Science Through Activities*

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Abstract

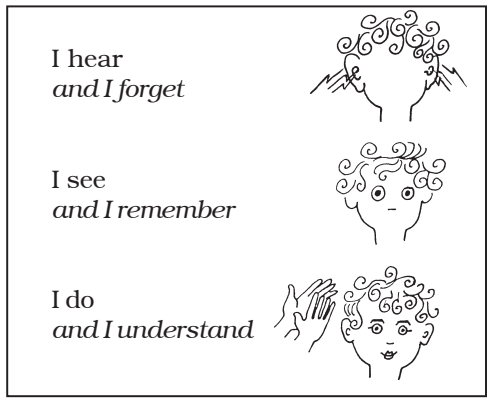
The search for teaching science meaningfully to rural children has been a very challenging task for educators. Many attempts have been made in the past and there are several lessons to be learnt from them. Some, like the Hoshangabad Science Teaching Programme (HSTP) worked in over a 1000 village schools for over two decades. The HSTP unleashed the creativity of thousands of children and teachers, but was ultimately shut down by the State government. Every innovation leaves behind seeds for future innovation.

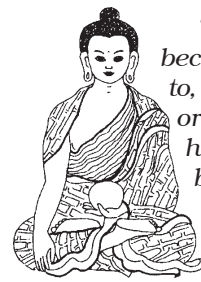
Is the chalk-talk method best suited to teach science? Is the ability to regurgitate a few definitions an indicator of comprehension? Isn't expensive glassware and sophisticated plastic equipment in a typical school science laboratory a little out of sync with the lives of ordinary village children? Shouldn't the learning of science be made more contextual – something which a child can relate to with her everyday experiences?

How do children learn science? Perhaps science is learnt best when it goes beyond the four walls of the classroom and addresses the concerns and problems of the larger community. Then science becomes alive and vibrant. Also the use of local materials for making simple science models helps children assimilate them better.

Apart from outlining tried and tested field experiments the talk will be interspersed with practical and fascinating demonstrations.

Science Through Activities





"Believe nothing, merely because you have been told to, or because it is traditional, or because you yourself have imagined it. Do not believe what your teacher tells you... merely out of respect for the teacher. But whenever after due examination and analysis you find conducive to the good, and benefit the welfare of all beings, that doctrine believe and cling to and take it as your goal."

– Buddha

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Everything has a History

In most schools science is still learnt by rote. Children mug up definitions and formula and spit them out in the exam. This is certainly not a good way to learn science. Science is perhaps a unique subject. The uniqueness stems from the fact that many of its postulates can be tested and verified by practical experiments. Most other subjects can be learned with ordinary tools—such as pencil, paper, blackboard, textbooks and a few supplementary aids. These are also essential for the teaching of science but, if they are the only tools, science becomes a dull and an uninteresting subject. This uniqueness results from the variety of materials and experiments necessary for its effective teaching.

If it is to be learned effectively science must be experienced. It must be learned and not learned about.

The Philosophy

Ann Sayre Wiseman, creative director of the Children's Museum in Boston and the author of the landmark book, *Making Things*, summed up the essence of good science in these words:

It's OK to fail.
It's OK to make mistakes.
You will learn a lot from them.
It's OK to take risks.
It's OK to take your time.
It's OK to find your own pace.
It's OK to try it your own way.
It's Ok to fail.
You can always try again free of fear.
It's OK to look foolish.
It's OK to be different.
It's OK to wait until you are ready.
It's OK to experiment (in safety).
It's OK to question the "shoulds".
It's special to be you.
It is necessary to make a mess
Which you are willing to clean up.
(The act of creation is often messy)

Gleam in the Eye

Children are naturally curious and have an innate desire to learn. Children also have a tremendous power to concentrate. If they are interested in a particular thing they put their heart and soul into it. They want to know it. They have a tremendous desire to understand how it works. Children learn a great deal without being taught.

Maria Montessori demonstrated this over a hundred years ago. She was Italy's first woman doctor. After getting her medical degree, Montessori started working with the children of slum dwellers. Montessori is famous the world over for her deep pedagogical insights. She had designed hundreds of teaching-aids for children. Several of them are still in active use, for instance, the post-box. This is a hollow wooden cubical box. On each surface of the box there is a cut-

out of a particular geometrical shape — a circle, triangle, square, etc. There are corresponding wooden blocks which have to be posted in the respective slots. A wooden ball, for instance, would go into the circular hole and a prism in a triangular slot.

