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The Scientific Method and the Growth of Scientific Knowledge

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Abstract:
One of the products of the scientific revolution is the general procedure for conducting scientific enquiry called the scientific method. The scientific method came to replace Aristotle's (384 – 322 BC) methods which was considered by some philosophers as non-systematic, non-verifiable and non-justifiable and therefore could not produce verifiable and justifiable knowledge. It was these characteristics of the Aristotle's purely deductive method that led philosophers to advocate and propagate a new way of forming knowledge. One of such philosophers who made significant impact on the formulation of the scientific method was Francis Bacon (1561 - 1626). Bacon proposed that theories should be drawn from several observations which are free from the observers' prejudices. Bacon's proposal was contested later by David Hume (1711-1776) and Karl Popper (1902 - 1994). Hume and Popper did not just contest Bacon's method, they offered suggestions that shaped the scientific method into a resilient method. For example, they proposed that scientific enquiry should not begin with observations, it should rather begin with what we now call hypothesis or research question. The contribution of Bacon, Hume and Popper to the emergence of the scientific method and the growth of scientific knowledge are enormous.

1. Introduction

Science and its products have tremendous impact on our lives and how we influence our immediate environment and the world at large. The importance of science goes far beyond how the product of science and technology influence us. Science, as compared to other areas of study or institutions, enjoys an unparalleled prestige in society (Delfino, 2014). This is why nations are making every effort to provide funding for science and technology projects and research, and provide incentives and scholarships to those who have chosen to study science. No wonder people trust what the scientist says than what a farmer, journalist, politician or businessman will say, even though the scientists may be not be saying so much. People often ask whether what is being said is scientifically proven. Science is seen by many as a highly rational and non-subjective inquiry, and scientists are seen as people who are able to collect, infer from evidence, and depend on evidence to derive 'scientifically proven' conclusion. The scientifically proven conclusions are devoid of prejudice and are not the product of ideology. Somehow these characteristics are paramount in the philosophy of science.

According to Makumba (2005), philosophy of science may be looked at in three ways. First, as the formulation of worldviews that are consistent with important scientific theories as "an exposition of the presuppositions and predispositions of scientists" (p. 74) and thirdly as a discipline in which concepts and theories in the field of the sciences are critically analyzed and clarified. Philosophy of science may either be epistemology or metaphysics. Whichever way we look at the philosophy of science the general aim is to describe and understand how science works within all of its branches.

We may have philosophical interest in Science because of the influence of science on us, but besides this, science answers some philosophical questions and is therefore important to philosophy. One of such questions has to do with the ways by which we can gain knowledge as opposed to beliefs and opinions (Mingers, 2008) and the general answer to such a question is that the scientific method must be followed. Whatever a government may believe, be it right or wrong, about the effects of filth on beaches, it will not act till science provides evidence in support of such belief. The views of scientist are accorded respect due to the fact that conclusions drawn by scientists are reached through proper and standard methods of collecting and analyzing evidence, and hence the conclusions of scientists are justified. Even in some cases, the conclusions are tested with the intention of making them false. Since Francis Bacon proposed the 'scientific method', it has been subjected to criticism, like that of Hume and Popper. It has seen modifications and alternatives, like the falsificationism doctrine Karl Popper preached. This essay discusses the philosophy of science by looking at two major areas; the scientific method and the growth of scientific knowledge.

2. The Scientific Method

The 'method' which later became known as the scientific method emerged in the sixteenth and by the end the seventeenth century it had gained popularity. This is the period within which the science we know today emerged. It was in this era that certain theories which had been widely accepted and theories that had become known and acceptable to the general public were somewhat discredited and abandoned. While abandoning and discrediting others, fresh theoretical developments in areas such as physics and astronomy were established. Three outstanding developments during this period were Galileo Galilei's (1564–1642) telescope and his work which said that the earth revolves around the sun and vice versa, the publication of Isaac Newton's (1642–1727) work, and the development of the microscope. This period where there was intellectual advancement in the area of science is known as the scientific revolution. The most significant development that the scientific revolution brought was the breakaway from the Aristotelean theories. Prior to the scientific revolution, humanity had religiously held on to the ideas of Aristotle (384–322 BC). New ideas, we can now call theories were proposed. However, the event leading to the proposal of these new theories were somewhat not systematic and justifiable. Some natural philosopher therefore begun to search for an alternative method which would produce justifiable knowledge. The basic idea was that if the knowledge is justifiable then those proposing it must think of following a specific procedure while generating that knowledge. The debate which went on in scientific revolution era, initiated the formulation of the scientific method.

