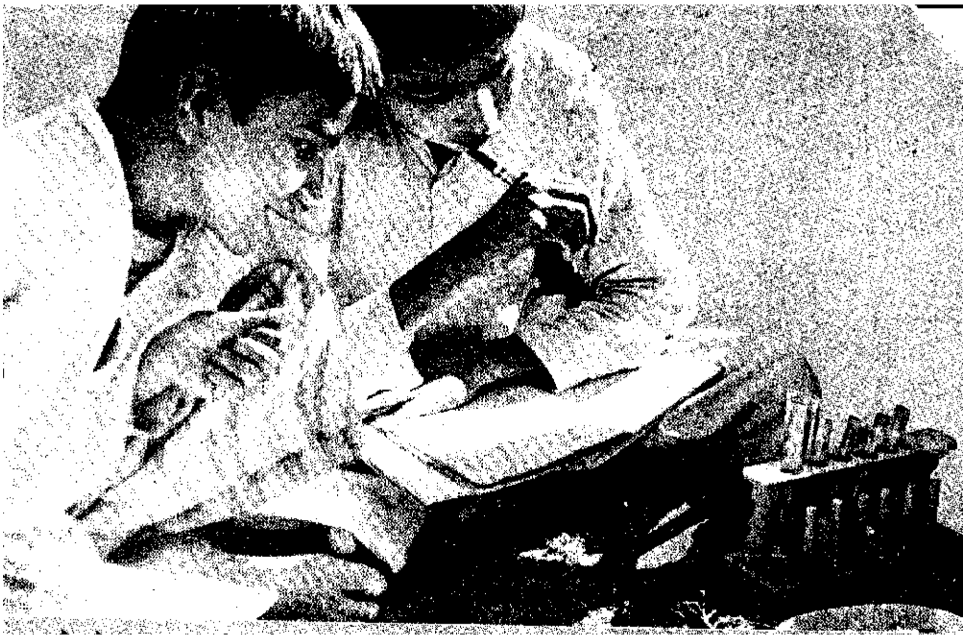
The Hoshangabad Vigyan

(*Science Today* 1977)

Over the past five years, two voluntary agencies in the Hoshangabad District of Madhya Pradesh, Friends Rural Centre, Rasulia, and Kishore Bharati, Malhanwada (via Bankhedi) have conducted what may be called a pioneering experiment in science education in village schools. The experiment involved the teachers and children of 16 village schools of Hoshangabad district, and the emphasis was on 'learning by discovery'. But it was soon discovered, the phrase can remain a seminar cliché, unless educational innovations take the socio-economic factors into account.

Here is the report on the Hoshangabad Science Education Programme jointly prepared by the Delhi University Science Teaching Group, Friends Rural Centre, Rasulia and Kishore Bharati.

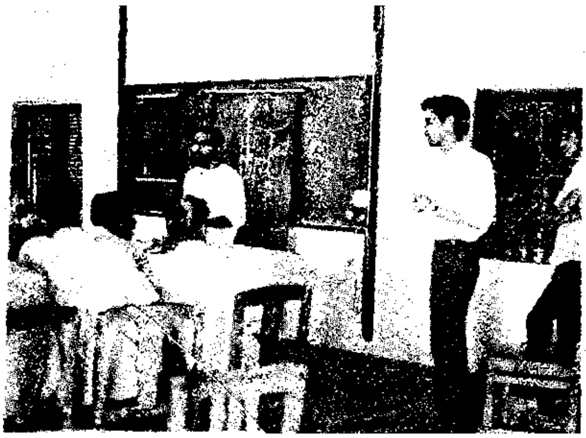
It was examination time. Bhaiyalal sat memorising hard. The topic was, 'Preparation of Oxygen.' Parrot-like he repeated. 'One by heating glass. Two by heating potassium permagnate. Three by heating….' The possibility of glass releasing oxygen was something new for us. The boy insisted, 'Guruji told us that glass, when heated, well gave off oxygen.' His class notes daily corrected by the teacher confirmed his statement. We were puzzled. Going through his textbook, the mystery was solved. It said that oxygen can be prepared by heating the oxide of lead (*seesa* in Hindi). The teacher applied his ingenuity to interpret 'seesa' as 'sheesha' (meaning glass). From 'sheesha' to kanch (glass) was the next step. The 'oxide' fell on the wayside.



Takhat Singh was a brilliant student. The teacher liked to present him as an example to any visitor. One day we visited Takhat's school. With his teacher looking proudly on, he rattled off the names of different parts of a flower: calyx, corolla, anthers, stamens, gynaecium, carpels…onwards to nucleus (Hindi equivalent's of course). However, when a flower was placed before him, he was stumped.

Some children sat drawing circles of different diameters with the help of their compasses. The teacher had trained them well. A casual question was posed by one of us, 'Can you draw a circle of 4-feet diameter?' The whole class looked dumbfounded. The school had taught them to draw circles using only a compass. A compass had its limits. 'If you had to dig a well, 4-feet in diameter, how would you begin?' we prompted. The young faces lit up, 'That's easy – using a peg and a string!' They confidently sat about demonstrating their skill.

The incidents described above were some of the first hand observations made by us in some village schools in Madhya Pradesh. This illustrates a serious malady in the teaching of science in rural schools. (Urban schools fare, perhaps, just a bit better!) In our perspective of rural development, a wide-ranging attack on such significant gaps between expectations and reality in education occupies a prominent place. Why does a child have to memorise a whole range of disconnected and irrelevant facts in the name of science? These facts often make little sense to the teachers themselves and are seldom remembered beyond the examination. What use is terminology, which conveys nothing beyond imposing words? What use is education, which builds up barriers between classroom learning and real life experiences? What use is information if it cannot be applied to solving practical problems?



We are faced with some stark facts. First, knowledge is growing exponentially. No one is expected to know or retain any significant fraction of it. Secondly, it is generally accepted that 60 to 70 percent of village children do not enter the school system or drop out at an early age. To those who do manage to continue, a mere one-fifth enter high school in rural areas. Our present education is mainly designed for those privileged few. This, to us, was a contradiction. The focus of education, we felt, should be to prepare the vast majority, which drops out midway for facing the tough school of earning a livelihood. Educational objectives, thus, need to be re-defined in this perspective. Science education must aim at developing skills and attitudes, which enable students to learn directly from their environment and experiences.