There was an elderly priest who was very interested in Montessori's work. He would drop-by on a Sunday to see the various experiments, which Montessori was doing with the children. One day, Montessori took the priest to one corner of the class, where a little girl, was playing with the post-box. The little girl was deeply absorbed in her work. Montessori asked the other children to encircle the little girl and to sing a song aloud so as to disturb her concentration. But the little girl was so absorbed in her work—in trying to figure out which block will go into which slot that she did not even look up.

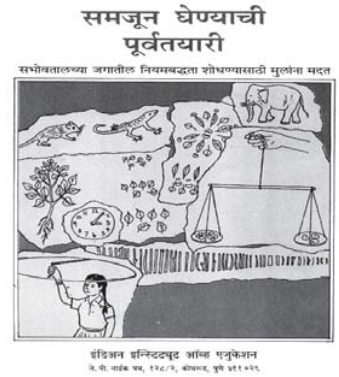
After some time Montessori lifted the little girl and seated her on a table. As soon as the little girl got her berth she once again got absorbed in trying to figure-out the block which will go into a particular slot. She was totally lost in her own world.

The priest—a good old Samaritan, often used to bring some toffees and chocolates for the children. On that day he had got a big box of biscuits. He started distributing biscuits to the children. He also gave the little girl a biscuit. The little girl reluctantly took the biscuit. She intently looked at it. She saw that the biscuit was rectangular in shape. So, she posted the biscuit in the rectangular slot of the post-box. Children do not learn through bribes. They learn because they want to understand the world. Mark sheets, certificates, medals and prizes are bad substitutes for the real joy of knowing the world.

The Beginning

Several pioneering experiments were done in India prior to Independence to make the learning of science contextual and interesting. One such well documented experiment took place in Himachal Pradesh in the 1920s.

Satyanand Stokes was an American who came to India in 1910. He pioneered the plantation and propagation of apples in Himachal Pradesh. Being a philanthropist, he also set up a school in Kotgarh for the local children. In 1920, the American economist Richard Greggs—deeply inspired by Gandhiji—came to work in India. For two years, Greggs taught activity based science to children in Stoke's school at Kotgarh. Based on his real life experiences with Indian children, he wrote a book titled *Preparation for Science* in 1928. This book was first printed by *Navjivan Prakashan* from Ahmedabad. This remains the most pioneering treatise on how science should be taught to children in Indian schools.

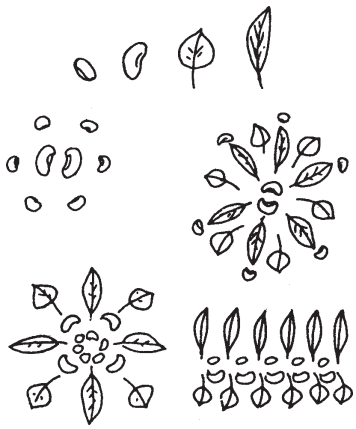


Greggs wrote:

> *The apparatus required is exceedingly simple and inexpensive, and almost all of it is familiar to village children. Most of it can be made by village carpenters, potters or blacksmiths. The children must not get an idea that science is machinery or strange technology. The great pioneers of science did their work with very simple apparatus. It is possible, therefore, to follow their footsteps and learn to do scientific thinking without much expensive or elaborate apparatus. After all, the student's mind is the most expensive piece of apparatus involved.*

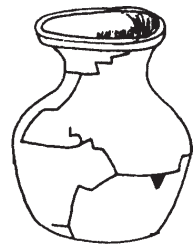
Greggs further commented:

> *I do not want Indian children in villages to get the idea that science is only a school affair or only relates to shiny brass and glass devices and paraphernalia. I believe they can learn to think more clearly and to acquire a scientific attitude without all the expensive and complicated apparatus used in western laboratories, or at least with extremely little of it.*



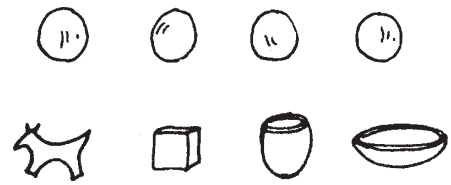
As has often happened in the history of science, the prophetic book written in 1928 remained buried until Keith Warren, a UNICEF consultant rediscovered it in 1975, illustrated parts of it, and brought it out as *Preparation for Understanding*.

