group of scientists are solving the same jigsaw puzzle under the same set of rules, namely trying to fit the right locations of pieces.

Once a popular model is established as a paradigm and survive for three or four generations, it will be considered as truth. Thus, there occurs inevitably many problems. Scientists who share a particular paradigm become very conservative and try to protect it or reject others without much consideration. For example, even when a particular paradigm is confronted by serious observed facts, such as a newly found (D), scientists in a paradigm do not, in general, respond to or disregard them; they think that such an anomaly could be eventually solved when the paradigm progresses or refined.

They firmly believe that they are along the right track, so that their task is to improve their paradigm by fixing anomaly. This situation is described in detail by Kuhn (1962). Thus, a younger generation improves the accomplishments of his/her professors

5. Paradigm Change

When they are working on a particular puzzle (the set, A, J, M, S,T, X), some of them may find that if they choose a new set (G, I, J, M, X, P, Q) fits better to another puzzle than the one they are working on; in this case, factors G, I, P, Q were considered to be anomalies in the old paradigm. This is a paradigm change.

A new paradigm emerges for various reasons, but the most cases occur when a new synthesis can (or appears to) explain a particular phenomenon better than the previous paradigm does. Nevertheless, a typical reaction to a new paradigm by the old paradigm is to condemn the new one as nonsense, primitive, because a well-developed paradigm can defend the old one with a well-developed theoretical consideration (right or wrong).

One of the best examples in such a situation is expressed by Sir W. L. Bragg (1982), British physicist, on the occasion of emergence of a new paradigm, the continental drift theory by A. Wegener, the present Plate Tectonics:

The local geologists were furious. Words cannot describe their utter scorn of anything so ridiculous as this theory which is now proved so abundantly to be right.

This particular paradigm change is great enough to be called "scientific revolution" in earth science, but paradigm changes in smaller scales are happening in each field of science from time to time. Such a case is called a breakthrough.

A paradigm change can cause a major change in the direction of research and methodology. Science progresses gradually during the period of paradigm. However, a step-wise progress occurs at the time of paradigm change. Excitements at the time of major paradigm changes are described by Koestler (1964).

Examples of paradigm changes in solar-terrestrial physics (including space physics, geomagnetism, magnetospheric physics and auroral physics) are described by Akasofu (2015).

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