The contribution of philosophers and scientists who could describe, advocate and propagate this new way of forming knowledge being sought was necessary for the emergence of modern science. To succeed, the new way of forming knowledge ought to be attractive to everyone, especially those indoctrinated by Aristotelian thinking. The most outstanding advocate and propagandists, who, according to Yager and Lui (2008), proposed a method to replace Aristotle's method was Francis Bacon (1561–1626). Bacon was able to set out a method in great detail. Francis Bacon saw that if his method was employed by several people collectively working, it would lead to the production of knowledge about nature, as a social process. Let us now take a look at Bacon's Method.

2.1. Bacon's Method

The method Francis Bacon's proposed came to replace Aristotelian logic in textbooks. The Aristotelian logic by its characteristics is *Teleology*. The Aristotelian logic principally employed deductive logic. In deductive reasoning, the conclusions are drawn based on some premises – axioms. If there are true premises from which the conclusion is to be drawn, the conclusion cannot be false, simply because the premises are not false. It does means that the conclusions of deductive logic do not say more than is implied in the premises. This is a major setback of deductive logic. From this argument, we can say that we cannot expand our knowledge by employing deductive logic. The reason is this, the conclusion tells us something we already know. Take for example, the argument that all mammals feed through holozoic nutrition, Human beings feed by holozoic nutrition, and therefore human beings are mammals. In the Aristotelian logic, the conception of knowledge limits what is knowable to that which is necessary and cannot in anyway be otherwise. The deductive logic used by Aristotle demanded the use of intuition that permits someone to directly recognize the cause of something. The aim of scientific inquiry based on Aristotelian method was to determine the final cause of something. The Aristotelian science was viewed, during the scientific revolution, as one which avoided the use of the senses in the process of acquiring knowledge about how natural things work. From Bacon's perspective, science is, and must be seen to be associated with data collection and experimentation (Applebaum, 2005). Thus, to the modern mind, science belongs to an area of epistemology called empiricism**.**

According to the empiricists we can only obtain knowledge by using our senses to study about things in nature and not through the application of pure reason or thought. The empiricists say that making observations and collecting data is the method through which justifiable knowledge is obtained. To the empiricist, the observations and data gathered serve as evidence of knowledge. The empiricist approach is generally described as induction. Bacon's replacement of Aristotelian deductive logic was 'inductive logic'. We need not think that Bacon's method and for that matter, the scientific method does not have disadvantages. For example, when we think of scientists today, we think of them as people who must be skeptical and also be prepared to breakaway with long-standing 'wisdom' and jump into conclusion, at the initial stages of their investigation. Things obviously can interfere with the scientists' observation to cause them to observe things in a somewhat skewed manner. A typical example is the scientists' knowledge. If the scientists' knowledge is weak he/she would fail to discover many things, because if you do not know something you will hardly recognize it. Bacon saw such interferences as possible treats to the empiricists' inductive logic.

Bacon called the things that could potentially interfere with our inductive reasoning as the 'Idols of the Mind'. The idols, according to Corneanu and Vermeir (2012), may be images or ideas that are derived from the images of things. The description of images can be in two senses; neutral and evaluative. Either of the two can lead to the corruption of the images. The corruption being described here occurs as a result of "the disturbed functioning of the various faculties or operations of the mind" (p. 186). Bacon identified four idols of the mind. The idols are; the idols of the tribe, the idols of the cave, the idols of the marketplace and the idols of the theatre. The 'Idols of the Tribe', refers to the tendency for humans to see more order and regularity in nature than there actually is in reality. According to Hall (n. d), there are some inherent deceptive beliefs in the mind of man. These deceptive beliefs belong to the entire human race. The deceptive beliefs are abstractions in error which arises from man's propensity to exaggerate, distort and disproportionate information. The individual's weaknesses, our reasoning which is due to a person's likes and dislikes and also due to a person's personalities, he called the 'Idols of the Cave'.