Such ideas were concretised in a proposal we presented to the Director of Public Instruction at Bhopal in February 1972. We were apprehensive. We had no *locus standi* in the field of school education. The pre-eminence of professional and resourceful organisations like the National Council of Educational Research and Training (NCERT), State Institutes of Science Education engaged in the task of improving science teaching was fully recognized by us. There was a plus factor, however. We had sought and received the support of Mr. B.G. Pitre, and Mr. C.K. Dikshit of the All India Science Teacher's Association (AISTA) Physics Study Group and Prof Yash Pal and Mr. V. G. Kulkarni of the Tata Institute of Fundamental Research, Bombay. They had conducted pioneering trials in introducing the discovery approach to the learning of physics in a few Public and Municipal schools. Building upon their experience, we intended to test the feasibility of the discovery approach under village conditions. We would also cover all science subjects, utilizing the environment as a source of learning.

Children, our proposal stated, should learn science by performing experiments with their own hands, recording their observations, and deriving independent conclusions through discussions with their classmates and teachers. They should be encouraged to ask questions, critically examine evidence and analyse new situations that might arise. Rote learning of facts and definitions should be ruled out. Storage of information must not be the sole criterion of learning. The teacher would cease to be the fountainhead of all knowledge. His role, instead, would be that of a guide and helper. This meant that traditional barriers of syllabus, teaching methods, textbooks, teacher student relationships and school administration would emerge from the day-to-day experiences of the teachers and children, not from the scholarly expectations of city based experts. The demands of the examination system would also have to undergo a radical change in keeping with the new objectives. We sought freedom to do that.

The State Government gave us permission to experiment in 16 middle schools, nine around Friends Rural Centre in Hoshangabad Block, and seven around Kishore Bharati in Bankheri Block. The schools and the teachers were selected randomly to ensure representative conditions. The State and the District education authorities assured full co-operation. The continuous backing and unhesitating freedom given by the Government of Madhya Pradesh has not only been the cornerstone of the programme, but at times also its inspiration. This quality and extent of the Government support to a voluntary group for experimenting with school education within its own structure is perhaps without precedence in the country.

And, thus, the experiment began.

ENCOUNTERS WITH TEACHERS

The morning of 25 May 1972 saw an unsure faculty facing an apprehensive group of 34 teachers. The first Orientation Course had begun. There was no inauguration, no fanfare. The District Education Officer (DEO) had warned us that most of the teachers had studied only up to high school and had little or no science background. The older ones joined service after middle school. Only four or five were graduates, one in science.

The ice was broken by a question, "What do you find lacking in the present education system?" A lively dialogue was sparked off. It soon petered out into an uneasy silence with the arrival of the DEO. After an awkward pause, a teacher stood up and asked reverently, "If Sa'ab will not be offended, may I make a humble submission?" "Yes, yes", the DEO encouraged. "Could we not recreate the mood of the assembly, which existed before DEO Sa'ab joined us?" the teacher dared. Despite his appeal and the DEO's encouragement, the openness of the earlier discussion could not be reestablished. That was our first taste of the hierarchical structure of the Education Department, which stifles communications and feedback from the grassroots to the planners.

Only a year later, however, the same teachers took the visit of the State Education Minister in their stride. His arrival caused only a minor flutter. The teachers continued to perform the experiments even when the Minister stopped at their tables to observe them. Today these teachers can participate in uninhibited discussions with senior administrators, educationists, scientists and NCERT representatives.

The faculty had created an informal and open atmosphere from the very beginning. Small things like serving food and eating in the same *pangat* had their own significance. When teachers were reluctant to try out new experiments which appeared too simple, Prof. Yash Pal's " *Yar, kar ke to dekho"* with a friendly pat on the back made all the difference. The faculty even shocked many of the teachers by announcing that they were free to smoke *bidis* in the hall itself.

Throughout the 21- day Course, the teachers had free access to kit materials and books. For the first time in their experience of such courses (some had been through many), they were actually doing experiments. They were perplexed that these experiments could be performed with simple items like thread, balloons, rubber bands, paper clips, buttons and *kulhads* (Earthen cups).

The basic issues of the discovery approach soon began surfacing. For example, discussing plant life in a biology session, a teacher-farmer raised a question, " How do fertilizers in soil reach the leaves?" At once, an experiment was planned. A twig was cut and placed in red ink solution.

Half an hour later, the leaf veins turned red. The conclusion was obvious.

But one teacher was sceptical, "How can we be sure? Perhaps the veins turned red because we cut the twig. I have seen apples turn brown after cutting."

Although the question appeared trivial to us, it could not be ignored. Such questions form the backbone of the discovery approach, providing links for further experimentation. A heated debate followed. It was decided to modify the experiment by including a second twig placed in plain water. The concepts of using 'controls' was born.

The teachers were by now thoroughly engrossed in the spirit of enquiry. "What would happen if we used blue ink?" asked one. All faces turned to the faculty biologist. He shrugged, " I do not know". The teachers were flabbergasted. They asked in disbelief, " How did you get your PhD if you do not know such simple things?" It was a jolt to their value system. To them a PhD signified the end-point of all knowledge. Here was a chance to illustrate the open-endedness of scientific enquiry. The experiment was repeated with different inks. The selective absorption of different chemicals by plants was strikingly demonstrated. The full implications of the discovery approach only then dawned upon the teachers. They began to realise that they, too, would often be forced into such tight spots when they would have to admit, "I do not know the answer. Let us find out." It was a negation of the traditional pre-eminence of the teacher. It had been a long battle. The " I do not know" philosophy is only now slowly sinking in.

Even simple exercises, for instance, of measuring lengths, had many surprises in store for us. The teachers were asked to measure the length of a table. " *Arre*! This is child's play", they said. " Let us do something more serious". We persisted. One by one, reluctantly, they walked up to the table, metre sticks in hand. Their confidence soon paled to dismay. Some had problems in reading the scale, others with decimals, while a few could not even distinguish the centimetres from the inches. Sheepishly they submitted to the training of measurements. Everyone was asked to measure the length of the blackboard: 200.8 cm, 198.7 cm, 200.5 cm, 199.2 cm… ran the list. "Why this variation?" was the question. Maybe they had made mistakes. They measured again, more cautiously. They were visibly disturbed by the persistence of variation. For them the sanctity of science lay in its exactness. The weighings and measurements of shopkeepers, too, showed such variations, but they put that down to cheating. A cosmic ray physicist came forward to relate his experience of similar variations in cosmic ray measurements, even with 'phoren' equipment. That day a new word '*ghat-bad'*, literally decrease-increase was added to their scientific vocabulary.