This book helps children to discover an order in the world around them. Children are inspired to seek out patterns using pebbles, twigs, leaves, wire, seeds and other natural materials – stuff which is free and doesn't cost any money. Children who don't have paper or pencil could draw patterns on the ground with a stick. They could arrange leaves and seeds to make several *rangoli*-like patterns.



Pieces of a broken earthen pot could be joined with wet clay to create a whole. This is akin to solving a 3-D jigsaw-puzzle.

In another exercise, a child takes four similar balls of clay. She then moulds each into a different shaped animal, a cube, a pot and a plate.



The child is then asked: Which one is heavier? Does the shape change the weight? Children pour out the same cupful of water in four different containers. Then they are asked, "Which vessel contains more water?"

The basic tenet of the book is : Before children can understand a thing, they need experience—seeing, touching, hearing, tasting, smelling, choosing, arranging, putting things together and taking things apart. Children need to experiment with real things.

This book is perhaps still the most relevant book on science activities for Indian village children. There is no plastic or glass apparatus—specialised science equipment to be bought. It shows that children learn best from simple things. And naturally it is most helpful for them to understand first those things that are around them in their daily lives.

It is best for two or three children to work together at these activities so that they can share materials and help each other. Thus they begin to learn cooperation.

Science is built from curiosity, experience, analysis, and finally the expression of discovery. The main part of this process is arranging objects, activities and ideas so as to create a new order or pattern. Science is the discovery of new patterns. These exercises will help children discover the patterns and arrangements of the world around them by using their hands, senses and minds. So, understanding is the discovery of order.

The Hindi edition of the book *Preparation for Understanding, Samajh Ke Liye Taiyari* is fortunately still being published by the National Book Trust.

Other Experiments

After independence a few initiatives were taken in India to make science more interesting. During its formative years the NCERT reprinted a few science activity books developed by an American University. They were even translated into Hindi. Though the experiments came from an alien milieu and were not very contextual to Indian needs it was still a progressive step—a leap from the chalk-and-talk method and rote learning practised in most Indian schools. The NCERT also started the magazine *School Science* in which many pioneering Indian scientists – Prof. D. N. Wadia and Prof. P. N. Maheshwari regularly contributed articles of a very high quality. The classic *Story of Stone* by Prof. D. N. Wadia first printed in this magazine needs to be republished as an independent illustrated book at the earliest. Some of the other science classics published by the NCERT were the *Akashdarshan Atlas* – written by G.R. Paranjpe – the first Indian Director of the Royal Institute of Science, Bombay. This atlas gave the Indian names of all the stars and constellations and so it made much more sense to an Indian student. Other good science books published by the NCERT were *Our Tree Neighbours* by Chakravarti Venkatesh and *What on Earth is Energy* by D. P. Sengupta.

There were other isolated experiments to improve the way science was taught in schools. In the late sixties Meera Parasnis experimented in the Campus School in IIT, Kanpur to make the learning of science more experiential. She wrote a series of five illustrated books titled *Science in Action* in the early

seventies. These books were brought out by Macmillan and paved the way for further experiments.

Sputnik Spurs Race for Science Supremacy

On 4 October, 1957, the Soviet Union successfully launched the Sputnik. Sputnik's launch changed everything. It had a worldwide effect on the way science was taught in schools. As a technical achievement, Sputnik caught the world's attention and the American public off-guard. That launch ushered in new political, military, technological, and scientific developments. The Sputnik shock shook the US and UK science establishment. Several new initiatives were taken to make science teaching more interesting.

In a unipolar world it is easy to forget the major role played by the Russians in popularising science in India. Many Russian science classics like Physics for Fun *(1905),* Fun with Astronomy *written by the father of Russian popular science Yakov Perelman (1882-1942) were available in English, Hindi, Marathi and other regional languages in small towns on the pavement for a very moderate price. Whereas the American books were expensive and only available in big towns, these beautifully illustrated Russian science books were available in* taluka towns *at a very affordable price. Many people of my generation owe their interest in science to the Russian popular science books.*

In 1905, for instance, Perelman demonstrated the use of standard coins – roubles and kopecks as standard weights. As these coins had been mint-made they had a standard weight and could be used by children as reference "weights". Despite this it is sad to see the chapter on WEIGHT in most Indian books starts not with coins (which are accessible to every child) but with a picture of a fractional weight box!