Idols of the Cave thus pertains to the mind of the individual. Bacon described the mind as a cavern in which the Individual's mind roam. In the darkness of this cave are modified habits, education, temperaments, environments and accidents. If an individual decides to dedicate his/her mind to a particular area of learning, that individual is possessed by his/her own interest and so interprets all other things in relation to his/her area of devotion. For example, to the artists everything in the world is art and to the chemist there is chemistry in everything he/she sees (Hall, n.d). The 'Idols of the Marketplace' he described as the confusion that emerges from the language we use and various inappropriate terminologies which condition our reasoning. They could be philosophical systems that have some mistaken methods used in the acquisition of knowledge, like Aristotle's. Bacon called the inference of this sort 'idols of the Theatre'. From Hall's (n.d) perspective, the idols of the Theatre are "due to sophistry and false learning" (n. p). The idols of the theatre are common in fields of study such as science, religion and philosophy, where concepts are accepted by the masses without questioning.

Bacon's method begins with making several observations. These observations Bacon says should be free from the negative influence of the four idols. The reason for doing this is to enable the scientist reach the truth by collecting several data on the issue under investigation and then carefully analyze them in order obtain a general conclusion. According Bacon, this process known as the composition of natural and experimental history. We need not underestimate the value of experiments. When we observe occurrences in our immediate environment we are generally limited in the amount of data we can collect. Again, when experiments are performed we have the ability to control the conditions of observation and then alter the conditions of the experiment to see what will happen in conditions that would not ordinarily occur. The experiments actually allow us to ask ourselves what will occur if ...? One characteristic of experiments is that it must be repeatable as far as possible. This will enable others to check on the results published if they so wish. In order to minimize the effect of the observer's prejudice, the results of the experiments must be recorded with standard instruments and reported according to standard scales and definitions.

After gathering data from naturally occurring instances of the phenomenon for which the data are being collected, and the data produced by the manipulation of conditions through the experimental design is put in tables of various kinds. The final stage of the method Bacon proposed is the induction stage. At this stage, all information presented in tables are carefully analyzed and things that are common, absent, decrease or increase in proportion of the phenomenon are found. Those that satisfy the condition are identified not by guessing, but by elimination. It is worth noting that induction as used by Bacon is the type of reasoning where generalizations made from a large collection of instances or examples are used to draw general conclusion.

Bacon's method generally proceeded from the known to the unknown. First, large observations are made. The observations must be devoid of the negative elements of the first three idols. Experiments are conducted on the observations and where possible conditions are controlled and the outcomes are recorded using standard instruments and scales. The data gathered are then put into tables and the data in the tables are analyzed to find out common, absent or trends. The data that satisfy the conditions are identified through elimination. Generalizations are made and then conclusions are drawn. This inductive approach used by Francis Bacon was rejected by some philosophers, such as David Hume.

2.2. Hume and Induction

David Hume (1711–1776) one of the people who had profound influence on philosophy of science, appears to be the one those who first raised some legitimate concerns with induction as prescribed by Bacon (Prevos, 2005). To begin with, Hume categorized propositions into those which concern ideas and those that are facts. Propositions such as the sum of interior triangle is 180^{o}, airplanes fly and fish swims in water belongs to the propositions that concern ideas. They are connected to the ideas or concepts we have about things. The prepositions that concern matters of fact go beyond our conceptions and provides us with information regarding how our world is and works. If we say, for example that, water turns solid at 0^{o} and the metal mercury is liquid at room temperature, we are talking about something which is a matter of fact. The two examples used here are all true, however, there could be false ideas and facts. Since a whale lives in water it is a fish and Plato died in 399BC are examples of false idea and fact respectively. Hume's main concern was that a true proposition that concern relation of ideas is provable through deduction since a contradictory proposition will be generated when the proposition is negated. To Hume, knowledge that relates to facts are derived only through the use of the senses since the ideas that make up that knowledge are not logically related and for that matter, the propositions cannot be proven deductively. Take for example, the proposition that Volta is the largest man-made lake in Africa. Africa, man-made, largest and volta are some unrelated concepts we ought to know. In such cases, there is no way to find out whether or not the proposition is true by reasoning. The veracity of the statement must be investigated using the senses. The bottom line is that, we do not have innate ideas and concepts from which we can derive all the knowledge of the world, and justify them using perceptions gained through the senses. Hence, any *a prior* knowledge of matter concerning fact is impossible.

