The Need of Paradigm Shift in Indian Science Education

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I always wonder, "Why India is still one of the developing countries and what is stopping it from being a developed one? Why it is that even after 72 years of Independence, no Indian citizen has won the Nobel Prize in Science?" I think India's education system as an obstacle towards its objectives of achieving inclusive growth.

Indian Education System

Macaulay Education, a model set up by the British in India during the 18th century which focused on preparing children to work in factories and not to think. But the bad part is that we still follow this system which is guiding students in a way which is enough for a clerical job. For example, students are not allowed to think themselves but to learn what is given to them. ***And that is the reason why innovators in India are still less numbered.***

What is Science?

Science is the study of the nature and behaviour of natural things and the knowledge that we obtain about them. It is a systematic and logical approach to discovering how things in the universe work. It is also the body of knowledge accumulated through the discoveries about all the things in the universe. Science is based on fact, not opinion or preferences.

The earliest evidence of science can be found in prehistoric times, such as the discovery of fire, invention of the wheel and development of writing. Science became decidedly more scientific over time, however. The current speed of changes in the world requires a similar change in the meaning of "effective education," particularly as regards Science, Technology, Engineering and Mathematics (STEM). A good way to do this is by exposing children early on to an educational model in which they themselves are part of the teaching and learning process.

Status of Science Education in India

- If we look at the evolution of school science in India, we see a clear trend of including more and more content overwhelmingly in the form of factual information in the syllabus. Laboratories have declined, and even demonstrations, once common, are now confined to elite schools. Thus the factual information that dominates the syllabi is not supported by any kind of activity, which can make it plausible or even comprehensible. Students therefore have no option but to memorise the facts. The consequence of this is that students find science not only difficult but also boring. As a result, students don't want to opt for science at the Class XI level.
- The content of school science has an abstractness that makes it irrelevant. So much of what is taught in science is uninteresting because it is not related to our everyday lives. Science in films and in the media is often exciting, but that is not an aspect of the science we hear about in school.
- Currently we have a school science education that is disconnected from their own lives, a depersonalized science, where there is no space for themselves and their ideas. It is often related to learning information rather than to understanding concepts and investigating them. The main focus of the study of science was memorization and the organization of certain facts.
- The science classes are no different from history or geography or language. They are also taught by teachers from textbooks. The textbooks talk about things, experiments and processes and show pictures. They often take the route of not only describing the experiment, but also telling children what they will observe and

what they should conclude!—an implicit acceptance by those designing the textbooks that children will not actually get to do or see the things that are to be learnt about.

- Many teachers are not that much proficient with science knowledge in such a way to build the scientific temper within the students. It is essential to have teachers proficient in the basics of the various branches of science in order to implement a good science education program, in any form.

The urgent need of PARADIGM SHIFT

The Paradigm shift *is needed to meet the challenges discussed so far means that there will have to be changes in the way that students learn science in school. Improving science education in elementary and middle school education levels is not only intended to train scientists and engineers, but also to improve the scientific culture of society in general and contribute to the development of an organized, critical mind among citizens, which is useful for dealing with everyday problems more creatively and objectively.*

How School Science should be? School Science should be in such a way to emphasize working with ideas rather than transmitting information, through scientific investigations of students' own ideas, on science topics related to ongoing, current scientific issues of the day.

A. CURRICULUM CHANGE

We have to rethink how we structure the curriculum in science. Rather than being structured according to the ideas in scientists' science, we need to think of the curriculum structure from the perspective of students' learning and how their ideas might develop to those of standard science. A rich science curriculum can also help students share, develop and extend their experience to take them beyond their immediate environments.

Pedagogy for conceptual, procedural and NOS (Nature of Science) learning in science education could be more effective and inclusive when:

- The existing ideas and beliefs that learners bring to a lesson are elicited, addressed, and linked to their classroom experiences.
- Science is taught and learned in contexts in which students can make links between their existing knowledge, the classroom experiences, and the science to be learnt.
- The learning is set at an appropriate level of challenge and the development of ideas is clear – the teacher knows the science.
- The purpose(s) for which the learning is being carried out are clear to the students, especially in practical work situations.
- The students are engaged in thinking about the science they are learning during the learning tasks.
- Students' content knowledge, procedural knowledge, and knowledge about the nature and characteristics of scientific practice are developed together, not separately.
- The students are engaged in thinking about their own and others' thinking, thereby developing a metacognitive awareness of the basis for their own present thinking and of the development of their thinking as they learn.
- The teacher models theory/evidence interactions that link conceptual, procedural, and NOS outcomes and discussion and argumentation are used to critically examine the relationship between these different types of outcomes.