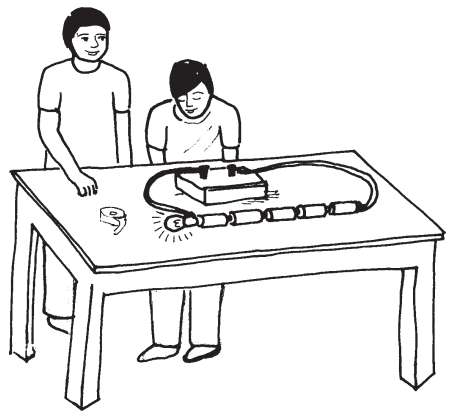
Nuffield Science

The Nuffield Science Programme in the UK in the early 60's based itself on the discovery approach. Children were not doled out readymade answers. Instead, they were encouraged to fend for themselves and to discover the answer themselves. Children learn a great deal by themselves. It is unfortunate that schools provide very little space for children to mess around and discover things for themselves. But whenever there is a pro-child atmosphere the results are simply electrifying.

This happened in a Nuffield Science classroom in England. The junior science students were given a lot of torch batteries, bulbs, wires, resistances, etc. to experiment with. The children were supposed to familiarise themselves with these components and learn to make simple circuits. After the children had played with them and learnt to make a rudimentary torch, etc. the teacher

decided to test their knowledge about these components and gave them a practical quiz.

She gave them four identical wooden boxes with only two terminals on their top. Inside the box, the two terminals were either connected to a battery, a bulb, a resistance or nothing at all (i.e., an open circuit). Children could only experiment by touching only the two terminals on the top of the box. They could only attach wires to these two terminals. They had to find out which box had which component hidden in its belly. It was fairly simple if there was just a battery hidden inside. The battery being an active element, if one just attached a bulb from outside it would glow. If there was an open circuit inside that was also easy to find out. But how does one find out whether it was a bulb or a resistance, hidden inside the box? It was a tough question and not at all easy to crack. If you connected a bulb and a battery from outside, in both cases the bulb would light up. Even the teacher, who had set up the quiz, did not have a clue to the answer.



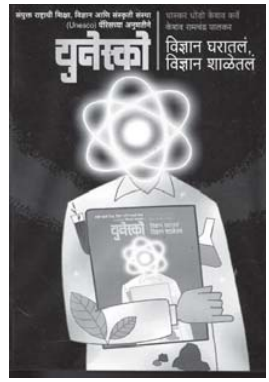
But a little boy found out the answer. When he connected a single battery and a bulb to the two terminals, his bulb lit up. As the glow of the bulb was a bit 'dim'—it meant that there was either a resistance or a bulb inside the box. Then he attached two batteries, and his bulb became a little bright. Then he just kept on adding more batteries and every time the glow of the bulb became brighter. But when he attached six batteries, the high voltage busted something inside and the circuit became open.

The little boy had found the answer because while playing he had fused two bulbs by connecting several batteries to them.

UNESCO Source Book for Science Teaching

Many nations were devastated during the Second World War. Later on, these countries built schools but had no money to set up science laboratories. At the behest of UNESCO, J.P. Stephenson, science master at the City of London School prepared a book on science activities titled *Suggestions for Science Teachers in Devastated Countries.* This fully illustrated book showed teachers how to make their own apparatus from simple, everyday materials at little cost.

The title of the book *Suggestions for Teachers in Devastated Countries* took the world by storm. It showed that expensive, fancy equipment were far removed from the lives of ordinary children – in fact very alienating. UNESCO agreed to widen and deepen the scope of the book and thus came out the famous *Unesco Source Book for Science Teaching* – which 50 years later still remains a bible for



science activities. In 1963 this book was translated in Hindi by Professor Gorakh Nath and published by the Publication Division. Its third and last edition appeared in 1981. But for over a quarter century this wonderful book has been out of print in Hindi. At about the same time this book was translated in Marathi by Bhaskar Dhondu Karve – son of the great social reformer Bharat Ratna Maharishi Karve. One lone edition of the Marathi edition was published by Orient Longman in 1963 and then the book was shelved. Recently the book has been republished by Manovikas Prakashan and has been hailed as the rebirth of a major classic. The *UNESCO Source Book for Science Teaching* must have been translated by inspired individuals in other Indian languages too. But given the apathy towards activity-based science learning these language editions too must have been long buried into obscurity. I wish that someone would digitise and upload them on the internet for posterity.