To Hume, all of our reasoning that extend beyond our present experiences and past experiences are based on cause and effect. We all know that when you pour water into a kettle and the kettle is plugged on, the water in it warms up and then boils. We know this because we have been observing this for a long time and each time the water warms up and then boils. We have inferred from the behavior of the past and have made this useful generalization that, so long as the kettle is on (and there is electricity) the water will behave in a particular way. We infer that plugging on the kettle causes the water to heat up and that, in future the water will behave as such. What Hume is drawing our attention to is that there is no contradiction in supposing that we will put water in a kettle and switched on the kettle, and the water will freeze. These ideas are connected by looking at the causal relationship between the kettle and the water. The thing is, if we really want to have a good understanding of knowledge concerning matter of fact, there is the need for us to look at our knowledge relating to cause and effect. Our knowledge of cause and effect is obtained only through experience since there is no contradictory evidence that a particular causal relationship does not hold.

Causation according to Hume is what is referred to as constant conjunction. If we assume that X causes Y, then it implies that in our experience with Y, X is always conjoined. So, if we see that an object is constantly attended with a particular effect, then we can foresee that when we encounter similar objects, it will be attended with an effect similar to what has already been experienced. Hume examined the concept of causality and found contiguity as an important feature causality. Contiguity we can say is the relation of being connected in time and space (Shaver, 2012). When we are able to identify a causal relationship between two events, we will notice the two events are either close in time and space or the period between the cause and effect are filled with a series of causes and effects of which each member in the series is close in time and space to the next. This tells us that the cause usually occurs before the effect in time. Sometimes the two events occur simultaneously and we may think that the effects we are seeing had no cause. Think of steel rods in concrete causing a high rise building to stand. The problem with causation is that the positive cause and negative cause are all possible at any given time. The high-rise building can fall when we expect it to stand and we may not be able to explain it. This is why Hume thinks that inductive reasoning that rests on causation has no foundation at all. It is possible for the other effect to show up. It is possible the causal effect will be different in future. We see the water in kettle warm up and boils each time, we see the moon appear every 28 days, and we see high rise building standing because they are well supported by steel rods, and from these we have the justification that the same is going to happen in future (Prevos, 2006). This is no justification at all because the moon my not show up tomorrow, the water in the kettle may not warm nor boil tomorrow and the high-rise building may not be supported by the steel rods tomorrow. It is such beliefs that make us think the devil is working, because we fail to acknowledge the other effect can happen at any time.

Hume's main issue with induction has to do with the fact, that it is possible any conclusion drawn from an inductive argument would be false, irrespective of the number observations made (Tsang and Williams, 2012). There are recorded cases where there are large numbers of observations documented to support a generalization and yet that generalization has been found to be wrong. A typical example is the generalization made that all swans were white, on the basis of many observations until black swans were found in Australia (Taleb, 2005). Bertrand Russell (1872–1970) contended, in support of Hume, that inductive reasoning may be likened to a turkey who trusts it will get food to eat from its keeper every day because not a single day has passed without receiving food, until one day it is cooked and served. When induction is defended by saying, it has been successful on a large number of cases on different occasions at different places, and under different conditions and therefore it works in general, Hume describes such argument as viciously circular. What is in doubt is the justification of inductive argument hence it is not legitimate to defend induction with an inductive argument.

Hume says our inductive practices are based on the causal relationship. That is, every effect has a cause. When we analyze this causal relationship, we will find that all that it is, is the regular conjunction of events. Considering the objective content of causal relationship, we get to know that there is always some pattern or regularity in the behavior of things which hold. It is this regular behavior that we extrapolate in induction. It is in this extrapolation that Hume's problem with induction lies. There is no justification of the extrapolation we make from past regularity, to the future behavior of things, because some cause and effect may not hold in future. This is because, it is possible, even if logically, that any regularity we have observed over a long period of time will not hold in future. The proof, and the only proof, we have for inductive inferences is the trust we have that the future and the past will always be alike. The notion that the future will always be like the past is justifiable, only, by our past experiences. Hume therefore says, we do not have any justification, whatsoever, for inductive practices, since they are only products of animal habit and instinct instead of reason.

