

DEVELOPMENT OF SCIENTIFIC ATTITUDE: A CRYING NEED

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The advancement in science and technology at individual level as well as for the nation as a whole largely depends on the scientific attitude of the people engaged in the activity of science and also the policy makers of the country. Apart from the advancement in science and technology, adoption of scientific attitude transforms an individual into an rational human being. Hence, in a wider sense, development of scientific attitude is not merely restricted to scientific community only, but as common trait to be present within every citizen of a progressive society. The article presents an introductory idea of scientific attitude and a brief account of a few important traits of scientific attitude that should be inculcated.

Introduction

Scientific attitude is regarded as a complex of ‘values and norms which are held to be binding on the man of science. The norms are expressed in the forms of prescriptions, proscriptions, preferences and permissions. They are legitimized in terms of institutional values’¹. The norms and values are supposed to be internalized by the individual scientist and, thereafter, they design his/her future course of scientific practice. The set of those common scientific attitudes are generally maintained and accepted by scientists throughout the world.

To have an idea of scientific attitude we need to look into the term *attitude* in general. In psychology, an attitude is a psychological construct, it is a mental and emotional entity that inheres in, or characterizes a person². It is an individual’s predisposed state of mind regarding a value that is precipitated through a responsive expression toward a person, place, thing, or event; which in turn influences almost every thought and action of the individual. It is a ‘readiness’ of psyche to act or react in a certain way. In the journey of life an individual come across various cross sections of society differing in person, place or event. It is *attitude*, which determines how the concerned person will

react or deal with these varied circumstances. Paul G Hewitt in his famous book *Conceptual Physics* mentions that ‘the success of science has more to do with an *attitude* common to scientists than with the particular method. This attitude is one of inquiry, experimentation, and humility before the facts.’

Historical Background

The current set of scientific attitudes namely objectivity, skepticism, open-mindedness etc. have evolved from a systematic identification of scientific norms and values. Scientists over the ages have internalized these attitudes. Many of them had to sacrifice their lives just because of their uncompromising scientific attitude. Their collective commitment and adherence to these attitudes defined modern day’s science and technology. It was Robert K Merton, one of the first sociologists of science, who described four sets of norms in an essay (1942)³. These are universalism, communalism, disinterestedness, and organized skepticism. These are now popularly known as ‘*Mertonian norms*’. The essay was originally published as ‘*Science and technology in a democratic order*’. It presents the basic principles on which is based the ethos of modern science. It is interesting to note that though ‘*Mertonian norms*’ gained huge popularity, the Merton’s paper was originally concerned with a political problem i.e. autonomy of science. As a sociologist, Merton was interested in

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understanding science as a social group. It was a volatile period of Second World War and author's intention was to free science from the clutches of politicians. However, his pithy formulation of four norms was never intended as an exhaustive specification of the entire normative system of science. Therefore, many more norms were included in the subsequent studies. Interestingly, few papers also appeared which dealt with 'Anti norms'. However, the scientific community believes that the success of science and technology to a large extent can be attributed to these norms.

The Set of Scientific Attitude

The methods and skills used by scientists are intimately connected to a set of attitudes common in the practice of science. There is no exclusive list which claims to be complete. But the following sets of attitudes are very common to scientific communities. Though the list appears to be long enough but in practice the principle of many the attitudes can be derived from the others. In some cases

a combination of two or more attitudes collectively named a new one. In fact, in some cases the presence of a particular scientific attitude demands the presence of another. The naming of the scientific attitudes has been made separately so that each of the items is recognized easily. In order to have an introductory idea the characteristics of few scientific attitudes will be discussed in brief.

Critical-mindedness / Critical Thinking

Critical thinking is a process of analyzing arguments and conclusion on evidences. It is self-guided, self-disciplined thinking which attempts to reason at the highest of quality in a fair-minded way. Whenever a doubt arises, the scientist questions the veracity of a statement in relation to the evidence presented. In the process of examining the offered evidence a scientist takes the help of reasoning and critical thinking. In a scientific method which generally includes questioning, observing physical reality, testing, hypothesizing, analyzing, and communicating (not