The *UNESCO Source Book for Science Teaching* periodically revised and updated, has been translated into many languages of the world, reprinted scores of times and has sold several million copies.

Good science teaching must be based on observation and experiment. There can be no substitute for these. But performing experiments and learning to make close observations require special facilities, and these are lacking in many parts of the world, especially in the elementary and middle schools of poor countries. As a result, science teaching suffers a severe handicap in these regions. It is often believed—though erroneously—that to introduce laboratory teaching, even at the elementary level, requires elaborate equipment made by commercial manufacturers. Such materials are prohibitively expensive for most schools and in many parts of the world are quite unobtainable because they are not manufactured locally and cannot be imported because of the prohibitive costs.

Hoshangabad Science Teaching Programme

The best Indian effort to revitalise school science education was certainly the Hoshangabad Science Teaching Programme (HSTP). Started in 1972, the HSTP eventually spread over 1000 government middle schools in 14 districts of Madhya Pradesh. Inspired by the Nuffield Science Experiment it was based on the discovery method where children performed simple experiments and then answered questions based on what they did. They were not "passive consumers" but "real constructors" of knowledge. There were no textbooks, only workbooks. The programme involved the active participation of teachers in designing the curriculum. It attracted many passionate and competent people. Professor Yashpal came as the first teacher trainer. It unleashed tremendous energy and creativity. The

task was not just to replace standard flasks with local glass bottles. The search was for local substitutes, low-cost, non-alienating materials, close to the cultural milieu of the child. This required an open mind and a critical outlook. Children dispensed "dissecting needles" in favour of "babool" thorns (see the illustration). Phenolphthalein – an indicator used for titration—was discovered in the well known brand of laxative "Vaculax". The tablet was mixed in a known quantity of water to make a wonderful "indicator".

A THORNY ISSUE

The Hoshangabad Science Teaching Programme (HSTP) emphasised on activity-based science learning. It was thought that the best way to learn science was by doing scientific experiments. There was a lot of emphasis on learning from the environment.

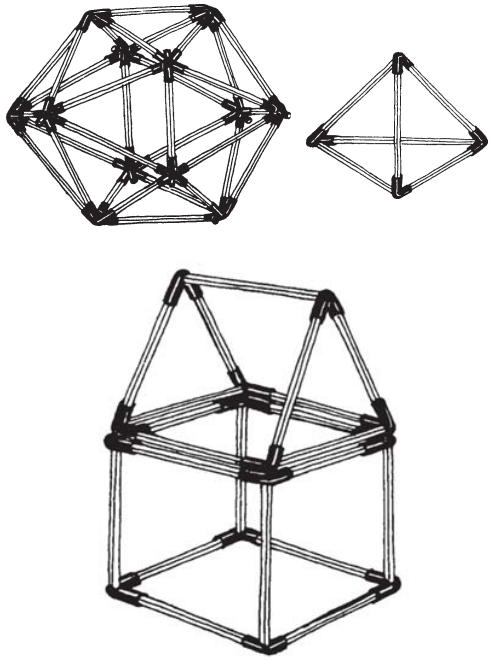
It was thought that the best way to learn about various types of plant roots was not by drawing pictures of taproots and fibrous roots on the blackboard but by actually stepping out of the classroom and studying these real plants in the field. For botanical observations the children were provided with hand lenses and dissecting needles.

One day the children went on a field trip. They were to collect different wild flowers and dissect them. Soon the children were cutting the flowers and examining the stamens, pistils and ovaries. They were all using their dissecting needles to pry open the flower parts. But one girl had forgotten to bring her dissecting needle. What could she do? She was searching for something pointed and sharp to open up the flowers. And soon she found a lot of *Babool* (Acacia arabica) thorns. These thorns were strewn all around and worked as beautiful dissecting needles.

This little girl had taught the Science Programme a great lesson. Why use the standard dissecting needle—a long steel needle embedded in a plastic handle, when you can use a thorn for the job. The needle had to be bought from the nearby town, as it was not available in the village. The thorn on the other hand was free. Millions of those thorns were crying to be picked up right there in the village. The humble *Babool* thorn had become an important tool for scientific inquiry!