3. Popper and the Growth of Scientific Knowledge

Karl Popper is one of the greatest British philosophers who had significant impact on philosophy of science in the 20th century (Thornton, 2014). The most influential of his works were the first four books he published. These books primarily tackled problems with simplicity, clarity and originality and had implications for philosophy, education, science and social science. However, it was his interest and work in scientific theory that brought him so much fame (Brantingham, 2007). This incidentally appeared in his first book. The book was first written in German in 1934 and then translated later, in 1959, into English. The book titled *The Logic of Scientific Discovery* became popular because of a number of topics, may be issues, covered. In the book, Popper made a distinction between science and pseudo-science. He also argued that scientific theory cannot be verified by way of gathering evidence in support, they can, however be falsified. He discussed the later as he looked into to what he believed is the main problem of epistemology – the problem of growth of knowledge.

We have already seen that the traditional view of science hinges on the method Francis Bacon proposed. Science from this perspective is an inductive process in which, according to Parvin (2010), "scientist begin by collating and systematizing observations about the world in order to extrapolate from their observations, overarching laws of nature" (p. 35). It is these laws of nature that are used in explaining the world, through verification of some claims about it, and predicting events that would occur in future. Science begins with observing natural behavior or properties of matter and the isolation of observable characteristics through experiment. It is the results gathered through these experiments that are used to generate generalizable laws we have. To Parvin (2010), the scientist must therefore establish a good and appropriate circumstances in which the observation can be made and tested in a way that does not lead to any unintended or any 'stained' consequences. We can say that the scientific theories we have are inferred from observed facts gathered through controlled experiments and empirical testing. The scientific theories therefore have a predictive and verification power (Uslu, 2013). Take for example, Newton's observation of falling apple. We can verify whether there can be a case where an apple falls upwards and then we can use that observation to then predict the direction a falling apple would go in the future. Scientific theories can be justified, in other words proven, by observed facts. What actually derives scientific progress, is the increase in numbers of theories that can be verified and justified. If a theory is found to be universally acceptable and applicable it is considered more important (Parvin, 2010). Theories developed in this manner are developed based on the induction process Bacon introduced.

This process has been used, and is still held in high esteem, by many scientists. The method has been used to generate great theories. Darwin's theory of evolution begun with the collection of several specimen from a number of islands. On the Galapagos Islands, he noted that finches, giant tortoises and mockingbirds differed in form from one Island to another and also between the islands and the South America mainland. The most striking difference in the finches of the different islands was the size and shape of their beaks (Dixon, 2008). It was these observations that led him to his controversial theory of evolution. Newton's work regarding gravitation started with a simple observation of a falling apple. From this single observation he was able to derive generalizable and universal natural laws. Scientist like Galileo and Kepler also used observations to make their generalizations concerning the basic structure of our universe. As noted by Parvin (2010), scientists have been employing inductive method in their quest to uncover the truth about our world, with the hope that observations will allow them to derive universally generalizable laws that would be capable of offering potent explanations and predict future events. It is this method that Popper, thinks are flawed.

Poppers believed the induction process, as a traditional understanding of science, is flawed. Popper's ideas on induction were similar to those of Hume. It appears that Popper found Hume's arguments against induction very appealing. This is evident in the first of a number of issues Popper raised concerning induction and scientific theory. To Popper, induction is heavily dependent on a basic philosophical and logical impossibility. The truth of a theory, he says, cannot be logically extracted from the truth of some statements based on observations. To him, we cannot have a rule that can guarantee that a certain generalization generated from observations is true, irrespective of how repetitive the observation is. Popper like Hume was saying that even if something has happened a thousand times, there is no guarantee that thing will happen in the same way in future. We cannot therefore predict the future by studying past events, like the inductive method says, by identifying trends in a record of observation (Parvin, 2010; Schulz, 2012). It is this that led to Popper's somewhat odd conclusion that the traditional view which says scientist must derive universally generalizable laws of natural events and facts from observation is erroneous and futile.

