Learning to question : a question of "learning methodology"

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Why science eludes us

Science in its general sense should mean the innate human ability of investigating the environs and turning the knowledge to ones advantage by some tinkering and fixing. It has been with us since the proverbial wheel, and yet science continues to puzzle us as a modern enigma. This is perhaps due to the hiatus that has arisen between the practicing scientist or technician and the general public. The situation is similar to that for language. Due to specific historical reasons, different strata of the community acquired linguistic skills in varying degrees. Formal language, in the sense of reading and writing, was abandoned completely by many strata.This situation is expected to be rectified by the universal educational system. The same is warranted in the case of science. In other words, we are proposing that science in its basic spirit should be treated as importantly as literacy.

The universal education system has been under scrutiny by many educationists as well as social activists for a long time, a great transformation having been initiated by Madame Montessori. Here we shall focus on a particular approach to primary education, called "learner-centered" method of instruction. This is why the title of this article refers to "learning methodology", not "teaching methodology". Let me present here a particular science teaching program that has touched the scientific sensibilities of many scientists and has excited many educationists. It will not be possible to trace the full history or give due credits to personalities. Rather the focus is the program itself and its many desirable aspects.

If a reader's interest is kindled by this article, the best thing for him or her to do is to actually visit the Teachers Training program of HSTP usually held for a few weeks during the summer. After all, doing is the best way of knowing; this is the philosophy we are pursuing, as will be apparent in what follows.

Science teaching with a difference

Eklavya is an NGO in Madhya Pradesh working for education and science popularisation through a variety of methods. Spread over thirteen districts of M.P., they run "Chakmak" Sci-

ence Clubs for children, local water table management efforts, employment generation based on traditional skills and so on. I will focus here on one of their endeavours, the so called Hoshangabad Science Teaching Program (HSTP). It is a science curriculum with a difference and it is bound to interest everyone interested in science or education.

At the outset, HSTP has to be distinguished from many efforts for “science popularisation”, in the sense that it is a program actually running as school curriculum. Whereas activities like science fairs and do-it-yourself activity books have their own value, a regular school curriculum has very different imperatives and presents totally new challenges. In the following I will first present the basic philosophy, aspects of its implementation, and then several features which make the whole program a rather comprehensive package. I do not belong to Eklavya so the views presented are my own, formed over some years of topical participation as a resource person.

Guided discovery

To begin with, HSTP purports to put curiosity back at the core of science. The classroom is at once the activity room. The laboratory is not separated from instruction. All concepts are brought out by performing experiments. Students formulate the outcome of the experiments in their own language. The process of science in practice has almost always involved a practical exploration of the phenomena, often out of sheer curiosity. Thus the program re-establishes the link of knowledge directly to ones own explorations. And this to my mind is the most outstanding ingredient of this program.

But curious explorations have no explicit goal to direct them. They are lengthy and time consuming. So this can clearly not be a strategy for mass education. The compromise is to have what is called "guided discovery". As such the HSTP text books are more correctly science workbooks. They begin with a brief preamble to the subject. Then they proceed to give step by step instructions for activity, punctuated by questions to be discussed by the group and by tables for recording observations.

Who performs the experiment? Demonstration experiments are a well developed educational tool. But nothing is more valuable than doing the experiment oneself. HSTP lives by a motto derived from an ancient Chinese proverb "I heard about it and I forgot/ I saw it and it stuck in my mind/ I did it myself and I understood it!" The practical implementation of this is that experiments are done in groups of four or five, often with sufficient equipment that several members of the same group can simultaneously do it with each others’ help. The teacher has to circulate in the class, aiding with the method of setting up and observing.

The teacher’s role is manifold and challenging. He or she has to begin the class with getting the children to give some examples of the subject matter from their daily lives. Interest has to be generated for taking up the experiments. However, neither the outcome of the experiments, nor the conclusions are to be told – neither at the beginning nor at the end! The observations will of course be done independently, then they will be shared with the whole class. Often, a member

of each group comes to the blackboard and enters the results of his or her group in a common table. The conclusion about the phenomenon studied will have to emerge through discussion and a set of "leading questions". By and large, after some discussion, a few in the class will latch on to what is really happening and then they will state it in their own words. If this doesn't happen, more hints have to be provided. The real demand on the teacher is to weather erroneous conclusions often resulting from wrong observations.

