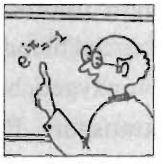
Classroom



In this section of* Resonance, *we invite readers to pose questions likely to be raised in a classroom situation. We may suggest strategies for dealing with them, or invite responses, or both. "Classroom" is equally a forum for raising broader issues and sharing personal experiences and viewpoints on matters related to teaching and learning science.

! The Concept of Experiment in Science

Samir Roy, Department of Computer Science and Engineering, NERIST, Nirjuli

Galileo established science as an independent and autonomous cognitive process. He achieved this with the introduction of the concept of *experiment* into the methodology of science. Prior to Galileo, science was just a part of philosophy in general where the method of obtaining knowledge was observation followed by intellectual speculation or, sometimes, purely intellectual speculation. Galileo distinguished science from philosophy, once and for all, by establishing experimentation as an indispensable tool of scientific cognition. Of course the scientific query, that is, asking questions about the nature of the physical world, and the subsequent human endeavour to discover the causal relationships among natural phenomena, is as old as the history of human consciousness. But the approach towards such questions was not essentially different from the approach of philosophy.

Though verification is the way to establish a scientific theory, the essence of a theory which is scientific lies in its fallibility rather than its verifiability.

Hence the cognitive process of science, as established by Galileo, consists of speculation (in the form of a hypothesis) – experimentation-verification. However, though verification is the way to establish a scientific theory, the essence of a theory which is scientific lies in its fallibility rather than its verifiability, as pointed out by Sir Karl Popper, the famous philosopher of

science of our age. Experimentation thus forms the very basis of scientific cognition. Therefore let us consider the concept of an experiment.

What really is an experiment? We shall try to grasp the concept of scientific experimentation with reference to a well known but simple experiment by Newton. The purpose of the experiment was to verify whether all bodies fall from a particular height with the same velocity. The notion that was prevalent at the time of Galileo was that heavier bodes fall more quickly than lighter bodies. Newton inserted a penny and a feather inside a long glass cylinder. He pumped out the air from the cylinder to minimize the resistance of the air during the fall. He kept the glass cylinder upright so that both the penny and the feather were at the bottom and then abruptly turned it upside down. He observed that the feather which is far lighter than the penny and the penny, both reached the bottom of the glass cylinder simultaneously, thus proving that the preconceived notion does not agree with reality, at least it does not agree with the outcome of the experiment.

To check the truth of a certain preconceived idea about a natural phenomenon Newton repeated the occurrence of that phenomenon deliberately in a contrived and artificial way; a way in which it never really occurs in nature. He demonstrated that the result contradicts the preconceived idea held till then.

Experimentation is a way to concentrate on the particular phenomenon we are concerned with.

In the world around us we never see things falling through vacuum. Still, to investigate the way things fall he tried to make them fall through vacuum. Why? Because he felt that the existence of air inside the cylinder is a disturbance, as far as the movement of a body towards earth is concerned. Why should we consider the existence of air to be a disturbance? Because we implicitly assume that the phenomenon of falling has nothing to do with air, they are totally unrelated. In this way science tacitly divides reality into myriads of compartments, presumably unrelated, and then strives to study them separately. Experimentation is a

A new theory is considered to be valid and in some sense closer to truth if its predictions agree with the results explained by the previous theory plus the new results which the old theory could not explain.

way to concentrate on the particular phenomenon we are concerned with. Ironically, the object of science is to find a pattern i.e. a causal relationship between diverse and apparently unrelated phenomena. This purpose is achieved as the scientist tries to find more generalized theories that embrace wider spheres of apparently unrelated phenomena (unrelated to our immediate sensory experience). For example, the phenomenon of high tide and low tide of the oceans and the fall of a mango from a tree are united through the theory of gravitation though, as far as our immediate sensory experience of these two phenomena is concerned, they are unrelated. Of course the scientist takes into account the knowledge already accumulated by the human race through ages.

Thus the essence of experimentation is to prepare an artificial environment, commonly known as the experimental set up, where for the sake of concentrating on a single phenomenon the occurrence of that phenomenon can be repeated in a manner detached from other phenomena. The main concern is to facilitate a particular aspect of reality to be highlighted. Based on the outcome of the experiment the scientist draws conclusions related to the phenomenon which either validates some hypothesis or falsifies it. So long as the theory is consistent with the results of the experiments it is considered to be valid. Whenever people begin to find phenomena which do not fit into the pattern already laid down by some previous theory, the theory is considered to be inadequate and scientists search for a new theory. A new theory is considered to be valid and in some sense closer to truth if its predictions agree with the results explained by the previous theory plus the new results which the old theory could not explain. The fate of the new theory is, perhaps, no better. This will also be made obsolete by some other theory which might be able to unite a larger number of phenomena through its explanations. In this sense any scientific theory is fallible, by virtue of its being scientific. Science believes that it gets closer to the truth in this way, and experimentation is the only methodological light that can help us to choose the right path in this endless journey.