OF THEIVES, PACKING CASES & AMALGAMATED FUNDS

It had become a familiar story. The teachers were once again complaining of the sorry state of their kit. It lay scattered, open to attack from rats, thieves, wind, rain and dust. 'No extra almirahs can be given for storing the kit' the teachers had been informed by the authorities. We had suggested packing cases as an alternative. The teachers were cynical. The kit cannot fit into packing cases, they insisted. We showed them how to do it by building shelves, hooks, slots and covers with hinges and latches. Such cases, with fittings could be assembled by the children themselves at a cost of about Rs. 15 per school. ' Where is this money to come from?' asked the teachers at a monthly meeting. The DEO reminded them of the Amalgamated fund, which is built up from small annual contributions from the children and is meant for such miscellaneous school expenses. Nothing happened.

At the beginning of the next academic year we raised the issue of the packing cases again. By now, we had some fresh information. An assistant district inspector of schools had quite enthusiastically informed us that he could supply all the cases the schools needed. Consignments of chalk for the school came to his office packed in such cases. The packing cases, after emptying were usually 'gifted' away. He had assured us that these would be reserved for the schools to build kit cases.

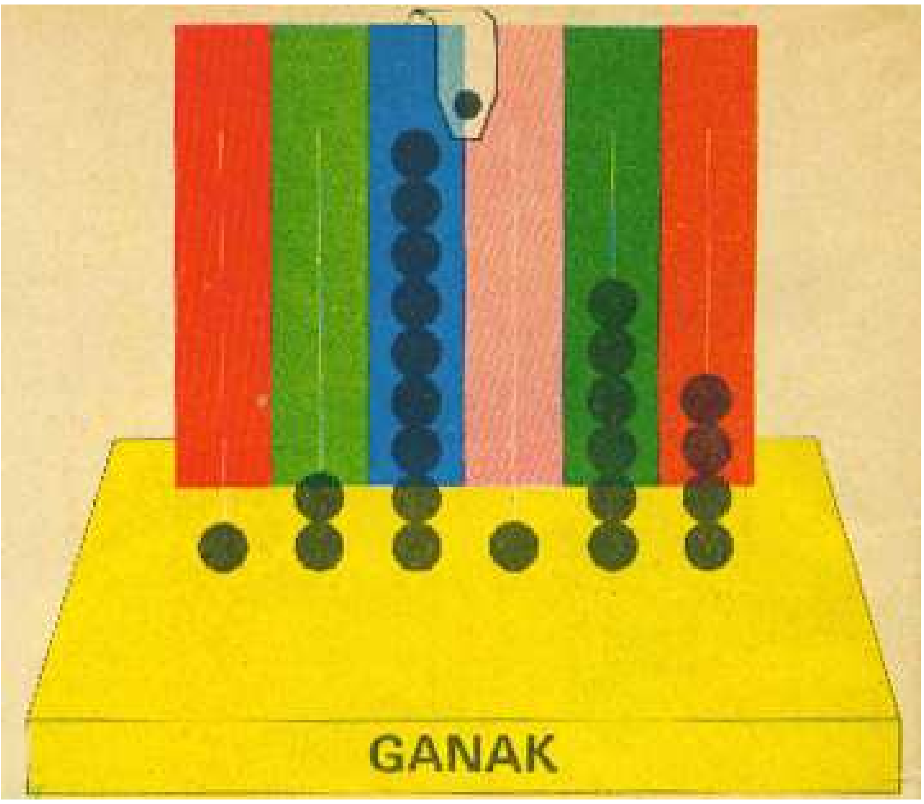
One year passed. No packing cases had gone to the schools. In many schools the kit continues to lie scattered open to attack from rats, thieves…

THE UNIVERSAL CUBE

The markets of Hoshangabad, Piparia, Itarsi, Bhopal, Delhi and Bombay had been ransacked. Several workshops said, "It is impossible at your cost." We were looking for 1-gm weights for experiments on springs and balances. Each school needed approximately 100 such weights. Where were we to find them? It suddenly struck us, the answer was in our kit. There were 1-cubic centimetre plastic cubes in the kit, which had been included in the first place for volume experiments. These cubes were slightly heavier than water and weighed 1-gm each to an accuracy of 10 per cent. Expensive weights were no longer required.

It later occurred to us that, since each surface of the cube was a unit area and each edge a unit length, they were suitable for experiments on the measurement of area, length and perimeter. When the chapter, 'Chance and probability' was developed, the cubes served as dice with white dots painted on their faces. In one of the monthly meetings, a teacher narrated how he had used the cubes to form 3-dimensional histogram when children experienced difficulties in plotting them on paper.



'4 FEET 8 INCHES = 4.8 FEET'

On a rainy august day in 1972, within barely six-weeks of the beginning of the programme, a follow up visit to one of the schools brought out a situation for which we were least prepared. The children were found engrossed in measuring the height of one anther with the meter sticks provided in the kits. The heights were being recorded on the blackboard by one of the students in order to prepare a histogram. One boy was 4-feet and 8-inhces tall. The student at he blackboard wrote it down as 4-feet and 8-inches. Suddenly, a sharp reaction from the teacher sent a shiver down his spine: 'Why don't you write this in decimals.' The student just stared blankly. Came a further prompt, 'Write 4.8-feet'. The student quietly complied. We just could not believe this. The alarm had been sounded. All follow-up workers were asked to check on the children and teacher's understanding of decimals. In a majority of cases, the first experience was confirmed.

In the next follow-up meeting with the teachers the issue was raised. The teacher's were adamant. According to them, the children understood decimals as they were supposed to have mastered these in primary classes. The question of the teacher's ignorance, of course, did not arise. The teacher's sensitivity on this issue made remedial measures impossible. It was more a psychological problem then an academic one. It had to be tackled on that plane.