Preparing for the process

This immediately begs two questions. How does one ensure so much equipment? How can the teacher stand up to such a demanding task? In the urban setting, the kind of equipment needed is neither extravagant nor excessive. Any normal school should be able to stock and maintain it. In municipal or government schools and in rural setting it may appear difficult both from the point of finance and availability. Happily, over the years many efforts have focussed precisely on this issue; that of inexpensive and locally available material for instructive experiments. During the course of development of HSTP, which is both rurally based and in government schools, this particular aspect was vitally incorporated from the start. The so called "kit supply" for all the classes is inexpensive, yet does not sacrifice on what may be essential such as test tubes, magnets, lenses and so on. The expense is modest enough that it has been sanctioned in M.P. where education budget is low. It has been found sufficient to charge students one Rupee a month to compensate for wear and tear.

We now turn to the question of how teachers can be prepared for this kind of open ended classroom. The first thing to be realised is that once children begin to do things on their own and begin to throw up questions about everything they see, it becomes difficult even for experts to answer everything satisfactorily and on the spot. This has to be experienced to be believed. Observations concerning phenomena are not neatly divided into Physics Chemistry and Biology. So that every once in a while a child will ask something, that I as a Physics person had to say "Hmm ... may be due to some process occurring here that Organic Chemists may know."

Other than that, a simple query may well cross the limitations of the curriculum and the level of the class. "How does a tube light work?" immediately requires you to say something about electrons and ionisation. This can perhaps be evaded out of hand by saying "too advanced", but other questions of great practical importance cannot be avoided, such as what is "earthing" of electrical equipment. And one is instantly off to a discussion of electrical forces at large. Not that this is not done in the usual curriculum. But if you can tell the child "read up this paragraph on earthing and memorise these four questions that can be asked on it", it is much easier than a carefully worded discourse answering all the major queries the child can raise in her own language and couched in her own overall perception.

Thus, the kind of classroom session HSTP results in is a challenge to everyone, at some level or the other. The strategy adopted by HSTP to meet this challenge is to have monthly meetings of all the science teachers from one educational block in the presence of a resource

person who should preferably be a college level teacher. This does well to resolve questions that arose in the class and to share common experiences. But the meetings also bring very valuable feed-back from the field about the experiments. Many important suggestions for improving the experiments have been incorporated into the textbooks.

Transformed classroom, transformed roles

As the reader can imagine, this approach to teaching completely transforms the classroom setting. On the face of it, it does have the character of a laboratory in early college. But it is much more. The college "laboratory" is conceived as a supplement to "theory". The student already knows the concepts. Laboratory is just a time to verify some of the known things, to repeat some of the classic experiments and to pick up the techniques, such as use of voltmeters, burettes and pippets. In the discovery approach this is turned the other way around. One is prompted to take up some activity including the very preparation itself. It may involve going out and gathering leaf, soil or insect samples; it may also involve playing some games. The experimental procedure is well specified. But what its outcome may be is not even hinted at. Leading questions are asked to accompany the activity. When one experiment is complete, the teacher will lead a combined discussion for the whole class. The observation process automatically becomes careful since one will be held responsible for it and the observations will get compared against those of rest of the class.

Knower vs. knowledge

Next the students will themselves have to guess at how to formulate what they observed. They have to formulate their own laws! Incorrect and hilarious conclusions will be suggested if the observations were not careful. This may seem preposterous. But HSTP follows this method, sometimes to a fault. But imagine the responsibility and autonomy it grants to the student. No "definitive" conclusions are dictated. The formulated empirical law may well have deficiencies in it when compared to standardised science. But though sufficient discussion the teacher will smooth it out enough that, at the level of the class, it is quite adequate and not contradicting anything. But isn't this how science unfold even in practice?

This does leave many with an uneasy feeling although there is no reason for it. The brainwash of usual pedagogy is very strong. The teacher is always right. The "expert" is a know-all, supreme. Knowledge has open boundaries but at the school level, well, isn't it "complete"? Nothing is farther from the truth. Most of the myths are defense mechanisms invented and perpetuated by authority. It is the tentativeness of the conclusions, that makes them so novel. The habit of learning through ones own activity, albeit with some flaws, may be of greater use in the long run. Between the integrity of standardised knowledge and the self-reliance of the knower we are opting for the latter.

For this reason this program has also fulfilled the goals of "learner centred" education long before it came to be known that way.