We hear from many scientists that a theory has been scientifically proven, but Popper says we cannot prove a scientific theory, we can only falsify it (Delfino, 2014). Going back to the 'all swans are white' statement, we can notice that, what made people invalidate that statement was the observation of non-white swans. So long as people decided to validate the statement, they failed to add to their knowledge that non-white swans exist. If they had focused on making the statement invalid, they would have found the black swans earlier. From Popper, facts can only show a theory to be false. It cannot do otherwise. It seems that proving something to be false is much more definite and makes the refuted statement very useful, not invaluable, like the traditional scientific view holds. Once a theory is shown to be false, it becomes a real contribution to knowledge. For a long time, science said the smallest indivisible part of matter is the atom. This view was held until the discovery of the sub-atomic particles falsified it. It the theories on the sub-atomic particles that are now being used to explain chemical bonding in chemistry and the flow of electricity in physics. When one theory we are so used to is falsified, it is worth a celebration. For without falsification, we cannot know what is true and what is not – our scientific knowledge would thus not grow. Again, will not know what is scientific and what is not.

Popper used falsification to demarcate what is scientific and what is unscientific. A statement or theory is considered unscientific if it cannot be falsified conversely, if it can be refuted then it is scientific. Take for example, the following simple statements.

I. Since the sky is bright today, the sun will shine brightly tomorrow.
II. Since the sky is bright today, the sun will shine brightly in future.

Statement (I) is scientific since though we do not at the moment possess the requisite knowledge to invalidate it, it is constructed such that it is possible for us to refute it someday. We can wait until we have a bright sunny day and then check the weather with the aim of falsifying the statement. The other characteristics of Statement (I) are that it is precisely constructed, predictable and has the potential to add to our knowledge of the weather. Statement (II) is imprecise, unfalsifiable and therefore unscientific. According to Parvin (2010), Popper had the belief that predictions, wherever they may come from, are essential and possible, however; they must be falsifiable rather than unfalsifiable. The other things about predictive statements are that they should be short-term and tentative instead of radical and long-term in nature. Science must not focus on establishing theories which will prove certain things about our world. It should focus on eliminating errors in existing falsifiable theories (Parvin, 2010). This is a sure way of drawing the lines between scientific theories and unscientific theories.

There was and still exist a philosophical and longstanding accuracy that science starts with observation. Popper boldly disputed this view and proposed that scientist initiate their work by proposing theories relating to the problem they want to work on. He rejected the idea that science moves from observations to generation of theories and proposed the reverse instead. Like Hume, Popper saw science not as an inductive process but a deductive process. There is first, the identification of a real-world problem, a theory which will be used to solve the problem is proposed, and finally there are attempts to falsify the theory using some other theories or observations. Theories that are falsified are abandoned. In cases where falsification fails, the theory is retained. The retention of a theory does not mean falsification of that theory has ended. The theory will be subjected to falsification based on the knowledge available at the time, hence we cannot say that any particular theory is completely true. We can however, say, according to Parvin (2010) that, they are "hypothetically true or potentially true" (p. 39). We can say from these views of Popper that observations or facts are only used to prove stated theories and that the observations or facts are not the sources for the general laws of nature. They are only used to deduce whether a theory is correct or not, therefore a scientific activity does not begin with observation, it does begin with theories stated about a problem.

The fact that science begins with a stated theory defeats the notion that the scientist must be detached from the observations being made. Going back a bit, we learn that Bacon argued that if we truly want to understand the world we must purge our minds of prejudices, conjectures, and guesses (Lam, 2007). For if we do, our findings are stained and the truth is revealed, only, by our reason. Popper thinks otherwise. Scientific discoveries actually arise from the very things Bacon relegated to the background. To popper science must begin with a thorough discussion of myths. The prejudices, conjectures, and guesses which Popper collectively called myths, set the stage for and determine the scope of scientific investigations. In any way, every observation has some element of subjectivity in it. The object of interest is chosen by the investigator based his/her knowledge and interest in the puzzle he/she has decided to solve. Collecting random facts and observation is the prime work of the scientist. The scientist must be concerned primarily with how to solve problems through falsification of theories which exist (Gattei, 2009). Scientists cannot just observe, they ought to know what they are observing else they see nothing. Prior to observing they must know what they are looking for, else they will not be able to observe effectively and finally they can discover something if they had some prejudices, conjectures, and guesses already in mind. There could be discrepant events, but even with that as soon as glimpses of it show up guesses are made prior to the actual investigation of that event.