The HSTP inspired by the Nuffield philosophy of "learning by doing" had to reinvent all the hardware to suit local conditions. The idea was to critically look at local resources and find possibilities of doing innovative science using local, low-cost, easily accessible materials. The *Matchstick Mecanno* was used successfully to learn geometry and three-dimensional shapes. It used little bits of

cycle valve tubes and matchsticks to make an array of 3-D structures. Matchsticks were readily found at home and as bicycles had made inroads in all our villages cycle valve tube could be bought locally.



The HSTP slowly spread from just 16 schools in the district of Hoshangabad to more than 1000 schools in 14 districts of Madhya Pradesh. At its peak over one hundred thousand village children learnt science using appropriate teaching aids, where the emphasis was on comprehension and not rote learning. Especial testing methods and examinations were devised which tested the child's "understanding" and not his/her ability to mug and spit.

But despite its innovative features the HSTP was shut down by the Government of Madhya Pradesh in 2002. Today, when the government is welcoming corporate partnership in the education sector, the HSTP was hailed as the largest intervention in science education and a grand partnership between the government and an NGO. The government provided the infrastructure, money and, in turn, the NGO providing the passionate human inputs. But, despite the fact that the programme had succeeded in demonstrating a paradigm shift—from rote learning to understanding, it was shut down. It was a big blow for thinking people. Why was this relevant, appropriate, cost-effective, tried and tested programme shut down? The reasons soon became clear. No government whether of the left of the right wants any organisation (private or NGO) to intervene in education at the mass level. The government feels deeply threatened. As long as NGO's work in a few schools the state is happy. If there are more NGOs and more experiments the better for the state, because then the state can "showcase" and trumpet this "bouquet" of educational initiatives and can take legitimate credit for its liberal attitude for "letting a thousand flowers

bloom". But if the experiment is of a radical nature promoting the attitude of "questioning" everything and if the intervention is on a large scale then the ruling class becomes jittery and politically stalls and "kills" the initiative.

The HSTP unleashed the creativity of thousands of teachers and gave an opportunity to academics in some of India's best research institutes to contribute their bit to make the learning of science more interesting in village schools—where their help was most needed. Though the Hoshangabad Science Teaching Programme was shut down the experience conclusively demonstrated that good science education in our village schools could be made interesting and fun and relevant using very cost-effective methods. The HSTP has inspired scores of individuals who are trying to implement it in their own regions with variations and regional specificities.

Science Kits

Experience the world over has shown that prepackaged science kits seldom work. On several occasions multi-national organisations have appointed consultants and experts to design science kits for village schools. Then these kits are "mass" produced and distributed by a central authority to far flung village schools. This process is not unique to India alone. This is the experience of many developing countries. In most cases the kits lie unopened. As the teacher did not think of them, design them, assemble them so s(he) does not feel confident to use them. The kit could break when used. Who will bear the consequences? So the teacher simply keeps it locked.

But whenever teachers have been shown possibilities of making simple science models using everyday materials, readily available in their surroundings they have shown great enthusiasm. When they make things with their own hands they feel "empowered" and are more likely to use them in practice. If something breaks they can always repair it.

We live in a consumerist society which produces mountains of junk—cardboard cartons, ball pen refills, old pens, coins, broomsticks, newspapers, cycle tubes, matchboxes, tetrapaks, milk bags, ice-cream sticks, straws, etc. The list is endless. All this stuff can be recycled back into joyous science models and toys for children.

Recycle! Reuse! Reduce!

This ancient story carries a deep lesson about conservation in a consumerist society.

We buy, use and throw. Often we buy much more than we actually need. The whole consumerist culture is based on the principle: "Buy more! Throw more!" Today as we splurge—we plunder the earth's scare resources and produce so much junk that not only our garbage dumps but even our parks overflow with rubbish.

But has it always been like this? Have we Indians always been so profligate and wasteful? No. History tells us that Indians have been fairly austere. They have had a different way of looking at the material world. According to this viewpoint a thing can have several uses.

Not just one, but several lives. The concept of reuse/recycle has very deep roots in the Indian culture. This 5,000 year-old story shows a deep respect and sensitivity for the material world. It has many lessons for modern day environmentalists.

One day the great Buddha was taking a round of the monastery. He was approached by a monk who wanted a new woollen shawl *(angarkha)*.

Buddha asked him, "What happened to your old shawl?"

"It had become very old and worn out. So I am presently using it like a bed sheet," replied the monk.

Buddha asked again, "But what happened to your old bed sheet?"