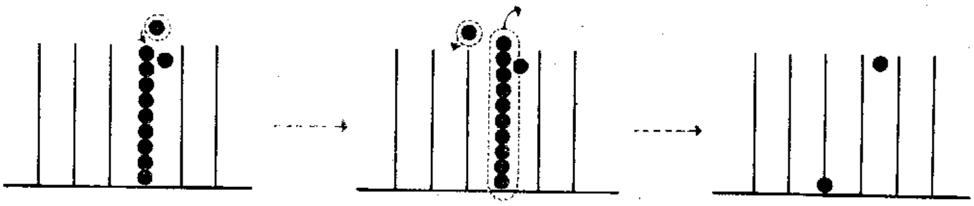
We had to wait until the next monthly meeting. An experiment was planned. Each teacher quietly and without any warning was given a scale, each with a different number of divisions per inch. When asked to measure the length of their books they reported results like – 10.2" with a scale of four divisions per inch and 8.11" (eight point eleven inches). With a scale having 12 divisions per inch. The game was now up.

The need for a remedial course, in decimals had been established. The resource group members put their heads together. A trial draft was ready by the 1974 orientation course. In this novel approach, the children were expected to make an abacus of their own and use it to understand the significance of place value and hence decimals. Two research students took up the challenge of designing an appropriate abacus. What came out of this effort has now come to be known as the *GANAK* – it is an assembly of six straight wires fixed vertically and equidistant on a wooden platform. The background is made of stiff rectangular paper pasted with strips of coloured paper and fitted with a small triangular paper rider to mark a decimal point. The length of the vertical wire is adjusted such that they accommodate exactly nine beads and no more. To add the tenth bead one has to remove all the beads and replace them with one bead on the next wire to the left. This simple device enables the students to discover for themselves the basic rules of addition and subtraction in decimals as well as conversion to fraction. The topic is introduced to the children in an interesting story of the beginning of counting based of our ten fingers. The abacus activity is backed up by concrete experiments on length, area, volume and weight.

Some of the senior most state and district level education officials who came to see the orientation course witnesses the teachers being trained in this new approach. They immediately wanted to know the reason for spending so much energy and time on decimals at the middle-school level. Soon a group of about 20 children studying in middle school were gathered from the neighbouring villages. An impromptu test produced irrefutable evidence. The remedial action in decimals through abacus and other experiments is now an integral part of the science programme in the 16 middle schools.

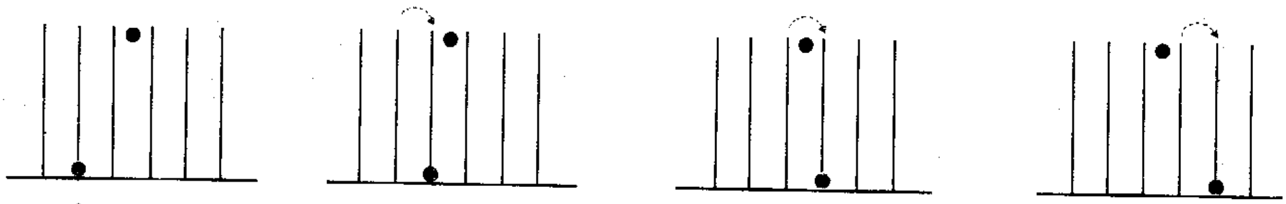
The process of convincing the teacher community and the education officials about the wide gap between the expectations and the reality in the case of decimals and of evolving an innovation has been one of the most exciting battles of the science education programme.

When a wire gets
the tenth bead



Ten beads on one wire is equal to one bead on the next wire to the left

THE "GANAK" PRINCIPLE

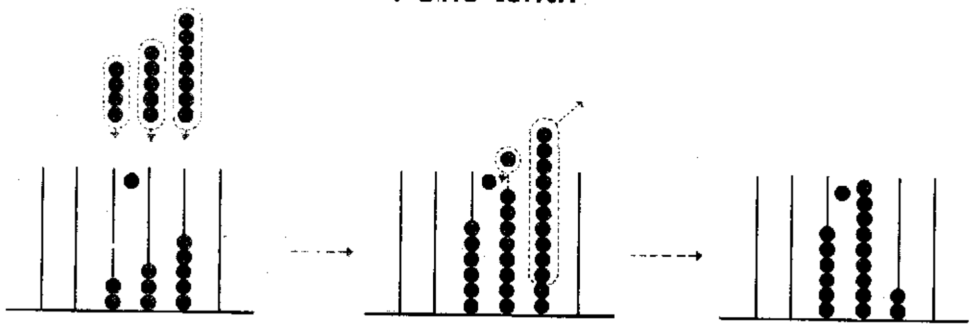


1 0.0	1.0	0.1 0	0.0 1
Ten	One	One-tenth	One-hundredth

Same bead on different wires has different value

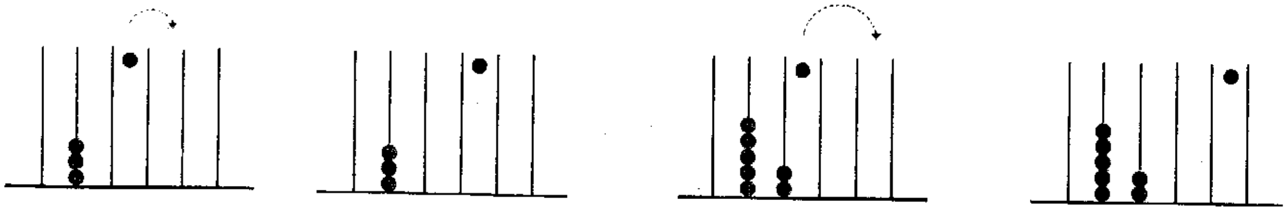
CONCEPT OF PLACE VALUE

Carrying Over
1 One-tenth



2.35 + 4.57 =6.92

ADDITION USING "GANAK"



3 0.0 X10 =3 0 0.0 5 2.0 X100 =5 2 0 0.0

MULTIPLICATION BY SHIFTING DECIMAL POINT

THE PROGRAMME GOES TO SCHOOLS

The teachers at once put their training to practice in their schools. They were no longer lecturing. Children were split into groups of four to five to do experiments. Later on, *Paribhraman* (field trips) was introduced as an integral part of the curriculum. Special emphasis was placed on the role of follow – up visits by faculty members to the classrooms - not for inspection but for assistance, assessment and collection of feedback. Initially, the teachers tended to hand over the class to us. We had to insist on our observer status. At times, our strong impulse to interfere had to be stifled. This was particularly difficult in situations of inept handling by the teachers, in moments of great excitement or when a teacher reverted to lecturing. Sitting with the children on the floor, we would go through their workbooks, assist in experiments, jot down our observations and collect criticisms and suggestions from them. We sometimes put new ideas and "Brainwaves" to test. When chance permitted, we would step aside for a brief discussion with the teacher. Informal after-class sessions with the children and teachers were often more revealing and helped in sorting out knotty problems.

