

Science Through Technical Education

Dr.S.S.Kalbag

Vigyan Ashram,Pabal,Dist. Pune, 412 403.

1.WHAT IS SCIENCE?

Why do we want to teach science to school students and if possible to every one? Science is a body of knowledge obtained through the use of scientific methodology; and it is this methodology that we want to teach, so that they use it to solve problems in everyday life and gain sore knowledge on their own.

So when we talk of teaching science we are really wanting to teach the methodology and concepts of science rather than a package of information.

This methodology involves observation, measurement, recording, classification, comparison, and recognising patterns, making a hypothesis, and then testing the hypothesis by experiment. This methodology has proved to be very fruitful because it depends on deriving information from action in the real life world. This is different from other methods, which depend on "truths" stated by an authority and accepted blindly by subordinates. Very often, these truths relate to situations where the veracity is difficult to test.

In this paper, I want to make the following points.

1. The above scientific methodology is very similar to the learning mechanism of the mind and every human is capable of using it.
- 2.The learning process for the basic scientific concepts has to be based on-activity.
3. It is advantageous to use technical education to give skills and then practice their application in everyday life and give actual experience of the scientific concepts involved; this is different from the current practice of using contrived "experiments" to demonstrate the concepts and "tell" about their application in life situations.

2.NATURE OF LEARNING PROCESS.

Here I am depending heavily on the Piaget theory, because it best fits my own experience.

Piaget was a biologist who drifted into psychology of learning, and intelligence and has put forth a theory that has great implications for education systems.

In brief the theory says that the human mind develops through its action on the environment. On this experience, it forms a mental "model" of the "reality", something as in the story of the elephant and the five blind men. With every action, the mind anticipates the response from the environment. If the response is as anticipated, the model is reinforced. This is assimilation of the experience. If the response is different, the model is adjusted to accommodate the new experience. For totally unexpected experiences, the phenomenon is kept aside as un-understandable or a miracle.

Each concept is understood by the mind, by forming a model of it-a structure in the mind. Later as the mind develops, it begins to do its operations on these mental structures (the concepts) just as it was doing it on material objects before. This is the beginning of abstract thinking.

This natural method of learning is independent of ethnic & economic factors. The variety of exposures in everyday life are so many that certain concepts are learnt by all, It is also seen that there is an order in which these concepts are learnt, and it is not possible to learn a new concept unless the structures prerequisite to it are ready. This learning method of the mind is akin to the scientific method of making a hypothesis and an experiment to test it.

Some of the concepts the mind learns by experience are as follows:

Class membership and inclusion / intersection etc.

Image through transformation,

One to one correspondence - number concept.

Conservation of length, substance, etc.

Reciprocity of relationship - addition and subtraction.
Special Coordinates, vertical, horizontal.
Probability.
Effects- "everything else being constant"
Permutations and combinations.
Proportions and rate (velocity etc.)
Projections.
Proof.
The above make up the logics mathematical reasoning.

Piaget's theory has major implications for all education and particularly for science education.

1. All science education must be activity based, particularly at the school level.
2. Motivation can best be achieved through challenging his mental structures.
3. Too much pressure can lead a student to rote learning instead of understanding.
4. The teacher can only produce an environment where the student learns by himself.

3. WHERE DO WE GO WRONG?

In a system of education such as ours, where teaching through spoken word and books are the methods used, and evaluation is based on producing the desired response, Piaget theory suggests that students resort to rote learning. Almost by definition, this cannot lead to application of this knowledge. Even the best of students will learn "how to" rather than have a conscious knowledge.

So our system "derails" the natural learning process. In order to put it back on rails, we need to find out what structures the student has acquired and then give his activities to encourage his forming new structures and learning by himself thereafter.

4. WHAT ARE THE BASIC CONCEPTS NEEDED?

The concepts listed earlier in Para 2 are basic to all life and we have only to make sure they are acquired by the students. This should be by the age of 13-14 years. The further concepts basic to school level science are as follows:

1. matter; energy and universe.
2. space and orthogonal directions;
3. types of growth; linear and exponential.
4. Structure of matter, molecules, atoms, protons, and electrons.
5. Physical and chemical changes.
6. States of matter; gas, liquid and solids.
7. Intensive and extensive properties; vectors and scalars.
8. Nature of living things.
9. Heredity- genes and evolution.
10. Radiation, waves and their properties, reflection-refraction.
11. Electro magnetic phenomenon.
12. Forces and strength.
13. Work energy, power.
14. Velocity and acceleration; rate.
15. Accuracy and error.
16. Field and its properties.

All these concepts can be given through activity based learning and most of them make sense when given with reference to their experience in practice of technology.

5. EXAMPLES

1. The IBM of conservation of mass and energy is one of the most fundamental laws, yet in the normal education it is hardly illustrated.

First let us note that it is an extension of the conservation laws the child discovers in its growth as per the Piaget theory.

Second, it gives rise to the concept of efficiency, stock inventory, and accounts etc., which are important in technology.

Third, it gives the basis for mass and energy balances - the very concept of balances; this is fundamental to all technology.

These are all covered in our system of science through technology application.

2. When we teach electricity, old books used to say it flows from + ve to - ve, Now we teach that electricity is a flow of electrons and they flow from -ve to +ve, (high pressure of electrons to shortage of electrons). How do they flow?

We ask students sitting on classroom benches that one of them is an electron, and the other two are nucleus. The front student walks off creating a "vacancy". The student behind moves into this vacancy and so on until the "vacant" seat moves to the back of the class, while the electrons move to the front. Thus the same process can be seen as electrons moving in one direction and as positive charges (holes) moving in opposite direction.

Similarly, we have illustrated 3-phase electricity by 3 boys running in a circle, representing the rotor in the generator.

3. The concepts of force and strength and work are much easier to teach as there are many applications of these in their practical work. To illustrate, we explain why trusses are based on triangles and why one strengthens a right angle joint by a diagonal.

Also they calculate the work done in many of their practicals e.g. pumping water.

4. The simple machines described in science lessons don't make sense in terms of the meaning of "machine" in every day language. We therefore like to bring one common machine, say the bench drill and show how it is a combination of the simple machines as described in the book viz. the lever, the screw, gears etc. Then the student can go round the workshop and examine any other machine and identify the simple machines used there.

5. Genes, heredity and evolution.

The concept of probability as applied to genetics, stresses that what is a matter of chance in small numbers, becomes a certainty when dealing with large numbers. This is best illustrated through a game.

Later the rules of heredity, which involve permutations and combinations, are presented by making a number of labels of different shapes and working out permutations and combinations of these to understand how hybrid seeds give rise to variations in future generations.

The above examples illustrate how science concepts can be made easier to understand in technical education, based on a wider common shared experiences. The students can also be asked to construct models for better understanding. This is easier in the technical stream than in conventional science.

The greatest benefit however should come from the continuous testing of their knowledge in the real life world. This is the basis of all science. Giving community services as part of the technical education ensures this.