"Master, that bed sheet got old with use. It was worn and torn. So I cut it up and made a pillow cover out of it," replied the monk.

"But there certainly was a pillow cover before you made a new one. What did you do to your old pillow cover?" asked the Buddha.

"My head had rubbed a million times against the old pillow cover and made a big hole in it. So I made a foot mat out of it," replied the monk in earnest.

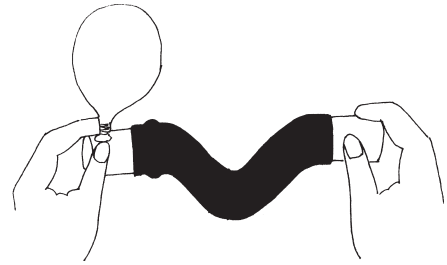
Buddha was not satisfied by this answer. He always delved deep into any issue. In the end he asked the monk, "Tell me what you did with your old door mat?"

The monk replied with folded hands, "Master the old door mat had got totally worn with use. Because of repeated use the warp and the weft had come out. So I took the cotton fibres and braided a wick out of them. Later I burned the cotton wick in the oil lamp."

Buddha smiled after listening to the monk. The monk got a new shawl.

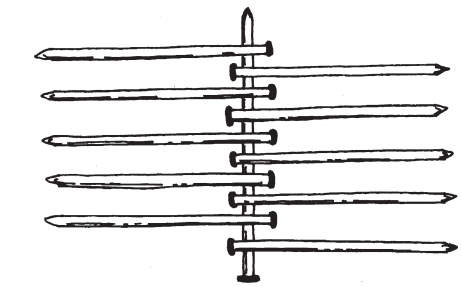
Toys and Trinkets

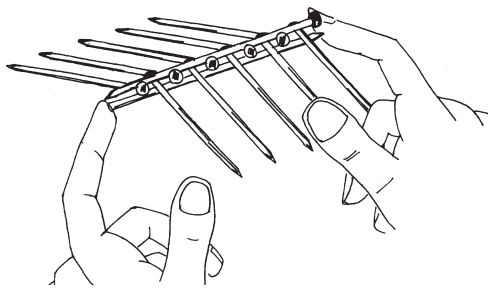
There are many examples of creating fairly sophisticated science models from junk. For instance, primary school children could make a wonderful hand pump with two film cans joined by a length of old cycle tube with flaps of sticky tape for "valves". This inexpensive pump can inflate a balloon and throw water 10 feet away!

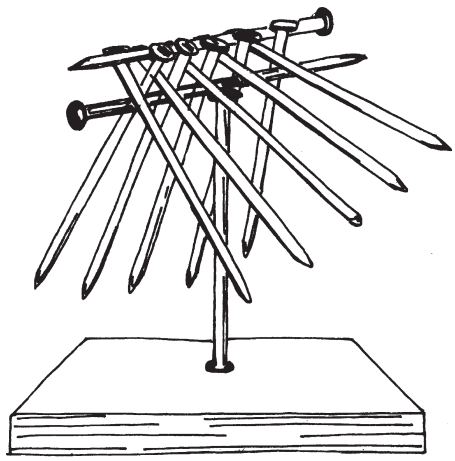


Another wonderful example is of trying to balance a dozen nails on the head of a vertical nail. This experiment does not require any specialised equipment—only nails and a piece of wood-materials which are amply available in the rural areas.

Toys have been used successfully to demonstrate principles of physics. Most inspiring physics teachers have their pet toys hidden away in drawers, cabinets and pant pockets. They include things like the dunking bird, gyroscopes, yo-yo's, a tippy-top, propeller on a notched stick, Newton's cradle, slinky and coupled pendulums. Most toys have an advantage over conventional demonstration equipment in their relatively low-cost and the fact that children relate well to them. Unfortunately most toys are not made for repeated use and that they are often no longer available when one looks for replacements!