Intensive school visits and teachers' monthly meetings soon destroyed many of our romantic notions. We often found the sixth, seventh and eighth class in one room, with the primary classes on the veranda religiously chanting their lessons. Sometimes, a single teacher would handle more than one class at a time. 'No classes was a frequent phenomenon (see my village school zodiac). Kit material was often left unclean and flung in disarray. Advance preparations for the day's experiments were uncommon. Record books of the children were infrequently checked. The kit was misused. Plastic buckets, scissors, blades, and threads found their way to private homes. Influential village leaders took the liberty of calling for plastic dishes, mugs, and tumblers for their wedding feasts. These sometimes never came back. Interesting items like magnets, torch, bulbs and lenses were irresistible to the children and were promptly pinched. Lack of cupboards posed a serious storage problem leading to alarming attrition rates.

We had not expected very high academic standards, but what startled us most was the rock-bottom level of children's development. Minimum capabilities of written expression, comprehension and mathematics, which they should have acquired in primary school, were glaringly missing. Children could not even write in simple Hindi an event, which they had observed. Elementary instructions in the workbook were not comprehended. Some could not even read. Those who could failed to link instructions to actions. They had been trained only to memorise. Primary numeracy skills were not fully developed. Basic concepts like place value and one-to-one correspondence had not been understood. A child who could count up to 500 when asked to write 501. Decimals were a disaster. All this adversely affected the children's capability to do and discuss science experiments.

Line diagrams conveyed precious little for them. They could not, for instance, associate a two-dimensional diagram of a beaker with an actual one. Their ability to draw objects in front of them was limited. Drawing from imagination was out of question. Proportion meant nothing. Common symbols like arrows and simple techniques to showing depth or distance in drawing were totally alien. The significance of using colours in drawings and maps was lost on them. This can largely be attributed to their non-exposure to standard communication material like magazines and books normally accessible to an urban child. Another major factor is the absence of drawing activity in primary school. Colours, crayons and paper are a rare phenomenon in their environment.

The teacher too, had their problems. Harassment, transfers, attachments, administrative and survey work, *nasbandi* (sterilization) campaigns, low salaries, bossism of local politicians are only some of the factors which take a teacher's mind off teaching. The teaching profession has lost its legendary prestige. Working under such adverse physical, social and economic conditions, is it any wonder that teaching takes a back seat? The discovery approach has failed to make any dent in these structural barriers. Unmotivated teachers remain uninspired.

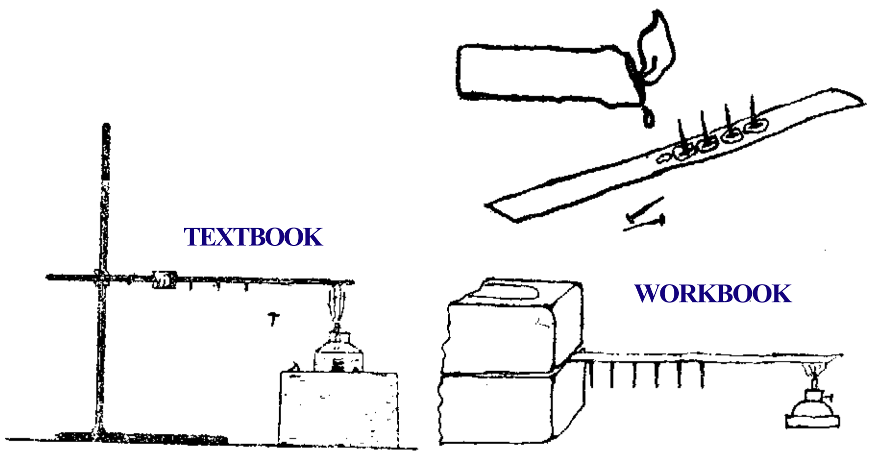
But there is a silver lining. About half the teachers who already had a high level of motivation, exploited the avenues opened up by the discovery approach. This, and the unbounded enthusiasm of the children, provided the rationale for such innovative efforts. There are teachers who have successfully inspired children to take complete responsibility for the management of the kit. In several instances, children and teachers have gathered after class hours to observe the night skies. Some children have shown initiative in going beyond class experiments by designing their own little gadgets like projectors, electric motors and bells, torches and musical toys from whatever materials they could lay their hands on.

There are schools where children organise themselves to continue experiments during the teacher's absence. During field trips, the natural of children is seen at its best. Diving into rivers, plodding through mud, climbing trees and daringly probing burrows, they come back with rare specimens of animals, plants, rocks, insects, eggs and nests. On holidays and Sundays, many frequently walk several kilometres to come to us with their queries, insisting upon being given materials to perform experiments and seeking appreciation for their creative efforts.

It has been our repeated experience that a crucial factor in the proper working of any school is the concern shown by the village people. A striking example is that of a teacher who hardly taught for three years in a village where people were disinterested. On being transferred to a village where people were concerned about the education of their children, his true potential came to the fore, so much so that he has proved to be one of the most enterprising teachers in the programme.

TEXTBOOK vs. WORKBOOK

A standard seventh class textbook widely used in schools gives the following experiment.



CONDUCTION OF HEAT

The transfer of heat between two objects in contact or between different parts of a single object is called conduction.