The prejudices, conjectures, and guesses are sometimes rooted in metaphysical ideas. Metaphysical ideas have been prominent in scientific advances made in the area of cosmology. From the pre-Socrates era, through to our days, metaphysical ideas have led some scientists into fame. It was not observation that led to the quantum theory Einstein proposed, it was pure speculative and abstract thinking that led him to that theory. Copernicus' thinking and proposition of a heliocentric universe was born from a religious or mythological idea not some observation. Science and metaphysical theorizing are thus miscible. This is because, according to Parvin (2010), prejudices, conjectures, and guesses – settled convictions and metaphysics, catalyzes scientific discoveries by guiding the questions the scientists ask and how they ask the questions. It is worth noting that science represents the route by which we get to know the metaphysical positions that must be supported. Our metaphysical ideas may come with errors or mistaken claims. These may be revealed and falsified through critical engagement. It is science that provides the tools for purging the parts of our metaphysical thinking that are mistaken, hence, making our metaphysical positions. Popper therefore advices that metaphysics should not be considered as a foe of science nor vice versa.

The character of Popper shows that it takes some effort to make discoveries and add to knowledge. We should be ready to challenge and make false some of the notions that have been upheld for centuries. We should dare to be different and have a strong conviction of what we are doing. Thinking of falsifying a theory or proposing one and subjecting it to falsification can lead us into making discoveries. We will not bring anything new to the table if all we do is to take what others have done and replicate them like we are taught in schools. For same method will yield same result and no new knowledge would be added to the existing ones. But if we propose theories based on our metaphysical ideas like some great scientists did we can add to knowledge.

4. Conclusion

If we are asked to describe the scientific method today we will give a minimum six-step procedure only because it has seen growth. First, we would say is that there should be a stated problem. This problem is generally the question or questions we would seek to answer. We then make a guess of the answer to the question raised. This guess is what is called hypothesis. After clearly stating the hypothesis, the series of activities that would be followed are stated. This is important because it will allow others who would want to replicate the experiment to do so. The next stage requires following the series of activities to collect data through experimentation. The results from the experiment are presented and analyzed and finally conclusions are drawn based on the result. This method was not in place prior to the 1500s and discoveries were made using different methods which were dependent on Aristotelean logic. It was Francis Bacon who initiated the formulation of a method that ought to be followed by all scientists.

Bacon proposed that our scientific investigations should begin with making several observations that are free from our prejudice, conjectures and guesses. To Bacon, if we allow our prejudice, conjectures and guesses to cloud our observation we will not be able to reach the truth. Bacon wanted the scientist to reach the truth by collecting several information on the phenomenon being investigated and then put all the data gathered into a table for analyses. He added that we can control certain aspect of the phenomenon using experiments in order to know what will happen if those conditions exit. The final stage relied on induction. At this stage, generalizations or conclusions are drawn based on the analyses made. The method Bacon proposed, we can say is egalitarian and also collectivist in principle. It can be seen as a social process in which the intellectuals and ordinary men and women can work together to cause changes in human knowledge and bring about a good understanding of natural phenomenon.

It was the reliance of Bacon's methods on induction that forced philosophers like Hume and Popper to make submissions on the method Bacon wanted all scientist to follow. Hume said, the induction applied by Bacon is not justified because the fact that something has been happening in the past does not mean it will continue to happen in future. For example, if for the last seven years, each morning you make a sacrifice, it rained in the afternoon, it is no guarantee that you will have the same result in future. Hume therefore concluded that inductive practices are not justifiable. Popper who also favored the deductive approach as practiced before Bacon focused his argument not just on induction but the procedure Bacon proposed and the theories derived from Bacon's method. On induction Popper says we cannot logically extract the truth of theory from the truth of some statements based on observations. Popper suggests that instead of starting with observation, the scientific method must start with a question. Popper did not just refute Bacon's method he proposed an alternative. In his method there is first, the identification of a real-world problem, then a theory which will be used to solve the problem is proposed, and finally there are attempts to falsify the theory using some other theories or observations. Popper held the view that we must not prove scientific theories, we must falsify them instead. This is because by falsifying them based on our current knowledge, we get to know the theories we must abandon and the ones we must keep. To Popper, this is a sure way of growing scientific knowledge. By adding to and taking from the scientific method proposed by Bacon that the scientific method is as refined as we see it today.

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