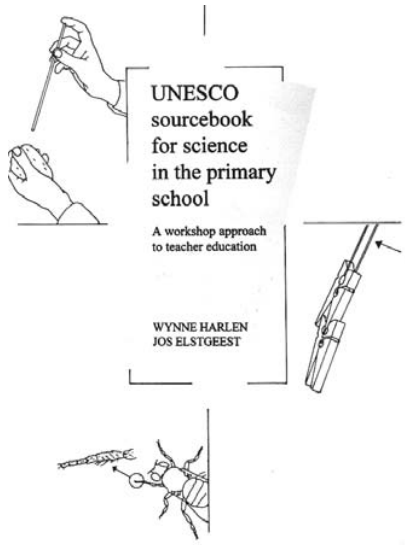


Children understand best when they see a science principle incorporated in a toy. If they can play with it, then they get a better "feel" for it. "Centrifugal" and "Centripetal" forces are abstract words and mean little to children. But a broomstick "spinner" can lend meaning to these words. A self-made toy acrobat which flays its hands and legs when spun can concretise this concept. A hundred such wonderful science toys have been collated in a book titled *The Joy of Making Indian Toys* by Sudarshan Khanna (published by the NBT and costing Rs 40 only). These toys have been there since ages. Every generation has enlarged this repertoire and left them behind in the public domain. These toys, made from 'throw away' stuff, are eco-friendly and the poorest children can enjoy them. In sculpting them, children learn to cut, trim, glue, fix and assemble together a variety of materials. They also learn great science.

The crisis of science is that people still do not want to dirty their hands. Rote learning, the chalk-and-talk method still reigns supreme. Everyone is out to "cover" the course, forgetting that the whole task of education is to "uncover" things.

Primary School Science

Over the years there has been a shift in thinking and schools are adopting more progressive measures. In many mainstream schools children in Class VII or VIII are taken to the laboratory where the teacher "demonstrates" certain experiments — how to make oxygen, etc. But still the children do not get a chance to do experiments with their own hands. Often the primary years are the most neglected phase where children seldom get a chance to mess around and do experiments.



The *UNESCO Source Book for Science in the Primary School*, authored by Winnie Harlen and Jos Elstgeest, was first published in the early 1990s. Its international edition was priced at US $20. Fortunately, the National Book Trust reprinted a low-cost Indian edition of this wonderful book priced at just Rs 95. This book has never been reviewed but it is still in the fourth reprint. This reposes our faith in ordinary teachers—a good book, reasonably priced, will sell well. The book has two parts: a theoretical section followed by four amazing science activity sections—Children and Water, Children and Balances, Children, Mirrors and Reflections and Children and the Environment. This book has already been translated and published in Hindi by the NBT. It will be wonderful if this book is published into other regional languages too.

Believing that science and the scientific method of problem-solving should play a significant role in any modern educational scheme, UNESCO offers this book in the hope that it will assist science teachers everywhere in their important work. The point of view taken is that science is most effectively taught and learned when both teacher and pupils practise the skills of problem-solving by engaging in group and individual study. The devising of experiments and the improvising of simple equipment for carrying them out should form no small part of such study. Thus, the present includes instructions for the making of many pieces of simple apparatus from materials usually found in almost any region. It also proposes a wide array of science experiments from which a teacher may select those most suitable for providing the observations upon which effective learning may be based.

In many parts of the world, science education occupies a comparatively insignificant place in primary-school education and unfortunately what actually happens in the classroom under the label of science is often totally inadequate. Teacher training both pre-service and in-service, is one of the keys to this problem. Starting from the premise that this training should be carried out in ways more closely related to the active methods which teachers are expected to use in their schools, this sourcebook provides a variety of materials for use in training workshops for primary-school teachers which can be used both in group-work and by individual teachers for independent study.

'The String and Sticky Tape Experiments' column was introduced in the magazine *The Physics Teacher* brought out by the American Association of Physics Teachers (AAPT), in the early 1980s. It showed experiments using the simplest, least expensive materials. The materials could be purchased at the nearest store – you did not need anything expensive – not even need a stopwatch. All you needed were common rubber bands, cello tape, styrofoam or paper cups, string, drinking straws, glass marbles, plastic ruler, coins, pencil, paper and scissors to perform a series of wonderful process-based experiments.

Conclusion

In the last few years there has been a silent revolution underway in terms of the quality of state textbooks. The NCERT has tapped the best talents in the country to revise and upgrade its textbooks. This is very significant. For most of our children the textbooks perhaps will be the only books they will ever read. So, making them world-class is a major achievement we all can be legitimately proud off. This is also true of the science textbooks. Today the NCERT textbooks set new benchmarks for the private sector publishers to emulate. The internet has been a great leveller too. There are many organisations working to make education and specially science education more interesting and relevant for our children. Some pioneering experiments like the Hoshangabad Science Teaching Programme might have been shut down for myopic political reasons, but they have left behind seeds for future innovations.