B. INQUIRY BASED LEARNING

Inquiry-Based science education is a process whereby children answer their own questions and satisfy their curiosity about the world around them through experiments. Inquiry-based strategies incorporate questioning and active engagement for student learning. In the Ontario Ministry of Education's report Inquiry-based Learning: On Transforming Wonder into Knowledge, inquiry-based learning is described as a teaching

approach that builds on the idea that educators and students both share responsibility for learning. Benefits of inquiry based leaning are as follows;

- Rather than memorizing facts from the teacher, inquiry-based learning enhances the learning process by letting students explore topics themselves.
- Teaches skills needed for all areas of learning.
- An inquiry-based learning approach lets students share their own ideas and questions about a topic. This helps foster more curiosity about the material and teaches skills students can use to continue exploring topics they are interested in.
- Deepens students' understanding of topics
- Allows students to take ownership of their learning
- Increases engagement with the material
- It is designed to teach students a love of learning. When students are able to engage with the material in their own way, not only they are able to gain a deeper understanding but also they are able to develop a passion for exploration and learning.

C. SCIENCE BEYOND CLASSROOM

Learning outside the classroom and outside the school has important contributions to make to science education. At its base, science is about curiosity. All of science starts with a question, a hypothesis, and we work to explore and understand. This fundamental curiosity allows for great opportunity for learning outside the classroom. While classrooms may seem intimidating, or textbooks dull and uninteresting, science out of classroom can offer a more experiential method of learning, creating memories that can translate into lessons. Understanding the changes in kinetic and potential energy of a swing can lead to questions, like why does a box in the backseat of a car slide when the car turns, or how does walking work? It fosters that sense of curiosity. The fun of playing in a playground creates a memory, while the description of physics for each of the activities allows for greater understanding that can lead to curiosity about things previously just accepted. In time, this creates a love and engagement in physics, and science in general, that feeds upon itself.

D. SHIT FROM EXHIBIT MIND SET TO RESEARCH MIND SET (*Say No To Science Exhibition And Yes To Science Fair*)

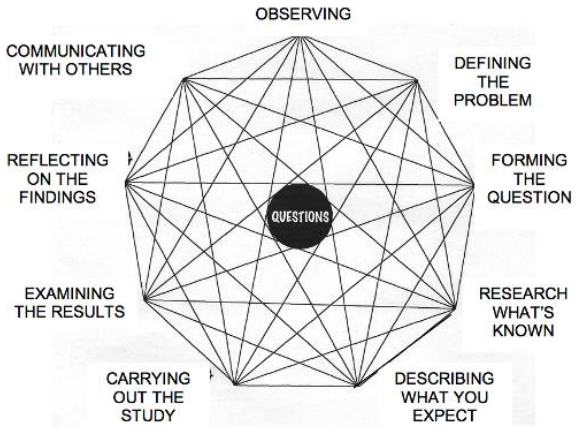
Usually many schools in India are conducting science exhibitions in which students just exhibit just the models they learned from you tube or textbook. But in many developing countries, they are conducting science fair every year. Even research projects are in- build in school curriculum at the basic elementary level. But here in India, research are meant in college level. As educators we need to change that.

Kids learn by doing, and a science fair gives them that chance. Science fair is an opportunity for students to apply the scientific method to conduct independent research in their own interested field. The results of each student's research is presented in a school wide science fair--or sponsored local science fair--where the student's efforts are displayed and where students are interviewed to determine scientific merit. Students who have been judged to have used the scientific method properly and who have demonstrated thoroughness in their studies and effort are awarded prizes and are advanced to compete in regional, state, national and international science fairs.