The conduction of heat can be understood properly from the following experiment:

Fix the end of a piece of thick copper wire to a stand. Stick small iron nails to this wire with the help of wax. Now heat the other end of the wire with a spirit lamp. You will observe that the nails start falling off one-by-one from the heated end. This clearly demonstrates that the heat is slowly conducted from one end of the wire to the other. Heat conduction can be explained on the basis of the molecular structure of matter. On receiving heat energy the molecules near the heated end start oscillating with a speed greater than that of other molecules in the vicinity. These molecules collide with their neighbours causing them also to start oscillating fast. The process continues and heat energy is thus conducted continuously from one layer to the next.

Dear reader, having been given the definition of conduction sketchy instructions to perform the experiment, the result, inference and the sophisticated explanation using kinetic molecular theory would you now proceed to perform this experiment? You will need a stand costing only about Rs. 13/- a spirit lamp costing Rs. 2.50, a thick copper wire (how much will it cost, and where is it available?) and a few nails. Wish you best of luck trying to stick nails with wax on a thick round copper wire!

Consider the same experiment from our workbook as performed in the schools:

TRANSFER OF HEAT

Take an iron strip approximately 15-cm long. Using a lighted candle, put a drop of molten wax on a strip about 4-cm from the end marked A. stick a 1.5-cm long nail in the wax as it cools. In this way, fix 5 more nails on the strip at 1-cm intervals. Now wedge end 'A' between two bricks with the nails pointing downwards. Heat the other end of the strip with the kerosene lamp. Record the time at which you start heating in a table. Also, record the time when each nail falls.

Why did the nails fall?

Why didn't all the nails fall together?

Plot a graph between the time when each nail falls and its distance from the heated end.

Is the graph a straight line?

On the basis of this experiment write your views on the transfer of heat in metals (solid).

Dear reader, perform the experiment and discover heat conduction for yourself. The bricks should cost you nothing, the nails not more than 5 paise and the kerosene lamp a rupee. The iron strip is simply a piece of a packing strip.

A WORKBOOK WITH A DIFFERENCE

The basic tenets of the workbook were defined early in the programme. Its text would make experiments inevitable. It would give instructions for performing these experiments, following by leading questions to initiate discussions. No definitions, no facts and no ready-made answers would be given. Adherence to these principles is crucial to the success of the 'discovery' approach. Textbooks in use today pay only lip service to the method of learning through experiments. Phrases such as 'Look and discover', 'What did you observe?', 'What do you conclude?' and 'Learning by doing' are often used in them. However, there is little scope for either experimentation or for drawing independent inferences. No time lag is given between two processes.

In is our contention that no appropriate workbook or kit can be evolved without direct interaction with the teachers and children under school conditions. We have innumerable examples where such interactions have led to major changes in the material, which otherwise we would never have thought. Most textbooks now in use have been prepared without the benefit of such interaction. (In fact, even the machinery for collecting and using feedback is either unutilized or not developed at all). This result of this lack of interaction is clearly evident in a set of attractive primary school textbooks professing to base science on experimentation. Children are asked to collect pictures of rockets and satellites from newspapers and magazines as part of their home assignment. Such printed material is almost always unavailable even among the affluent in the villages. The poor cannot even acquire scraps of waste paper for rough work. The demand for ice in one experiment and for a globe in another is further examples. Perhaps the most ironical example is the sentence meant for children in Madhya Pradesh: 'Your friends living near the sea must be familiar with high and low tides!'

Our workbook has thus evolved during the past five years through this process of continuous trial and error under field conditions. Yet we consider the totally revised version in use today as only tentative. It is bound to undergo further changes in order to reflect more closely the true-life situation. Meanwhile, the present draft, approved by the Madhya Pradesh Government is being published by the M.P. Text Book Corporation.

THORNS AND TEST TUBES – THE KIT

'We are a poor nation; we cannot supply kits for experiments. The discovery approach is a luxury only affluent nations can afford.' How often such apologies are heard. These derive from the myth that science experiments can be done only with fancy glassware, costly chemicals and sophisticated physical apparatus. Our experience has been totally to the contrary. The use of sophisticated equipment is not merely unnecessary but, in some cases, actually undesirable. It aids in the mystification of science, removing it farther from the day-to-day realities of life.

We designed our kit to suit the workbook. It is not a demonstration kit. For an average school comprising of 120 students in three classes, the kit originally cost slightly more than Rs. 1,000/- In its present form it costs about Rs. 800/-. The replacement cost (of consumables and breakable items) is about Rs. 150 per year per school, averaging Rs. 1.25 per student per year. Lower costs have been achieved by making some items more versatile and by replacing expensive materials with cheaper, locally available substitutes. For example, dissection needles have been withdrawn in favour of zero cost *babool ka kanta* (acacia spine). Costly iron stands have been made redundant by tying burettes to a pillar or the leg of an upturned table. Burettes themselves have given way to jet-siphons drawn from a bucket for water-clock experiments. Volumetric titrations are carried out using droppers, thus conveying the concept of neutralisation to a reasonable accuracy by counting the number of drops

DEVELOPING CONTENT

In an orientation course, a teacher raised a question, ' Is there variation in living things?' A biologist challenged the teachers to fetch any two identical leaves. An amusing but frustrating search ensued. Many a time the teachers thought that they had found identical leaves, only to discover small differences on closer observation. A comparison of their fingers proved that variations were inescapable. The faculty was excited. It had material for a new chapter, which the teacher promptly named '*Jeev jagat mein vividhta'*.

The teachers generally exhibited an implicit faith in destiny. This was an impediment to logical analysis and had a spill over effect on the children. When presented with a specific case of two apparently identical fields giving different yields, they promptly attributed the difference to the predetermined destiny of the owners of the field. Factors like soil types, seed rate, fertiliser use, etc were totally ignored. This lack of rationality had serious implications on their ability to moderate discussions. A physicist therefore developed a unique chapter on chance and probability. Using, coins, dice and marbles, students were exposed to random numbers, distribution and the law of probability. They simultaneously, learned to handle large masses of data in the form of tables, histograms, graphs and averages.