TABLE 1 Characteristics of Scientific Attitudes

Scientific Attitudes	
<ul style="list-style-type: none"> ● Critical-mindedness ● Questioning ● Skepticism ● Willing to doubt ● Curiosity ● Willing to change opinions ● Unbiasedness (Objectivity) ● Open-mindedness (respecting the ideas of others, liberal to accept criticism) ● Rationality (based on or in accordance with reason or logic, based on facts) ● Loyalty to reality ● Intellectual honesty (giving truthful report of observation) ● Creativity (generation of new and original ideas) ● Inventiveness ● Suspended judgment (waiting for all the facts before making a decision) ● Accuracy of observation ● Preciseness 	<ul style="list-style-type: none"> ● Empiricism (all knowledge is based on experience derived from senses) ● Determinism ("cause-and-effect" underlie everything) ● Risk-taking (risk of failure/ criticism) ● Tolerance of uncertainty (and striving for greater certainty) ● Awareness of assumptions ● An understanding that all knowledge has tolerance limits ● A respect for power of theoretical structure ● Parsimony (economy in the use of means to an end /Preference of simple explanation to the complex) ● Ability to isolate fundamental concepts from the pool of irrelevant or unimportant data ● Respect for quantification and appreciation of mathematics as a language of science ● A thirst for knowledge (enthusiastic about intellectual drive) ● An appreciation of probability and statistics ● Humility (a scientist is humble, he admits that he is not free from committing errors) ● A belief that problems have solutions ● Aversion to superstition and preference for scientific explanation ● Respect for paradigms (A paradigm is our overall understanding how the world works)[“Universally recognized scientific achievements that, for a time, provide model problems and solutions for a community of practitioners”]⁴

necessarily in that order) a scientist applies his or her critical thinking and reasoning at each and every step. Interestingly, a scientist is the first and big critic of his own work. Not only that, he invites criticism by publishing his findings. Without the critical thinking ability, a scientist would be misled by overconfidence of his judgments.

Questioning

Questioning is one of the important scientific attitudes which is frequently used by a scientist. It may be compared with the stethoscope of a doctor. 'Questioning' stands exactly at the opposite end of 'Belief'. The former finds its place in the activity of science while the latter is an integral part of religion. Time and again, the oppressive and authoritarian force always tried to stop questioning. If people stop questioning then the progress of civilization will come to a halt. The histories of mankind testify this. It helps scientists find out their inconsistencies. By raising questions one challenges the validity of unsupported data. The intention of questioning is not to belittle one's ideas or findings, rather it is a way of helping to attain perfection. In reality, the work of science is co-operative, a scientist takes his colleagues as judges, competitors and collaborators⁵

Skepticism

Skepticism is an essential part of a good scientist's mental makeup. In being interested in science, one needs to approach the things he examines with skepticism. In fact it is a vital step in the pursuit of scientific exploration. Skepticism is accompanied by open-mindedness - one should not immediately reject any idea simply because they sound improbable or nor immediately accept ideas that appear plausible. Reasoning and critical thinking are the two important tools frequently used by a skeptic. It is to be noted that skepticism is not a position, it is a process. The popular misconception is that skeptics, or critical thinkers, are who disbelieve things. And this bears a sense of negative implication. The true meaning of the word skepticism has nothing to do with doubt, disbelief, or negativity. Skepticism is the process of finding a supported conclusion, not the justification of a preconceived conclusion.

Will to Doubt

A skeptic is willing to doubt. In his famous book 'Will to Doubt' Bertrand Russell strongly advocates in favour of 'will to doubt.' Contrary to William James who used to

preach the 'will to believe'; Russell strongly opposed it. He says, 'For my part, I should wish to preach the 'will to doubt'.⁶ In science no one holds the supreme authority to say the final word. No theory, no person, no authority is above suspicion. If the scientists were satisfied with existing theories or explanations no new theory or explanation would appear. Hence, the attitude 'will to doubt' is deeply interconnected with the dynamic nature of science. What civilization today has acquired in the name of science and technology is nothing but the result of persistent 'will to doubt'. Scientists never get satisfied, a sense of incompleteness always haunts them.