The Scientific Method:

The scientific method is defined as a method of research in which a problem is identified, relevant data is gathered, a hypothesis is formulated from this data, and the hypothesis is empirically tested. There are steps you take when using the scientific method. Here is an example of the steps:

- Ask a question
- Gather information and observe (research)
- Make a hypothesis (guess the answer)
- Experiment and test your hypothesis
- Analyze your test results
- Present a conclusion



The scientific method wasn't invented by one person, but was developed by different scientists and philosophers over the years. The scientific method is the cornerstone to modern science. Without a formal method of determining questions and their answers, we wouldn't have science or the knowledge we have today.

Difference between Science Fair and Science Exhibition

Science Fair Project	Science Exhibition Project
Students think and work like a scientist	Students do not think like a scientist
Data is collected to find the results, which are not known before (Original concept, publishable)	Display already established facts and results (Not an original concept, not publishable)
Use their own creative scientific techniques, innovations and procedures	Just follow others methods, procedures and instructions
Follow scientific method (Planning and designing an experiment is required)	Do not use scientific method (Cook-book science experiments from text books)
A science fair project starts with inquiry, a question or a problem	Inquiry, question, and problem are not part of this activity
Students show lot of interest in doing science fair projects as those are their own research work	Students think science exhibition projects are part of school work, do not show much interest
Require days, months or years to do one project	These projects require short duration, sometime this could be done overnight
Students do lot of research prior to starting their projects beyond their text book contents	Building models and demonstrations do not require any extra research or scientific information

Both students and teachers get benefited with new scientific knowledge and information	No new information and scientific knowledge is gained

E. TEACHER EXCELLENCY:

In the case of Inquiry Based Science Education, teacher education is particularly important since children may ask a wide variety of questions both during the experiments and when they are positing hypotheses or drawing conclusions. In these cases, the teacher must be able to answer them or be able to say, "I do not know," something many dare not do for fear of losing face in front of their students. To help them overcome those fears, it is useful for teachers to know that one of the prerequisites for doing science-and of course teaching it-is humility. Saying, "I do not know" is what makes scientific research make sense. If a researcher assumes he will know the results of his research beforehand, this defeats the point of the exercise. It does precisely not know why things happen and, in the case of classes, not having the answer to questions that forces teachers to study to find the answer. This can open up a path that may become even more important than the answer to the question they were asked.

F. INTEGRATED WITH FOUR PILLARS OF EDUCATION:

It should build the four pillars of education as defined by Jacques Delors. In his paper for UNESCO, Delors identified four pillars for learning namely learning to live together, learning to be, learning to do and learning to know.

***Learning to live together*:** School science necessarily should imply practical work of different sorts. For a number of reasons, both for managing the class and for good pedagogical reasons, students work in groups to carry out science investigations. Given appropriate support from their teachers, students can learn that the quality of the outcomes is dependent on the work of all. Knowing how to present your views and listen to the views of others is an important skill in life and one that group work in science is well placed to develop. By working together to develop their science knowledge and processes, students learn to live together.

Learning to be: School science, through the way it is taught and learnt, should help to develop the way that students and future citizens should act. Science itself has its own values and ways of being and school science ought to parallel these. There is a portion of the human minds that good science education, better than any other school subject, can cultivate in school, such as for example;

- The spirit of observation
- Calmness
- Self-control
- The practice of looking for the causes of things
- Order
- Caution in making claims
- Admiration of nature
- Modesty
- Tolerance and so on.

Such outcomes from science education, combined with those from learning to live together, are a valuable contribution to the development of future citizens. They have to be developed through teaching. Rather than leaving such outcomes implicit as was often the case until now, making such desirable outcomes explicit should make their attainment more likely. Then the student will be better equipped to participate as an active citizen in society, where science related concerns are ever more pressing.

Learning to do: Through science learning, students should learn to define, refine and resolve problems and ideas. They should learn to do this through practical data gathering, collecting information from a range of sources, transforming that data to make broader generalizations, explaining their outcomes and justifying their positions.

Learning to know: Students should come to know basic concepts of science, how to use them to explain and understand the world around them, and how to change it.

Through these four pillars, students should have opportunities to develop their imagination and creativity as they become active learners. In the longer term, such developments will support the students to lead more fruitful lives individually and as members of future societies.

"Science education should be based on looking for the answers to the secrets of nature to enable students to discover basic science concepts on their own rather than through memorization.
Science classes should be given by teachers who understand the basic principles of science and are able to stimulate children's curiosity and help them develop their experimentation skills so that they can clarify their doubts on their own"

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