Instructor vs. the instructed

The dynamics of an HSTP classroom differs in an essential way from that of a conventional one. This also reflects itself in the relation between the teacher and the taught. From a one way relationship with passive and obedient role by the student, it becomes a dynamic relationship more like that between a sportsman and the coach. The coach remains the reliable source of inspiration and guidance. But all the activity and initiative must come from the performer, the student. The relationship automatically becomes cooperative rather than tense. It is essential that the teacher does not feel threatened by questions. It is necessary that the teacher holds his or her own even in the face of questions that cannot be fully answered. Similarly the student must appreciate the small extent of tentativeness in all knowledge and stop expecting the kind of finality and infallibility expected of a teacher in the usual classroom.

There are several very desirable byproducts. For one, if the teacher wants cooperation and wants to share what he has to give, he must treat the students more equitably, more tactfully. The usual habit of beating and corporeal punishment would only be counter-productive. But usually the session is interesting enough and provides sufficient freedom to the student that it is not necessary to discipline the children in any violent manner. This is what some of the teachers have reported from their own experience.

Instructor and the academic administration

The program is indeed "learner centred" in the sense that the learner is an active participant and only if he or she acts and absorbs what is being presented does the program succeed. This is unlike the usual process where it is the dictated program that is absolute, against which the student passes or fails.

But the implementation of the program is pivoted on the teacher. Much as we ensure the accessibility of the material and the activities to the student, the classroom can be dismal without the leadership role of the teacher as a coach. Thus in this program considerable autonomy is also vested in the teacher. One of the ways this is done is to seek teachers feedback as to success of the instructional material. Active "feedback" is sought from teachers for improving the presentation, content and experiments in the curriculum. One stage this is done is indeed in the monthly meetings spoken of above. A registry is kept of these transactions, and revisions incorporated in the text-books based on the same.

In addition, annual workshops for revision of the material are held with participation from resource persons of college, university and research level backgrounds. The teacher gets maximum attention here because he has the actual observations relating to the functioning of the program. (This is in the spirit of the scientific values we are imparting through the curriculum

itself. Field work is more important than theorising!) The teacher representatives in turn are reflecting the inputs of several of their colleagues. Thus a successful implementation of the program also envisages periodic revision with active inputs from teachers themselves. This has to be contrasted with the current practice of most school boards wherein a special group of "experts" and a few established teachers write the book which must then be obeyed to the letter by every teacher. Teacher participation of the type implemented here builds greater sense of identification with the course and greater responsibility while implementing it in the classroom.

A final most vital part of the whole package of HSTP is the exam system. An examination that is compatible with the overall philosophy of the course has to be designed. In a generous allowance to this particular educational intervention, the M.P. government granted a special permission to hold a parallel exam for HSTP for the class VIII school board which exists in M.P.. It would be a farce to train students to be explorative and inquisitive and then burden them with the usual rote exam. It is matter of historical record that M.P. government was the only one with sufficient faith in our own trained scientists (most of the core group belonged to Delhi University faculty or research scholars) to permit them the parallel exam. This exam is open book. Its questions are largely multiple choice. In many of these, practical situations are shown in sketches and students must respond based on their experiments.

It is important enough to bear repeating in a separate paragraph : the "discovery method" curriculum must have a compatible examination of its own.

Extensions and outlook

The HSTP program has continued as a funded project of D.S.T. and M.H.R.D. In early '90s the M.P. government established a high powered commission of eminent science educationists to report on the implementation and success of the program. They visited several schools in the districts and came back with praise for the essential contents of the program. The main issue they had was concerning State-wide implementation. Another point that has often been raised is linking it to high school science from ninth onwards. Both of these are open challenges. The core group or whoever that will take up the gauntlet must come up with a package that will fit the requirements. Also, equally importantly, the State must initiate action to see its successful implementation.

Several other states have evinced a keen interest in adopting the methodology. A sister program independently started in Gujarat met with sufficient amount of success that the "learner-centered" textbooks prepared there were substantially incorporated into the standard textbooks. The program however suffers from insufficient preparation at this stage. The experiment kits have not been supplied, and the onerous task of teacher training and orientation remains pending. But a large number of university teachers have come forward to help.

Several individuals from different states have participated in the teacher training and textbook writing of HSTP. Their feedback has been very valuable. A reader interested in seeing

the program first hand can attend their teacher training during summer by contacting Eklavya, Kothi Bazaar, Hoshangabad 461001.