Open-mindedness

Open-mindedness is receptiveness to new ideas. Scientists are not prisoners of knowledge. When investigating or evaluating a problem, scientists always consider alternative ways presented by others. In the path of scientific journey one may encounter contradictory views and opinions and takes the advantage of the differing views. In fact, 'A class of doctrines is not a disaster - it is an opportunity.'⁷ Hence, it is not surprising that the scientific community replaces an old theory by a new one when the former is inconsistent with the new findings. History of science is nothing but the story of replacement of old by the new. The acceptance of 'The Theory of Relativity' was one such striking example that portrayed the true spirit of scientific attitude. Bertrand Russell very nicely depicted it in his famous book 'Will to Doubt'. In his words,

'We have had in recent years a brilliant example of the scientific temper of mind in the theory of relativity and its reception by the world. Einstein, a German-Swiss-Jew pacifist, was appointed to a research professorship by German Government in the early days of the 1914-18 war; his predictions were verified by an English expedition which observed the eclipse of 1919, very soon after the Armistice. This theory upsets the whole theoretical framework of traditional physics; it is almost as damaging to orthodox dynamics as Darwin was to Genesis. Yet physicists everywhere have shown complete readiness to accept his theory as soon as it appeared that the evidence was in its favour. But none of them, least of all Einstein himself, would claim that he has said the last word. He has not built a monument of infallible dogma to stand for all time. There are difficulties he cannot solve; his doctrines will have to be modified in their turn as they have modified Newton's. This critical undogmatic receptiveness is the true attitude of science.'

Willing to Change Opinions

Scientists are not dogmatic in nature. A scientist listens to and respects the ideas of others. He accepts criticism and changes his mind if reliable evidence contradicts his findings. Personal ego never deters a scientist from accepting the truth. An instance relating to a well known Nobel laureate serves as a good example of a great mind of science. Harold Urey authored a book on planets which contained a theory on origin of moon's surface. But, after the successful completion of Apollo mission scientists got the opportunity to test the moon's rock and new facts gathered. Harold Urey immediately recognized that his theory did not fit the hard facts laying before him. Without any hesitation he proclaimed, 'I've been wrong!'. He did not make any attempt to defend his theory what he supported for decades. This is the true spirit of science. Boris Podolsky mentions: *'Having a scientific attitude consists in being willing to accept only carefully and objectively verified facts, and to hold a single fact above the authority of the oldest theories. Nothing can be called scientific that is not based on such an attitude.'*⁸

Curiosity

Curiosity is a fundamental characteristic of a good scientist. This primary characteristic of human mind is very influential in the original drive towards doing science. Curiosity, the overwhelming desire to know, is not characteristics of dead matter. An urge to know and to understand the natural world around us is embedded in the mind of every healthy growing child and it is how human learn to adapt to the world. Interestingly, this remains as an integral part of human psyche throughout his entire life. But most people get satisfied just by observing or enjoying these natural phenomena around them. A handful number of people extend their inquisitiveness to unveil the underlying principle behind the natural happenings. But scientists are not, their curiosity is not quenched by mere observing the nature. Their curiosity leads them to study how things in the natural world work. They try to understand the underlying law which governs the natural phenomena. That is why curiosity is thought to be the catalyst that creates knowledge. Curiosity compels one to think. As mentioned earlier, every human being is curious about a phenomenon which is taking place for first time (which belongs to natural curiosity) and this type of curiosity is related to know 'what' the phenomenon is. But a scientist's curiosity is not satisfied with mere knowledge of 'what' but concerned with 'why'. Another important scientific attitude 'questioning' comes through the spirit of curiosity.

Einstein echoes what numerous scientists say:

'The important thing is not to stop questioning. Curiosity has its own reason for existing. One cannot help but be in awe when he contemplates the mysteries of eternity, of life, of the marvelous structure of reality. It is enough if one tries merely to comprehend a little of this mystery every day. Never lose a holy curiosity.'

Hence, it is the task of science people to awaken curiosity among youngsters and keeping it afresh throughout life. Science people lacking 'curious mind' reduces the possibility of new discovery or invention.

Conclusions

There is no phase in the educative process so important as attitude. There would be no branch of knowledge discovered without proper assimilation of its essence. It is attitude that will take an individual farther than his talent. We have had a rather rapid scientific development, but we have not been so successful in securing the prevalence of scientific attitude. This is true not only of the average person, but also of many people who are deeply engaged in the activity of science. If we fail to inculcate the spirit of scientific attitude with the rapid progress of science and technology, we may have to face serious consequences. Scientific work without its attitude may halt or impede the progress of science, which in turn is associated with the progress and prosperity of a Nation. So, it is a duty of a Nation to pay special attention for the development of scientific attitude. It will certainly help grow democratic values and rational outlook among her fellow citizens.

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