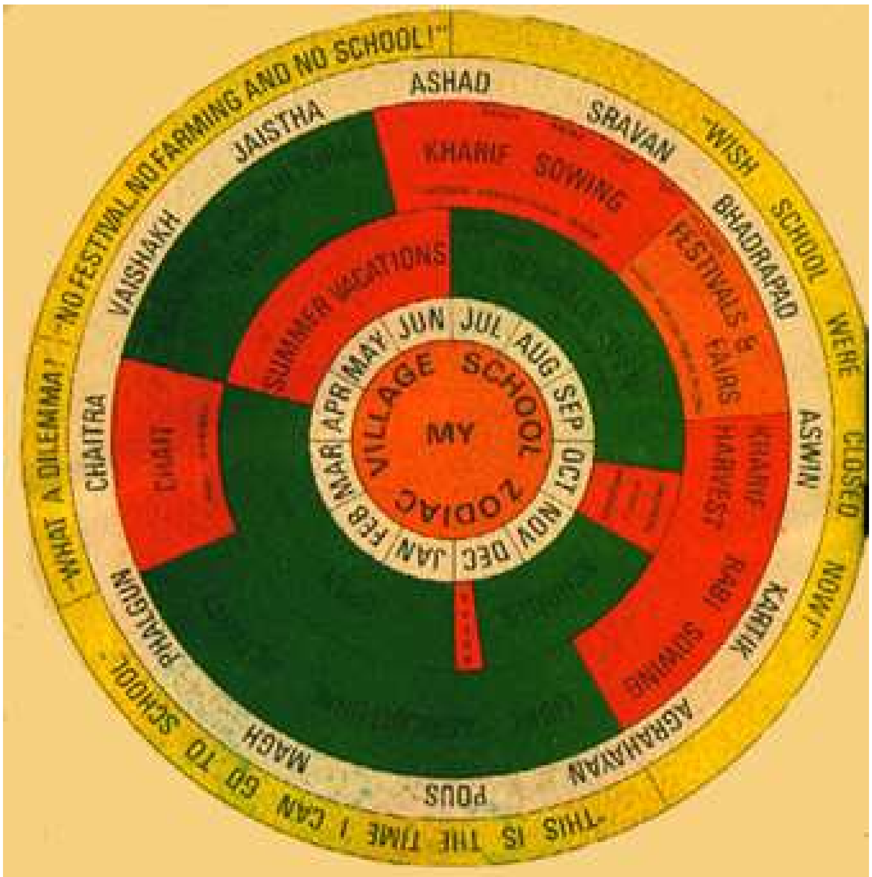
A conscious decision has been made to avoid standard biological classification with its overdose of Latinised terminology. Children are encouraged to build up their own systems of classification with its overdose and to discover the underlying principles while doing so. As an example, the children naturally prefer classifying animals into groups such as 'animals that live in water' and 'animals that fly', rather than into groups such as 'chordates' and 'non-chordates.'

The relatively elite value system of most of the teachers often places severe limitations on the learning system. This is one reason why we have been unable to base learning around active involvement in agriculture. Such barriers did not exist with children from landless and marginal farmer groups outside the schools in a non-formal programme. The social and cultural factors are also retarding factors. Teachers have been reluctant to dissect frogs to study anatomy and eggs to observe chick embryonic growth. Such activities would be possible if left to the children alone because of their uninhibited response and natural curiosity.

The crucial role played by the teachers and the children in curriculum development is now an accepted norm with us. The total learning time available is limited. The socio-economic contradictions and the needs of the rural community must influence educational priorities. These have been the touchstone for emphasising or de-emphasising subject matter. In spite of these limitations, we have been able to explore interesting phenomenon in day-to-day life. The skies are studied in '*Akaash ki ore'* and soil in '*Mitti*' and the crops in '*Hamari phaslein aur samuhikaran'*, the crop diseases and pests in '*Mitti, patthar aur chattane'*, and the local flora and fauna in a series of chapters such as '*Jad aur patti'*, '*Phool aur phal'*, '*keedon ki duniya'* and '*Jantuyon ka samuhikaran'*.

A commitment of learning through discovery, however, places constraints on exposing children to advanced scientific concepts arrived at through painstaking and sophisticated research. We have been unable to expose human anatomy, abstract chemical symbols and the theoretical concepts of atomic and molecular structure. For instance, to introduce the concept of molecules, the two experiments to be performed are (a) laws of chemical combination, and (b) Brownian law of motion or limits of thinning in oil films. The former leads to the demand for the existence of a unit, while the latter leads to its finite size. Several textbooks quote the dissolving of sugar in water or the increase in solubility with temperature rise as the basis of molecular theory. This, however, has no direct bearing on the kinetic molecular theory. All the great scientists from Newton to Dalton saw sugar dissolving in water and did not arrive at the conclusion that there were molecules. In needed the experimental evidence of chemistry to develop such a concept. We prefer delaying such concepts till skills of experimentation and deduction are sufficiently developed for children to appreciate the experiments of others. (For situations like this, we suggest the use of appropriate supplementary reading material. The development of such material is a pressing need.)

Chemical symbolism, too, has been ignored. Instead, we have stressed manipulative skills like distillation, crystallisation, preparation and testing of gases, chromatography, neutralisation, etc. The concepts of acids, bases and salts has been developed as a classification depending on colour changes of litmus, phenolphthalein, rose petal, turmeric, etc.



THE VILLAGE SCHOOL ZODIAC

It was mid-July in 1973. A young physicist from Delhi University arrived at Kishore Bharati bubbling with enthusiasm. This was his first follow up visit. The very next morning the villagers found him slowly cycling towards a village 10-kms away. He had spent several hours the previous night designing bright new experiments to try out with the children. But when he finally got to school he found that the headmaster laboriously filling up a pile of registers, and a few of the teachers sitting around in a gossip session. There was no sign of children. He was informed that the teachers were busy with the *admission ka chakkar* and with collecting information asked for by the District Authorities. The few children who did turn up by default had been given *chutti*. The young physicist thoughtfully cycled back, disappointed but hopeful that this *chutti* mood will not be a pattern. His hopes were soon belied. Next day in a different school he found even the teachers missing. It was the weekly market day.

The subsequent month revealed more and more reasons for the dismally irregular functioning of the school. These included paddy transplanting, leaking school roofs, inaccessibility due to villages being cut off by seasonal rivers, local festivals and village fairs. At times the teachers were absent having gone on leave or on administrative work. Once a month they walked to a village 2-3 kms away to collect their monthly salaries and preferred to call it a day. On another occasion the Delhi University physicist cycled to a school 14-kms away struggling through knee deep mud and often carrying the bicycle up in his hand and found the school locked. Enquiries revealed that the whole village had been invited to the *rasoi* (feast after the death of a family member) in the house of the village Patel (Headman). The second member of the Delhi University team stationed at Rasulia had similar experiences. Both the team members returned to the Delhi University by the end of October with first hand experiences of the contradictions between the life of the village and the school system. The schools are expected to function when the children are busy assisting their parents in the fields. Somehow, the school experts seem to be totally oblivious of the pressures of the sowing and harvesting seasons in the life of the village. The annual examination coincides with the *rabi* harvest period. While the weekly market day, a major social and economic event is ignored, the legacy of the Sunday holiday persists from the British Raj. The summer months when the children are relatively free find the schools closed for vacations. No one who matters in the education system of the country seems to be prepared to explain the reasons for this major disharmony affecting the lives of the millions of village children.

'DISCOVERY' EXAMINATION

A few years ago, a voluntary group of scientists had introduced the discovery approach in a few urban schools. For almost two and a half years, the teachers and the children shared the excitement of experimentation. The days of memorising science were gone. As the Board examinations neared, an uneasy question was on the teachers' mind, 'What kind of examination will the children have to undergo?' The concerned authorities refused to budge and inch and insisted that these schools should undergo the traditional Board examination. The teachers at once backtracked and spent the next few months, spoon-feeding answers to probable questions.

We had from the very start insisted on total freedom to develop our own examination system. With unprecedented foresight, the Madhya Pradesh Government recognized us as an independent examining body for the 16 schools in science. Methods have been developed to test qualities of independent observation, data collection free thinking and deduction. We also seek to test the extent of a child's readiness to innovate through physical experimentation when faced with a new problem. This is achieved partly through open book written examination and partly through an experimental test. Recall ability is given only peripheral emphasis.

A similar commitment to such evaluation objectives is expressed by official examining bodies, too. It is claimed that their new 'objective questions' achieve this. The following example from an official examination illustrates how these so-called objective tests merely test recall:

Choose correct answers and write them in your answer books:

1.Which of the following units is used to denote the quantity of electric charge?

(i) Coulomb, (ii) Ampere, (iii) Volts, (iv) Ohm

2.The enzyme pepsin is found in

(i) Intestinal juice, (ii) Blood, (iii) Stomach juice, (iv) Bile juice

A few samples of questions to show how we have tried to meet the objectives of the discovery approach are given below:

CLASS SIX

1. A scientist placed a few insects of two different species in the middle of a long glass tube. He sealed both its ends and placed it with one end in the sun and the other in the shade. An hour later, he observed that the two species had separated one collecting at the end in the sun and the other in the shade.

What inference do you draw from this experiment?

CLASS SEVEN

2. A gas was collected in two test tubes marked 'A' and 'B'. On adding copper sulphate solution to test-tube 'A' black colour was produced. Test-tube 'B' was held upside-down for a while. When copper sulphate solution was later added to this test-tube, no black colour was produced.

What properties of the gas are revealed by these observations?

CLASS EIGHT

3. You have been given a wooden strip, some string and two leaf cups. Using these materials make a reliable weighing balance.

A striking change has taken place in the attitude of the children towards such 'discovery' examinations. They no longer feel the need to make last-minute preparations. (No preparation can indeed be made for such an examination even if one wished to.) We have today with us over 3,500 answer sheets of open-book written tests and over 3,000 responses to oral-experimental tests from evaluations conducted over the last five years. Each provides a valuable insight into the response to the discovery approach, the analysis of which has enabled us to continuously evaluate the efficacy and the relevance of our programme. Consequently, significant changes have been introduced from time to time.

THE 'BRAINTRUST'

It has been a standing joke with us that during annual evaluations and orientation courses, a stone thrown in any direction would strike a PhD or a PhD-to-be. For, this is the time when our Resource Group members from AISTA, Delhi University, TIFR, IIT's, post graduate colleges of Madhya Pradesh and other places converge on Rasulia and Bankhedi. Intense discussions carry on deep into the night and often spill over to the Delhi University Coffee House and TIFR West Canteen where remote villages like Dolariya, Junetha, Chandon and Nimsadiya acquire real meaning.

The participation of the Delhi University Group in the programme got official sanction from the University Grants Commission and the University Authorities in 1973. It was the first time that a university group in the country was officially involved in improving school education. Faculty members spent a semester each at the field level. This close involvement has helped to 'conscientise' the university group about grassroots level contradictions and conditions. A faculty member of a post-graduate college in Madhya Pradesh will soon be joining us on a three-year deputation under a UGC fellowship. These have been important landmarks in the nation-wide debate on the social objectives of higher education. Education at the university level itself needs drastic changes, but such changes cannot precede, and certainly cannot be unrelated to, reform at the school level. In fact, meaningful reform at the school level will almost inevitably force reform at the universities. However, unless there is an official reorientation of the values of promotion of incentives, the vast potential in the nation's university system will remain untapped for the task of educational change.

Where do we go from here? A concrete proposal has been made to the Madhya Pradesh Government to take leadership of the programme into its own hands and to conduct a Pilot Project at the tehsil or district level. Education innovation has limited value if it remains a working model. To become effective and socially meaningful, it must be merged into the wider educational network. Otherwise, it becomes merely an island of pilgrimage.

The potential of a multiplier effect in teacher training has already been tested on two occasions. In May 1975, some teachers from the programme demonstrated the discovery approach to a batch of lecturers from the Basic Training Institutes of Madhya Pradesh at the Regional College of Education (NCERT), Bhopal. Five months later, they successfully trained a batch of teacher recruits to the programme. The Hoshangabad Group can thus aid in building up a resource group within the Department of Education. Simultaneously, Government agencies like NCERT, State Institutes of Education and teacher-training institutes must question and redefine their traditional roles.

The Hoshangabad experiment, we believe, has succeeded in bringing the concept of learning through the environment-based discovery approach from the level of a seminar cliché down to the plane of reality in village schools. The future success of the endeavour depends upon the political will of the Government and commitment from the academic community to better education in the schools of India's villages.

End